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DEPARTMENT OF PROJECT MANAGEMENT IN MASTERS PROGRAM

RISK MANAGEMENT PRACTICES IN ETHIOPIAN MEGA CONSTRUCTION PROJECTS

IN THE CASE OF ADWA MUSEUM ZERO KILOMETER PROJECT

By

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THIS RESEARCH THESIS HAVE SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS IN PROJECT MANAGEMENT (MPM).

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DECLARATION

I, Tamrat Ayalew, the under signed, declare that this thesis entitled: "**Risk Management Practices In Ethiopian Construction Projects (Mega Projects): The Case of Adwa Museum Zero Kilometer Project"** is my original work. I have undertaken the research work independently with the guidance and support of the research supervisor. This study has not been submitted for any degree or diploma program in this or any other institutions and that all sources of materials used for the thesis has been duly acknowledged.

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This is to certify that the thesis entitled "**Risk Management Practices In Ethiopian Mega Construction Projects: The Case Of Adwa Museum Zero Kilometer Project"** submitted in partial fulfillment of the requirements for the degree of Masters in Project Management of the Postgraduate Studies, in Addis College and is a record of original research carried out by Tamrat Ayalew .under my supervision, and no part of the thesis has been submitted for any other degree or diploma. The assistance and help received during the course of this investigation have been duly acknowledged. Therefore, I recommend it to be accepted as fulfilling the thesis requirements.

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(MEGA CONSTRUCTION PROJECTS)

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Abstract

This research investigates risk management practices in the Ethiopian construction industry through a combined approach of a questionnaire based survey and case studies of diverse construction companies. The study explores the significance, responsibility, and effectiveness of various risk management techniques, focusing on both preventive and remedial measures. Analysis reveals construction material delay, weather disruptions, and design modifications as the most significant risks affecting construction projects in Ethiopia and the research aims to identify and analyze key construction project risks, evaluate the effectiveness of common risk management techniques, establish a risk ranking and investigate the roles and responsibilities of clients and contractors in risk management and investigate the effectiveness of different risk management techniques across companies of various sizes and nationalities in addition the analysis reveals that effective preventive techniques include producing detailed schedules with updated project data and leveraging insights from past project, Close supervision and coordination within project teams emerged as highly effective remedial measures. The findings contribute to a better understanding of risk management practices in the Ethiopian construction industry, identifying areas for improvement and promoting convergence between theoretical frameworks and practical applications for successful project execution.

Keywords: Risk Management, Survey, Case Study, Risk Assessment, Risk Management Framework

Preface

Effective risk management is crucial in the construction industry where uncertainty can significantly impact project outcomes. This research dives into the complexities of risk assessment, mitigation, and responsibility allocation within the Ethiopian construction sector. Recognizing that risks can represent potential losses and opportunities for gain, the research emphasizes a holistic approach to risk management, advocating for structured and integrated strategies at the organizational level. By integrating risk management practices across the entire company, businesses can improve strategic decision-making and gain a competitive edge.

The research acknowledges the evolving landscape of risk management in construction companies, where the focus has shifted towards embracing risk as a tool for value creation rather than mere avoidance. It highlights the importance of strategic risk management, engaging the board of directors, management, and other stakeholders in identifying potential events that could impact the organization's objectives. This process, termed Construction Risk Management (CRM), aims to align risk management strategies with the organization's risk appetite to ensure the achievement of its goals.

External pressures, such as regulatory requirements, market dynamics, and the need for competitive advantage, have driven organizations to adopt more robust risk management practices. Recognizing the increasing complexity and interconnectedness of risks, companies are adopting a more quantifiable and qualitative approach to risk assessment. Lessons learned from past financial crises, coupled with the reinforcement of corporate governance and internal controls, have further underscored the importance of proactive risk management strategies.

This study addresses the critical challenge of optimizing risk management processes within the Ethiopian construction industry. By exploring the theoretical underpinnings of risk as both a threat and an opportunity, it offers insights into enhancing risk identification, management techniques, and stakeholder responsibilities. Through a comprehensive analysis of the construction industry practices and theoretical frameworks, this research aims to equip construction firms with the tools necessary to navigate uncertainties effectively, optimize decision making processes, and foster sustainable growth and competitiveness in the dynamic construction landscape.

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CHAPTER ONE

1.1 Introduction

The construction industry plays a crucial role in driving economic development by delivering infrastructure, housing, and commercial facilities essential for societal growth. However, construction projects are inherently complex and exposed to numerous risks due to their dynamic nature, involvement of multiple stakeholders, and dependency on uncertain factors such as material availability, labor productivity, environmental conditions, and financial constraints. These risks can significantly affect project performance in terms of cost, time, quality, and safety, making effective risk management practices critical for successful project delivery.

Risk in construction projects is broadly defined as the probability of an event occurring that may have a positive or negative impact on project objectives (Project Management Institute [PMI], 2021). While some risks can present opportunities for innovation and cost savings, most pose potential threats, including budget overruns, schedule delays, design failures, safety hazards, contractual disputes, and regulatory non-compliance. The occurrence of unmanaged risks can lead to project underperformance or even project failure, resulting in financial losses, reputational damage, and strained stakeholder relationships.

Risk management, as guided by frameworks such as ISO 31000 and the PMBOK Guide, provides a structured approach to identifying, analyzing, evaluating, and mitigating risks. Within the construction industry, risk management practices encompass techniques such as risk assessment matrices, probabilistic modeling, Monte Carlo simulations, sensitivity analysis, contingency planning, and contractual risk transfer. These practices not only enhance project resilience but also improve decision-making, optimize resource allocation, and minimize potential losses.

In recent years, the increasing complexity of construction projects, rising client expectations, and technological advancements have further highlighted the need for robust risk management frameworks. Tools such as Building Information Modeling (BIM), data analytics, and artificial intelligence are increasingly being integrated into risk management processes to improve accuracy in risk prediction and control strategies.

Despite its importance, research shows that many construction projects, particularly in developing regions, still face significant challenges in effectively implementing risk management practices due to lack of expertise, inadequate frameworks, insufficient stakeholder collaboration, and limited use of quantitative tools. Consequently, understanding the current practices, effectiveness, and challenges of risk management in construction projects is essential for improving project performance and enhancing organizational competitiveness.

Risk, is an inherent aspect of the construction industry, where uncertainty can significantly influence project outcomes (Casualty Actuarial Society [CAS], 2003). In mega construction projects, this uncertainty is amplified by their scale, complexity, and the involvement of diverse stakeholders. Events rarely lie at the extremes of complete certainty (100% probability) or total uncertainty (0% probability); instead, they fall within a spectrum, necessitating comprehensive risk management strategies.

A holistic approach to Construction Risk Management (CRM) is essential, aligning risk strategies with organizational objectives and risk appetite to achieve project success (Committee of Sponsoring Organizations of the Treadway Commission [COSO], 2004). Such an approach addresses external drivers, including market demands, regulatory compliance, and stakeholder expectations, as well as internal challenges, such as project complexity and resource constraints (Corporate Executive Board, 2007).

The interconnected nature of risks and the lessons learned from past failures underscore the critical need for proactive risk management strategies. These lessons, coupled with advancements in corporate governance and internal controls, highlight the importance of integrating risks into project management frameworks to ensure resilience and sustainability (Beasley, Clune & Hermanson, 2005; James Lam & Associates, 2006).

This study aims to examine risk management practices in the construction industry, focusing on the identification, assessment, and mitigation of project risks, and to explore how modern tools such as Monte Carlo simulation can provide quantitative insights that support ISO 31000’s risk management framework.

1.1.1 Background of the Study

The construction industry is a critical driver of economic growth, providing essential infrastructure, housing, and commercial facilities. However, the industry is inherently characterized by high uncertainty, dynamic environments, and complex stakeholder interactions. Projects often involve large financial investments, long implementation timelines, and diverse parties such as owners, contractors, consultants, suppliers, and regulators. These complexities expose construction projects to numerous risks that can significantly impact cost, schedule, quality, and safety (El-Sayegh, 2018).

Globally, studies have shown that approximately 70% of construction projects experience cost overruns or delays due to poor risk identification and ineffective mitigation strategies

(Agyekum-Mensah & Knight, 2021). Common risk factors include material shortages, labor disputes, equipment failures, design changes, safety incidents, weather disruptions, and financial instability. In developing countries, such as Ethiopia, these challenges are even more pronounced due to limited resources, regulatory inefficiencies, inadequate risk management frameworks, and poor project monitoring systems (Bekele & Yimam, 2020).

To address these challenges, modern project management emphasizes the implementation of structured risk management practices guided by international standards such as ISO 31000 and the PMBOK Guide. These frameworks recommend a systematic process for risk identification, analysis, evaluation, and treatment, ensuring that project uncertainties are proactively managed.

Furthermore, the integration of quantitative risk analysis tools—such as Monte Carlo simulation, sensitivity analysis, and probability-based forecasting—has transformed construction risk management. Monte Carlo simulation, in particular, enables project managers to model uncertainties, simulate thousands of potential outcomes, and evaluate the likelihood of cost overruns or schedule delays under different risk scenarios. This approach provides data-driven insights that improve decision-making and enhance overall project performance (Abdul-Rahman et al., 2022).

Despite its proven benefits, many construction firms continue to rely heavily on qualitative approaches—such as expert judgment and risk matrices—while underutilizing quantitative techniques. This results in incomplete risk assessments, limited predictive capability, and inadequate contingency planning, leading to frequent project failures. Therefore, understanding the current risk management practices and adopting advanced quantitative tools are crucial for improving project success rates, particularly in emerging economies.

1.2 Statement of the Problem

Construction projects(Mega) are inherently vulnerable to multiple, interrelated risks that can compromise project objectives. While risk management frameworks such as ISO 31000 provide structured guidelines, many construction firms, especially in developing regions, struggle to implement comprehensive and effective risk management practices.

In our country Ethiopia and similar contexts, construction projects frequently experience cost overruns, schedule delays, safety incidents, and quality failures due to ineffective risk identification, inadequate assessment methods, and poor integration of risk management into project planning (Teshome & Alemu, 2021). A lack of standardized frameworks, insufficient use of data-driven tools, and limited stakeholder collaboration exacerbate these challenges.

Moreover, most current studies and industry practices focus primarily on qualitative risk assessment techniques—such as risk checklists and expert judgment—which, while useful, often fail to capture the probabilistic nature of construction risks. Without the application of quantitative techniques like Monte Carlo simulation, project managers are unable to evaluate the full range of possible outcomes or estimate the probability of exceeding cost and schedule targets. This gap leads to reactive rather than proactive decision-making, resulting in repeated project underperformance.

Therefore, there is a pressing need to investigate risk management practices in the construction industry and integrate probabilistic simulation techniques with established frameworks like ISO 31000. Such an approach can enhance the accuracy of risk analysis, prioritize high-impact risks, and enable construction firms to develop effective mitigation strategies, ultimately improving project success rates.

This study aims to address these challenges by exploring the application of risk management practices in mega construction projects, focusing on the development of tailored approaches that align with project-specific contexts and objectives.

1.3 Research Objectives:

1.3.1 General Objective:

To improve the culture of risk management practices in the Ethiopian Mega construction project, leading to enhanced project outcomes, improved operational efficiency, and overall industry sustainability.

1.3.2 Specific Objectives:

- To identify key risks specific to mega construction projects within the Ethiopian context.
- To evaluate the effectiveness of risk management techniques, including preventive and remedial strategies.
- To develop a risk ranking for proper mitigation effort
- To develop responsibility framework

1.3.2.1 Research Questions

1. How effectively are risk management practices applied in construction projects?
2. What is the relationship between risk management practices and project performance?
3. How do organizational factors influence the effectiveness of risk management?
4. What challenges hinder proper implementation of risk management practices?

1.3.2.2 Research Variables

Table 1 Research Variables

Variable Type	Variable	Indicators / Measurement
Independent Variables	Risk Management Practices	Risk identification, risk assessment, mitigation strategies, monitoring & control
	Organizational Factors	Policies, training, stakeholder engagement, leadership support
Dependent Variables	Project Performance	Cost adherence, timely completion, quality, client satisfaction
Control Variables	Project size, budget, location, contractor experience	Contextual effects on results

1.3.2.3 Conceptual Framework

Risk Management Practices *(Independent Variables)* → **Project Performance** *(Dependent Variable)*

- **Risk Identification** → Better anticipation of project uncertainties
- **Risk Assessment & Analysis** → Accurate prioritization of threats
- **Risk Mitigation Strategies** → Reduced delays and cost overruns
- **Risk Monitoring & Control** → Continuous performance improvement

Organizational factors act as moderators, meaning they strengthen or weaken the relationship between risk management practices and project performance.

1.4 Research Hypotheses

1.4.1 Main Hypothesis

H1: Effective implementation of risk management practices significantly improves project performance in the construction industry.

H0: Risk management practices do not significantly affect project performance in the construction industry.

1.4.2 Sub-Hypotheses

A. Risk Identification

H1a: There is a significant positive relationship between effective risk identification and project performance.

H0a: Risk identification has no significant impact on project performance.

B. Risk Assessment

H1b: Systematic risk assessment significantly reduces project cost overruns and delays.

H0b: Risk assessment has no significant effect on project cost and schedule performance.

C. Risk Mitigation Strategies

H1c: Adoption of comprehensive risk mitigation strategies leads to higher quality project outcomes.

H0c: Risk mitigation strategies do not significantly affect project quality.

D. Organizational Factors

H1d: Construction firms with structured risk management policies and training achieve better project outcomes.

H0d: Organizational policies and training have no significant influence on project performance.

E. Stakeholder Engagement

H1e: Active stakeholder engagement in risk management positively impacts project success.

H0e: Stakeholder engagement has no significant effect on project success.

1.4.3 Example Model for Testing

Independent Variables → Risk Management Practices

- Risk Identification
- Risk Assessment
- Risk Mitigation
- Risk Monitoring

Moderating Variables → Organizational Factors

- Policies & Procedures
- Training & Capacity Building
- Stakeholder Engagement

Dependent Variable → Project Performance

- Cost
- Time
- Quality
- Stakeholder Satisfaction

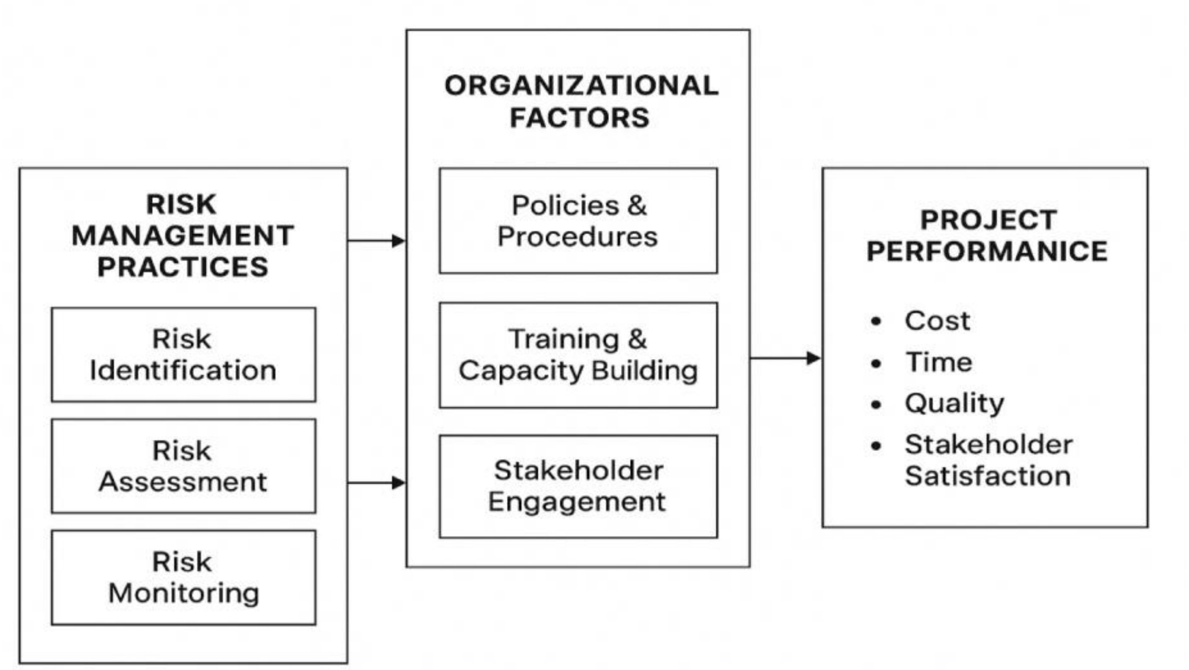


Figure 1 Graphical conceptual framework

1.5 Significance of the Study

This research on risk management in mega construction projects addresses critical gaps in practice and implementation, with the following contributions:

- **Enhancing Project Success:** By identifying and managing risks effectively, the study aims to improve project outcomes, ensuring timely completion, cost efficiency, and alignment with project objectives.
- **Clarifying Stakeholder Roles:** Establishing a risk ranking and responsibility framework promotes collaboration, ensures accountability, and fosters better coordination among stakeholders.
- **Driving Competitiveness:** By reframing risks as opportunities, the study enables companies to minimize losses and create value, providing a strategic advantage in the competitive construction sector.

1.6 Organization of the Research

The paper is organized as follows:-

1.7 Scope of the Study

- This study focuses on examining risk management practices within the construction industry, with a particular emphasis on how these practices influence project performance in terms of cost, time, quality, and stakeholder satisfaction.

The research will cover:-

1.7.1 Geographical Scope: Mega Construction projects within [Ethiopia].

1.7.2 Thematic Scope:

- Risk identification practices
- Risk assessment and analysis
- Risk mitigation and control strategies
- Monitoring and communication of risks
- Influence of organizational factors such as policies, training, and stakeholder engagement.

1.7.3 Time Scope

Data will be collected from ongoing and recently completed projects within the last five years to ensure relevance and accuracy.

1.7.4 Population and Sampling:

The study will involve project managers, engineers, site supervisors, and Stakeholders directly involved in construction projects. A purposive sampling technique will be used to target respondents with relevant experience.

1.8 Limitations of the Study

While the study seeks to provide a comprehensive understanding of risk management practices, it is subject to several limitations:

1. **Geographical Limitation**
    - The study focuses only on construction projects within **[specific region/country]** and may not represent practices in other regions.
2. **Sample Limitation**
    - Only selected **construction firms and projects** are included; therefore, results may not be fully generalizable across the entire industry.
    -

3. **Data Availability and Reliability**
    - Access to detailed project records and sensitive financial information may be limited.
    - Some responses may rely on self-reporting, which could introduce **response bias**.
4. **Time Constraints**
    - The study will collect data within a defined period, potentially missing insights from projects outside this timeframe.
5. **Dynamic Nature of the Industry**
    - Rapid changes in construction technologies, regulations, and risk management tools may affect the applicability of findings in the long term.

1.9 Operational Definitions:-

To ensure clarity, the following key terms are defined as they are used in this study:-

Term	Operational Definition
Risk	An uncertain event or condition that, if it occurs, can have a positive or negative effect on project objectives such as cost, time, quality, or safety.
Risk Management	A systematic process of identifying, assessing, mitigating, and monitoring risks throughout a project's lifecycle to ensure project objectives are achieved.
Risk Identification	The process of recognizing potential project risks through brainstorming, expert judgment, historical data, and risk checklists.
Risk Assessment	The process of evaluating the probability and impact of identified risks to prioritize mitigation efforts.
Risk Mitigation	Strategies and actions implemented to reduce the likelihood or impact of risks on project objectives.
Risk Monitoring and Control	Continuous tracking and review of identified risks, assessing residual risks, and ensuring appropriate responses are executed.
Organizational Factors	Internal attributes such as policies, procedures, training, leadership support, and stakeholder engagement that influence the success of risk management.
Project Performance	The degree to which a project meets its objectives in terms of cost, time, quality, and stakeholder satisfaction.

CHAPTER TWO

REVIEW OF THE RELATED LITERATURE

2.1 Introduction

This chapter reviews the existing body of knowledge on risk management practices in the construction industry, with emphasis on the concepts of risk, the importance of risk management, frameworks and standards such as ISO 31000, and the application of qualitative and quantitative risk analysis techniques, particularly Monte Carlo simulation. The review synthesizes global and local perspectives, highlighting gaps that justify the present study.

2.2 Concept of Risk in Construction Projects:-

Risk in construction is commonly defined as the possibility of an event occurring that may affect project objectives such as cost, schedule, quality, and safety (Project Management Institute [PMI], 2021). Construction projects are particularly vulnerable due to dynamic environments, multiple stakeholders, and interdependent processes.

Several scholars classify risks into categories, including:

- **Technical risks** (design errors, defective materials, equipment failures).
- **Financial risks** (budget overruns, inflation, payment delays).
- **Environmental risks** (weather disruptions, natural disasters).
- **Managerial risks** (poor planning, communication breakdowns).
- **Legal and regulatory risks** (disputes, contract ambiguities, compliance failures) (El-Sayegh, 2018; Zou et al., 2017).

Understanding these risks is the foundation for developing effective risk management strategies

2.3 Importance of Risk Management in Construction:-

Effective risk management is essential for improving project success rates. Research indicates that projects with structured risk management are more likely to meet their time, cost, and quality targets (Mhetre, Konnur, & Landage, 2016). In the construction industry, risk management:

1. **Improves decision-making** by providing insights into uncertainties.
2. **Minimizes project failures** through proactive identification and mitigation of risks.
3. **Enhances stakeholder confidence** by ensuring transparency and accountability.
4. **Optimizes resource allocation**, enabling better planning and cost control (Hillson & Murray-Webster, 2017).

However, studies in developing countries highlight persistent weaknesses in risk management practices, often due to **limited expertise, resource constraints, and inadequate application of quantitative tools** (Bekele & Yimam, 2020).

2.4 Frameworks and Standards for Risk Management:-

The ISO 31000:2018 standard provides internationally recognized principles and guidelines for risk management. It emphasizes:

- Integration: Embedding risk management in organizational processes.
- Structured process: Identification, analysis, evaluation, and treatment of risks.
- Continuous improvement: Monitoring and reviewing risks throughout the project lifecycle (International Organization for Standardization [ISO], 2018).

The framework is widely adaptable but often underutilized in construction projects due to lack of institutional enforcement and expertise.

PMBOK Guide:-

The Project Management Body of Knowledge (PMBOK Guide) also offers structured processes for risk management, including planning, identification, qualitative analysis, quantitative analysis, response planning, and monitoring (PMI, 2021). While widely used, it is often applied partially in construction projects

2.5 Local Practices of Construction Risk Management:-

In Ethiopia and similar developing contexts, risk management remains largely informal, with emphasis on reactive measures rather than proactive planning (Teshome & Alemu, 2021). This underscores the need for adopting standardized frameworks such as ISO 31000 to improve outcomes.

2.6 Qualitative Risk Analysis in Construction:-

Qualitative risk analysis relies on expert judgment, interviews, checklists, and risk matrices to prioritize risks based on their likelihood and impact. Advantages include simplicity, cost-effectiveness, and applicability in data-scarce environments (Zou et al., 2017).

However, qualitative methods face several limitations:

- Subjectivity due to reliance on expert opinions.
- Inability to capture probabilities of different outcomes.
- Limited predictive accuracy, especially in complex projects (Mhetre et al., 2016).

Thus, while qualitative approaches are useful for initial screening of risks, they are insufficient for comprehensive risk management.

2.7 Quantitative Risk Analysis in Construction:-

Quantitative methods address the shortcomings of qualitative approaches by applying **mathematical and statistical techniques** to model uncertainties. Common methods include:

2.7.1 Sensitivity analysis: Identifies how variations in one variable affect outcomes.

2.7.2 Decision tree analysis: Models risks through branching decision paths.

2.7.3 Probability distributions: Represents variability in project parameters.

2.7.4 Monte Carlo simulation: Uses random sampling to simulate thousands of scenarios and predict outcome ranges (Abdul-Rahman et al., 2022).

These methods provide probability-based insights, enabling managers to anticipate potential overruns and allocate resources effectively.

- **Monte Carlo Simulation in Risk Management:-**

Monte Carlo simulation is one of the most widely used quantitative risk analysis techniques in construction projects. It involves:

1. Defining **input variables** (e.g., cost, duration).
2. Assigning **probability distributions** to uncertain parameters.
3. Running thousands of simulations to generate **output distributions** (e.g., likelihood of cost overruns).

Studies demonstrate its effectiveness in:

- Estimating **probability of exceeding budgets or schedules**.
- Prioritizing high-risk activities.
- Enhancing contingency planning (Hulett, 2016).

Despite these benefits, adoption remains low in many developing regions due to lack of technical expertise, software tools, and training (Bekele & Yimam, 2020).

2.8 Empirical Studies on Risk Management in Construction:-

Empirical research indicates that construction projects continue to suffer from inadequate risk management practices. For instance:

2.8.1 Global evidence

Zou et al. (2017) found that most construction firms rely on qualitative methods, with limited use of simulations.

2.8.2 African context

Osei-Kyei and Chan (2017) reported significant risks in public-private partnership (PPP) projects, with poor quantitative risk assessment practices.

Ethiopian context: Teshome and Alemu (2021) noted that most contractors adopt ad-hoc approaches to risk management, lacking formal frameworks such as ISO 31000.

These studies emphasize the need for integrating **structured frameworks** with **quantitative tools** to strengthen risk management practices.

Research Gaps:-

From the reviewed literature, the following gaps are identified:

1. **Over-reliance on qualitative methods** in construction risk management, with limited application of probabilistic tools such as Monte Carlo simulation.
2. **Low adoption of ISO 31000** in developing contexts, despite its potential to provide structured risk management processes.
3. **Limited empirical studies** in Ethiopia that integrate both qualitative and quantitative approaches to analyze construction risks.
4. **Limited Focus on Organizational and Cultural Factors**: - Gap: Insufficient understanding of how organizational policies, training, and stakeholder engagement moderate risk management effectiveness.
5. **Inconsistent Link Between Risk Practices and Project Performance** :- Gap: A lack of empirical evidence linking risk management practices with project performance metrics (cost, time, quality, and client satisfaction).
6. **Minimal Use of Technology and Modern Tools** :- Gap: Limited integration of technology-driven solutions into construction risk management practices.

This study seeks to address these gaps by combining **qualitative assessment** with **Monte Carlo simulation**, aligned with **ISO 31000**, to provide comprehensive insights into risk management practices in the Ethiopian construction industry.

This literature review examines the current landscape of risk management in mega construction projects, focusing on two key frameworks: the Aon Construction Company Risk Management Maturity Model and the Marsh/RIMS Risk Management Model. It explores the shift from traditional, reactive risk management practices to more strategic and proactive approaches that improve organizational resilience, adaptability, and overall project success.

2.9 Risk Management Model

This literature review examines the current landscape of risk management in mega construction projects, focusing on two key frameworks: the Aon Construction Company Risk Management Maturity Model and the Marsh/RIMS Risk Management Model. It explores the shift from traditional, reactive risk management practices to more strategic and proactive approaches that improve organizational resilience, adaptability, and overall project success.

This research relies Based on AON Risk Management Maturity Model.

2.9.1 The Aon Construction Company Risk Management Maturity Model

Developed in 2010, the Aon model provides a structured framework for assessing and enhancing risk management capabilities within construction organizations. It outlines five maturity stages, each representing a different level of sophistication in risk management practices:

1. Initial Stage: At this stage, organizations engage in minimal risk management activities, typically relying on ad hoc approaches. There is a lack of systematic processes for identifying, assessing, managing, and monitoring risks. This level is often marked by reactive responses to risks, rather than proactive measures. For example, Dr. N.J. van den Berg (2018) highlights how currency fluctuations can greatly affect the construction industry, emphasizing the need for more structured and systematic risk identification.

A. Adhoc Practices

Reactive Nature: In this stage, risk management is not a planned or systematic process. Instead, organizations respond to risks as they arise, often after a problem has already occurred (Smith, 2020). This reactive approach can lead to crises that could have been mitigated or avoided altogether (Jones & Lee, 2019).

Case by Case Decisions: Each situation is treated independently, with decisions made based on immediate circumstances rather than a comprehensive understanding of potential risks (Brown, 2021). For example, if a project encounters a delay due to weather conditions, the team may scramble to find solutions without considering how similar weatherrelated risks could be managed in future projects (Williams, 2022).

Implications: Increased Vulnerability: This lack of foresight means that organizations are often caught off guard by risks, leading to project delays, cost overruns, and even safety incidents (Taylor et al., 2020).

Inefficient Resource Use: Resources may be allocated inefficiently as teams react to problems rather than implementing preventative measures (Davis & Martin, 2021).

B. Limited Awareness

Lack of Risk Identification: Employees may not be trained to recognize various types of risks, such as financial, operational, legal, or environmental (Green & Patel, 2018). This ignorance can lead to significant vulnerabilities that go unaddressed.

Siloed Knowledge: Knowledge about potential risks is often confined to specific departments or individuals (Adams, 2023). For example, a project manager may be aware of scheduling risks but not of potential regulatory changes affecting the project.

C. Implications:

Unaddressed Vulnerabilities: Without a clear understanding of the risk landscape, organizations leave themselves open to threats that could derail projects or harm their reputation (Roberts, 2019).

Missed Learning Opportunities: Limited awareness prevents organizations from learning from past experiences (Harris & Thompson, 2020). Each project may face similar risks, but without documentation and shared knowledge, lessons learned are lost.

D. Informal Communication

Unstructured Information Sharing*:* Riskrelated information is often communicated through informal channels, such as casual conversations or unstructured emails (Miller & Young, 2022). This lack of formal communication leads to inconsistencies in how risks are perceived and addressed across the organization.

Limited Collaboration: When information is not shared systematically, collaboration between teams suffers (Clark et al., 2021). For instance, if one team identifies a potential safety hazard but does not communicate it effectively, other teams may unknowingly expose themselves to the same risk.

Inconsistencies in Risk Management: Different teams may adopt varying approaches to risk management based on the information they have access to (Evans & Wright, 2020). This inconsistency can create confusion and lead to ineffective risk responses.

Lost Opportunities for Improvement: Informal communication can lead to missed opportunities for collaboration and innovation (Stewart & Green, 2021). Teams may miss out on valuable insights that could enhance risk management practices across the

2. Basic Stage: At this level, organizations begin to acknowledge the importance of risk management but lack the capabilities for effective implementation. There is an evident gap in establishing comprehensive processes that can adequately address risks. The American Society of Civil Engineers (ASCE) (2022) emphasizes that organizations in this stage must improve their understanding and application of risk management principles to navigate volatile environments effectively.

3. Defined Stage: Organizations in this phase have made strides in developing capabilities to identify, measure, manage, report, and monitor significant risks. Policies and techniques become standardized and consistently applied, leading to a more structured approach to risk management. The Chartered Institute of Building (CIOB) (2017) notes that defined risk management practices enhance clarity and accountability within organizations.

4. Operational Stage: Here, organizations demonstrate a consistent ability to manage risks effectively. Standardized policies are not only established but are also actively applied throughout the organization, resulting in improved risk mitigation and control. The Royal Institution of Chartered Surveyors (RICS) (2020) highlights that operational maturity enables organizations to navigate complex projects more successfully.

5. Advanced Stage: Organizations at this pinnacle possess a sophisticated capacity to proactively identify measure, manage, and monitor risks across all levels. The risk management process is dynamic and adaptable, responding effectively to evolving risks and business cycles. Integrating risk considerations into strategic decision making processes is crucial for success, as noted by The International Journal of Sustainable Construction (2023).

2.9.2 The Marsh/RIMS Risk Management Model

Introduced in 2009, the Marsh/RIMS model provides an alternative categorization of risk management practices within construction firms.

It classifies methods into three main categories:

1. **Risk Avoidance**

Definition*:* This approach focuses on eliminating potential risks before they impact a project. It involves strategic planning and decision making that prioritize safety and efficiency.

Application in Construction: In construction, risk avoidance might involve selecting project sites with lower environmental risks or choosing construction methods that minimize exposure to hazards. For example, a firm may opt for a more expensive but safer construction material to avoid potential structural failures (Häkkinen & Belloni, 2011).

2. Risk Transfer

Definition: Risk transfer involves shifting the responsibility for certain risks to another party, typically through contracts, insurance, or outsourcing.

Application in Construction: In the construction sector, this could mean subcontracting tasks to specialized firms better equipped to handle specific risks, such as electrical installations or heavy machinery operations. Additionally, firms may invest in comprehensive insurance policies to mitigate financial losses from unforeseen events like accidents or natural disasters (Smith & Merna, 2016).

3. Risk Mitigation

Definition: This category encompasses strategies aimed at reducing the impact or likelihood of identified risks. It involves implementing measures that enhance safety and minimize potential disruptions.

Application in Construction: For instance, a construction firm may conduct regular safety training for workers to reduce the likelihood of accidents onsite. They may also establish contingency plans to address potential delays caused by weather conditions or supply chain disruptions (Kumar & Kumar, 2018).

- **Importance of the Model**

The Marsh/RIMS model is significant for several reasons:

Holistic Approach: By categorizing risk management practices into these three distinct areas, the model encourages construction firms to adopt a more holistic approach to risk management. Rather than relying on a single strategy, firms can evaluate and implement a combination of avoidance, transfer, and mitigation techniques tailored to their specific projects and environments (Marsh & RIMS, 2009).

Enhanced Decision Making: This classification aids decisionmakers in understanding the various options available for managing risks. It enables them to assess the potential impacts of different strategies and choose the most effective course of action based on their project's unique circumstances (Hillson, 2017).

Improved Risk Awareness: The model promotes greater awareness of the diverse nature of risks within construction projects. By recognizing that risks can be managed in multiple ways, firms can foster a culture of proactive risk management among their teams (Bannerman, 2008).

It classifies approaches into three main categories:

2.10 Traditional vs. Progressive vs. Strategic Risk Management

This foundational approach emphasizes identifying, assessing, and mitigating risks through established methods. While essential, it often lacks the flexibility required to address emerging challenges.

Traditional risk management serves as the bedrock of risk handling practices across various industries, including construction. This foundational approach focuses primarily on three core activities: identifying, assessing, and mitigating risks. It typically employs established methodologies and frameworks that have been developed over time to address known risks and threats.

Key Components

Identification of Risks:

In this phase, organizations systematically identify potential risks that could impact project outcomes. Techniques such as checklists, brainstorming sessions, and historical data analysis are commonly employed. The aim is to create a comprehensive inventory of risks, ranging from financial uncertainties to safety hazards.

Assessment of Risks:

Once risks are identified, they are assessed based on their likelihood and potential impact. This often involves qualitative methods (like risk matrices) or quantitative analyses (such as statistical modeling). The goal is to prioritize risks, allowing organizations to focus their resources on the most critical threats.

Mitigation Strategies:

After assessment, organizations develop strategies to mitigate identified risks. This can include risk avoidance (changing project plans), risk transfer (through insurance), or risk reduction (implementing safety protocols). The emphasis is on minimizing the negative impacts of risks on project timelines, budgets, and overall success.

Limitations of Traditional Risk Management

While traditional risk management is essential for establishing a basic framework for handling risks, it has notable limitations:

A. Lack of Flexibility:

Traditional methods often rely on static processes that may not adapt well to rapidly changing environments. In the construction industry, where projects can be influenced by numerous external factors—such as regulatory changes, market volatility, and technological advancements—rigid frameworks may fail to address emerging challenges effectively.

B. Reactive Nature:

This approach tends to be more reactive than proactive. Organizations may find themselves responding to risks only after they materialize rather than anticipating potential issues before they occur. This can lead to increased costs and project delays, undermining overall project success.

C. Focus on Known Risks:

Traditional risk management primarily concentrates on known risks that have been previously identified. This can create blind spots for emerging or unforeseen risks—such as cyber threats or environmental changes—that may not have been considered in the initial assessments.

D. **Limited Stakeholder Engagemen**t:

Often, traditional approaches do not involve comprehensive stakeholder engagement in the risk management process. This can result in a lack of diverse perspectives and insights, which are crucial for identifying a wider array of potential risks.

E. Siloed Approach:

Risk management in traditional frameworks is often conducted in isolation from other organizational functions. This siloed approach can hinder effective communication and collaboration, limiting the organization's ability to respond holistically to risks that span multiple areas.

The progressive category of risk management represents a significant evolution from traditional methods. It emphasizes proactive and integrated practices that not only identify and mitigate risks but also anticipate and adapt to changing circumstances. This approach is particularly crucial in dynamic sectors like construction, where risks can emerge rapidly and from various sources.

Key Features of Progressive Risk Management

a. Proactive Risk Assessment Techniques:

Dynamic Risk Assessment: Unlike traditional static assessments, progressive organizations employ dynamic risk assessment techniques that continuously evaluate risks throughout the project lifecycle. This can involve regular workshops, scenario planning, and realtime feedback loops to ensure that emerging risks are identified and addressed promptly.

Risk Heat Maps: Utilizing advanced visualization tools, organizations create risk heat maps that provide a clear overview of risk exposure across different project phases. This helps teams prioritize focus areas and allocate resources more effectively.

b. Data Analytics for Risk Monitoring:

Predictive Analytics*:* By harnessing big data and machine learning algorithms, organizations can analyze historical data to predict potential risks. Predictive models can identify patterns and trends that may indicate future vulnerabilities, allowing for preemptive action.

Real Time Monitoring: Utilizing IoT devices and sensors, organizations can monitor project conditions in real time. This allows for immediate detection of anomalies—such as equipment malfunctions or environmental changes—that could lead to risks, enabling swift intervention.

c. Innovative Risk Transfer Mechanisms:

Parametric Insurance: This emerging form of insurance provides coverage based on predefined parameters rather than actual losses. For example, a construction project may secure insurance that pays out automatically if a certain weather threshold is exceeded, offering financial protection without lengthy claims processes.

Risk Sharing Agreements: Organizations may enter into collaborative agreements with stakeholders, such as contractors or suppliers, to share specific risks. This fosters a sense of collective responsibility and encourages all parties to work together to mitigate risks effectively.

d. Integrated Risk Management Frameworks:

Cross Functional Collaboration: Progressive risk management encourages collaboration across departments—such as finance, operations, and safety—to create a holistic view of risks. This integration ensures that all aspects of the organization are aligned in their risk management efforts.

Stakeholder Engagement: Involving a diverse range of stakeholders—including employees, clients, suppliers, and community members—in the risk management process enhances the identification of potential risks. This collaborative approach can lead to innovative solutions and greater buying from all parties involved.

e. Continuous Learning and Adaptation:

Feedback Mechanisms: Organizations implement structured feedback mechanisms to learn from past projects. Post project reviews and lessons learned sessions help teams identify what worked well and what didn't, fostering a culture of continuous improvement.

Agile Methodologies: By adopting agile practices, organizations can remain flexible in their risk management approaches. This allows them to pivot quickly in response to new information or changing conditions, ensuring that risk management remains relevant throughout the project lifecycle.

The strategic category reflects a holistic and forward thinking approach to risk management that aligns risk management practices with overall business objectives and strategic goals.

Organizations practicing strategic risk management may integrate risk considerations into decision-making processes, leverage risk as a strategic advantage, and prioritize longterm resilience and sustainability.

By categorizing risk management practices into Traditional, Progressive, and Strategic categories, the Marsh/RIMS model offers organizations a broader perspective on the evolution and maturity of risk management capabilities within construction companies. This alternative classification allows organizations to assess their current risk management practices, identify areas for improvement or enhancement, and choose the model that best aligns with their specific needs and goals for enhancing risk management effectiveness. It provides a framework for organizations to tailor their risk management approaches based on their unique risk profiles, industry challenges, and strategic priorities.

Overall, both models provide valuable insights and guidance for construction companies looking to enhance their risk management practices and drive value through comprehensive risk management strategies. Organizations can leverage these models to strengthen their risk management frameworks and ensure effective risk mitigation in construction projects.

While the construction company risk management maturity model developed by Aon and the Marsh/RIMS risk management model offers valuable frameworks for assessing and enhancing risk management practices, there are some potential gaps and limitations that organizations should be aware of as stated in the next detail.

2.11 Risk management Practices gaps in construction

a) Culture and Risk Awareness

The significance of promoting a culture of risk awareness and information dissemination throughout an organization cannot be overstated. Green and JenningMares (2008) emphasize that the cornerstone of effective risk management lies in cultivating a coherent and consistent risk culture. Nambiar (2006) suggests that implementing an educational program aimed at fostering this culture should be a priority for all managers and employees within the company. According to the Economist Intelligence Unit (EIU) (2007), the key to successful risk management lies in ensuring that a strong risk culture and awareness permeate every level of the organization. Protiviti (2006) highlights that the lack of a common language and awareness hinders the sharing of best practices among construction organizations, leading to increased uncertainty.

b) Risk Integration Across the Organization

The evolution of the risk management function has transformed it into a fundamental aspect of business practice, guided by the board but integrated at all levels of the organization.

The objective now extends beyond mere loss prevention to enhancing reputation and gaining a competitive edge (EIU, 2007). Both Protiviti (2006) and Harner (2010) concur that while enterprise risk management (ERM) responsibilities typically begin at the top of the organizational hierarchy, managers at all levels should actively participate in enhancing the risk management process.

C) Predicted Growth in Risk Management Investments

Organizations worldwide, regardless of size or industry, are increasingly planning to boost investments in various facets of risk management. These areas include enhancing data quality and reporting, fortifying risk assessment processes, providing management training in risk management, implementing analytics and quantification techniques, developing risk frameworks or models, and defining roles and responsibilities for risk committees (EIU, 2007). The Marsh/RIMS (2009) study underscores that 42% of companies with comprehensive risk management programs (referred to as strategic companies) are poised to increase their investments in risk management in the foreseeable future.

In conclusion, establishing a robust risk culture, integrating risk management practices across all organizational levels, and prioritizing investments in risk management are crucial components of effective company risk management practices. These good practices not only enhance risk mitigation efforts but also contribute to organizational resilience, reputation enhancement, and sustainable competitive advantage.

2.12 Summary

This chapter reviewed relevant literature on risk management practices in the construction industry. It highlighted the **concept of risk, importance of risk management, existing frameworks (ISO 31000, PMBOK), qualitative and quantitative methods, and Monte Carlo simulation**. The literature shows that while qualitative methods dominate current practices, they fail to adequately capture uncertainty. Monte Carlo simulation, aligned with ISO 31000, provides a robust solution but remains underutilized in developing countries. These gaps justify the need for this study.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research methodology adopted for the study on risk management practices in the construction industry. It outlines the research design, unit of analysis, population and sampling, data sources, data collection methods, data analysis techniques, validity and reliability considerations, and ethical issues. The study adopts a mixed-methods approach, integrating both qualitative and quantitative techniques, to provide a comprehensive understanding of risk management practices.

3.2 Description of the Research project Area

The Adwa Museum Zero KM Project is a landmark cultural and historical development situated in the heart of Addis Ababa, Ethiopia. This project commemorates Ethiopia's historic victory at the Battle of Adwa in 1896, where Ethiopian forces triumphed over Italian colonialists. This victory, a pivotal event in African resistance against colonization, has made the site an enduring symbol of bravery, independence, and Pan-African pride.

3.2.1 Location and Strategic Significance

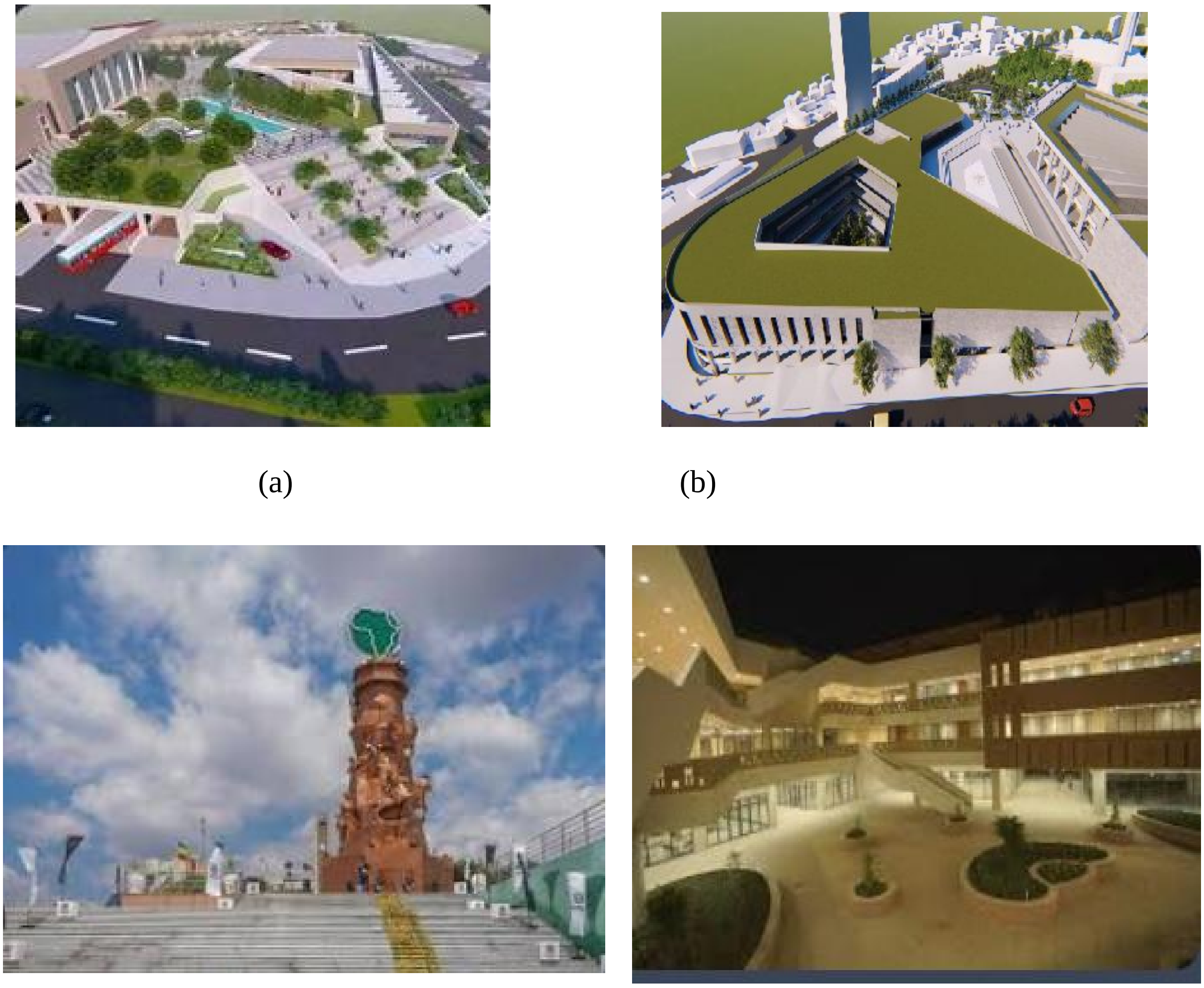
Located in Addis Ababa's Piazza area within the Arada district, the Adwa Museum Zero KM stands adjacent to several iconic landmarks, including the statue of Emperor Menelik II and St. George's Cathedral. Its proximity to the Addis Ababa Mayor's Office further underscores its significance as a national and civic monument. As the centerpiece of Addis Ababa's cultural and historical landscape, the project's location represents the bridge between historical legacy and its modern aspirations.

SOURCE:https://www.cityaddisababa.gov.et/en/projects/adwa-zero-zero-km-musium project

Figure 2 A Google Map Image of the Adwa Museum 0km project on February 2024 G.C

3.2.2 Architectural Features

The museum, designed by renowned Ethiopian architect Eskender Wubetu, spans 1.5 hectares and consists of 11 blocks over five floors. Its architectural design integrates traditional Ethiopian symbols, drawing inspiration from the Axum obelisks and the rock-hewn churches of Lalibela. These influences are reflected in the museum's corridors, staircases, and structural elements. Notably, a bridge connecting the museum to the Addis Ababa Mayor's Office symbolizes the intersection of Ethiopia's historical achievements and its contemporary governance.



(a) (b)

(c) (d)

Figure 3 : (a) Exterior View of the Adwa Museum; (b) Detailed Corridor Design; (c) Adwa Museum Amphitheater; (d) Bridge Connection to Addis Ababa Mayor's Office; (e) Night View of the Adwa Museum.

3.2.3 Facilities and Functions

The museum is designed to serve multiple purposes:

- **Memorial Museum**: Exhibits focused on the Battle of Adwa and Ethiopia’s resistance to colonial forces.
- **Amphitheater**: A venue for cultural performances and public gatherings.
- **Libraries and Youth Centers**: Spaces dedicated to education, research, and community engagement.

The project aims to rejuvenate the spirit of Pan-Africanism while fostering a deep connection to Ethiopia’s history. It also seeks to engage both local and international communities, offering a living legacy of resistance and resilience.

3.2.4 Development and Cultural Impact

Initiated in 2019 with a budget of 4.6 billion birr, the Adwa Museum Zero KM Project faced delays due to the COVID-19 pandemic but was completed in early 2024. The museum was inaugurated in the presence of national leaders, including Prime Minister Abiy Ahmed and Addis Ababa Mayor Adanech Abiebie, who emphasized its role in preserving Ethiopia's triumphs and inspiring national pride. Since its opening, the museum has drawn over 31,000 visitors in its first month, serving as both a center for education and a hub for cultural preservation.

In conclusion, the Adwa Museum Zero KM Project stands as Ethiopia’s largest cultural initiative, blending historical preservation with modern architectural innovation. It symbolizes the nation’s enduring spirit and its commitment to educating future generations about the importance of independence, unity, and resilience.

3.3 Research Design and Approach

The study employs a **mixed-methods research design**, combining **qualitative** and **quantitative** approaches.

- **Qualitative Design:** Used to explore current risk management practices, perceptions of stakeholders, and alignment with ISO 31000. Methods such as interviews and document reviews are employed.
- **Quantitative Design:** Used to analyze risk probabilities and impacts using **Monte Carlo simulation**, based on collected project data (e.g., costs, schedules, delays).

This design ensures **triangulation**, allowing for richer insights and minimizing biases inherent in single-method approaches.

The museum being one of the largest cultural and historical developments of its kind in Ethiopia. The project was done to commemorate the Battle of Adwa and celebrate Ethiopia’s independence, making it a symbol of national pride. Given the scale and cultural importance of the project, this research focuses on the risk management practices employed throughout its lifecycle, applying the ISO 31000 risk management framework to assess how risks are identified, assessed, and mitigated. By using a case study design, the study provides an in-depth exploration of risk management within large-scale, culturally and historically symbolic projects, offering valuable insights into the unique challenges these projects face.

A mixed-methods approach is utilized to collect both qualitative and quantitative data, enabling a comprehensive analysis of the project’s risk management strategies across three distinct stages: planning, execution, and operation. This combination of methods allows for a holistic understanding of how risk management evolves as the project progresses, integrating detailed, narrative insights from stakeholders with measurable data to support the findings.

The qualitative data is gathered through semi-structured interviews, document analysis, and site observations, providing rich, contextual understanding of the challenges and responses during the project's implementation. The quantitative data, collected via surveys, offers measurable insights into stakeholder perceptions and the effectiveness of risk management efforts.

In sum, this research employs a systematic approach to examine the Adwa Museum Zero KM project’s risk management practices, combining qualitative depth and quantitative rigor to track the evolution of risk management strategies throughout the lifecycle of this landmark development.

3.4 Population and sampling

Population: The study population consists stakeholders directly involved in the Adwa Museum Zero KM project, representing various roles and responsibilities essential to its development and risk management processes. Project managers and engineers provided expertise in overseeing execution, monitoring progress, and implementing mitigation strategies, offering insights into the technical and managerial aspects of the project. Construction contractors and subcontractors, actively engaged in the physical construction, contributed practical perspectives on challenges such as resource constraints, logistical issues, and the application of risk management protocols.

Additionally, representatives from the Addis Ababa City Administration played a pivotal role in regulatory oversight, ensuring compliance with urban planning requirements and integrating cultural and symbolic considerations into the project’s framework. To address the community’s perspective, local members were included to shed light on cultural preservation efforts, public engagement, and the symbolic impact of the museum as a representation of Pan-Africanism.

3.5 Unit of Analysis

The unit of analysis in construction projects undertaken in Ethiopia, with a particular focus on large-scale infrastructure and building projects. The study emphasizes risk management practices across different stages: planning, execution, and monitoring.

The unit of analysis for this study is the Adwa Museum Zero KM project, specifically focusing on its risk management practices throughout the various stages of the project: planning, execution, and operation. This project, a landmark cultural and historical development, presents complex risks at each phase of its implementation, and the research examines how these risks are managed to ensure the successful completion of the project.

Planning Stage

At the **planning stage**, the research explores how potential risks were identified before the project's implementation. These risks include **financial** risks (e.g., budget constraints and funding delays), **cultural** risks (e.g., challenges in preserving historical and cultural integrity), and **logistical** risks (e.g., delays in securing materials and permits). The study analyzes how these risks were recognized early on and what mitigation strategies were put in place to address them.

Execution Stage

During the execution stage, the study investigates how the risks identified during the planning phase are addressed in real-time. This includes assessing the implementation of mitigation strategies, such as managing construction delays, budget overruns, and public perception of the project’s cultural and historical significance. The risk management strategies used during this phase are crucial for ensuring that the project stays on track both in terms of time and resources.

Operational Stage

Finally, in the operational stage, the study examines the ongoing management of risks after the museum has been completed and is operational. At this stage, risks related to the sustainability of the project, such as operational costs, visitor engagement and maintenance challenges are critical. The research investigates how these risks are monitored and managed to ensure that the museum continues to fulfill its cultural mission and remains sustainable in the long term.

Throughout all these stages, the research analyzes how the risk management practices employed aligns with the ISO 31000 risk management framework. This internationally recognized standard emphasizes a structured approach to identifying, assessing, and mitigating risks, and its principles are applied to the Adwa Museum project to ensure effective risk management.

By focusing on these stages, the research aims to provide a comprehensive understanding of how risks evolve throughout the lifecycle of the Adwa Museum Zero KM project and how risk management practices are adapted to address emerging challenges. This alignment with ISO 31000 ensures that the project remains on track to meet its objectives while managing potential disruptions.

Sampling Technique: stratified sampling is applied to select participants with direct involvement in risk management.

Sample Size: Approximately 100–150 respondents for surveys and 8–12 key informants for in-depth interviews. This ensures both breadth (quantitative data) and depth (qualitative insights).

This diverse target population ensured the study captured a holistic view of the project, combining technical, operational, regulatory, and community dimensions for a comprehensive understanding of its risk management practices.

3.6 Data Type and Source

The study utilizes both primary and secondary data sources:

- Primary Data: Collected through structured questionnaires (for quantitative analysis) and semi-structured interviews (for qualitative insights).
- Secondary Data: Project documents, risk registers, contract reports, and academic studies related to construction risk management.

The study employed a mixed-methods approach, integrating both qualitative and quantitative data to comprehensively assess risk management practices in the Adwa Zero Kilometer

Museum Project.

Qualitative data were collected through semi-structured interviews with key stakeholders, offering detailed insights into challenges such as balancing cultural preservation, Pan-African symbolism, and logistical execution. Document reviews of critical project materials, including blueprints, budgets, risk registers, and construction plans, provided a deeper understanding of strategies for risk anticipation, planning, and mitigation. Additionally, on-site observations offered real-time insights into implementation challenges and the alignment of actual practices with planned risk management protocols.

Quantitative data collection involved structured surveys distributed to stakeholders to gather measurable perceptions of the effectiveness of risk management practices and their influence on achieving project goals. Project metrics, such as timelines, cost management records, and incident reports, were analyzed to provide objective measures of performance and outcomes related to risk management decisions. This combination of methods ensured a robust and holistic understanding of the project's risk management dynamics.

By triangulating data from these diverse sources, the study ensured a robust analysis. Primary data collected through interviews, surveys, and observations were complemented by secondary data from project records and scholarly literature. This methodological rigor enhanced the study's validity and reliability, as recommended by Creswell (2018) and Yin (2018).

The mixed-methods approach facilitated a comprehensive understanding of both the qualitative complexities and quantitative impacts of risk management in mega-construction projects.

3.7 Data Collection Methods

3.7.1 Survey Questionnaire

Administered to project professionals to gather quantitative data on risk frequency, severity, and management practices.

3.7.2 Key Informant Interviews

Conducted with project managers and consultants to capture qualitative insights into challenges, perceptions, and alignment with ISO 31000.

3.7.3 Document Review

Analysis of risk registers, progress reports, and contracts to supplement survey and interview findings.

3.7.4 Site Observations

On-site evaluations were conducted to directly observe project implementation and identify potential real-time challenges or deviations from planned risk management strategies.

3.8Data Analysis Technique

The study applies **both qualitative and quantitative data analysis methods**:

3.8.1 Qualitative Analysis

- Thematic analysis of interview transcripts.
- Coding responses to identify common themes (e.g., barriers to ISO 31000 adoption, reliance on qualitative risk methods).
- Comparison of findings with international best practices

3.8.2 Quantitative Analysis

The quantitative analysis uses **Monte Carlo simulation** to model risks.

Steps:

1. Risk Identification: Input variables such as material delays, labor shortages, equipment failures, design changes, and weather disruptions.
2. Assign Probability Distributions: For each variable, define probability distributions (e.g., triangular, normal, or uniform) based on historical data and expert judgment.
3. Run Simulation: Conduct at least 10,000 iterations to simulate cost and schedule outcomes.
4. Output Analysis: Generate probability distributions of project cost and duration, highlighting the likelihood of overruns.
5. Scenario Testing: Compare different risk response strategies to evaluate effectiveness.

Tools: Monte Carlo simulation can be implemented using software such as **@Risk, Crystal Ball, or Python-based simulation models**.

3.9 Alignment with ISO 31000

The data analysis process is aligned with ISO 31000’s risk management framework, ensuring systematic handling of risks:

1. **Risk Identification:** From surveys, interviews, and documents.
2. **Risk Analysis:** Monte Carlo simulation to quantify likelihood and impact.

3. **Risk Evaluation:** Prioritizing risks based on probability and severity.
4. **Risk Treatment:** Assessing mitigation measures and their effectiveness.
5. **Monitoring and Review:** Continuous feedback from stakeholders.
6. **Integration:** Embedding findings into organizational decision-making.

3.10 Validity and Reliability

- **Validity:** Ensured through triangulation of multiple data sources (survey, interviews, documents). Expert validation is sought for probability distributions used in Monte Carlo simulation.
- **Reliability:** Consistency is maintained by using standardized instruments (questionnaire, interview guide). Simulation models are tested and validated against historical project data.

3.11 Ethical Considerations

- Informed consent obtained from all participants.
- Confidentiality of project data and anonymity of respondents guaranteed.
- Data used solely for academic purposes.
- Compliance with institutional research ethics guidelines.

3.12 Summary

This chapter presented the research methodology adopted for the study. It applied a mixed-methods design, using surveys, interviews, and document reviews for data collection, and thematic analysis and Monte Carlo simulation for data analysis. The methodology is explicitly aligned with ISO 31000 to ensure systematic risk management analysis in the Ethiopian construction industry.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION

4.1 Introduction

The study employed Monte Carlo simulation to analyze the impact of various risks on construction project performance. Monte Carlo simulation is a probabilistic technique that uses repeated random sampling to quantify the likelihood of different outcomes under uncertainty. This approach is particularly useful in construction risk management, where project delays, cost overruns, and quality issues often result from multiple interacting risk factors.

In research analysis Data is the most important input to provide proper mitigation measure of the problem and it helps in knowing the actual scenario. Therefore, the careful analysis of data has a significant contribution to the research study and the result obtained from this chapter will providing sufficient focus on collecting and analyzing those data effectively.

This particular research is the risk management practice in construction projects and its reflection on the performance management. The research helps to identify the potential risks and impact on the performance of the project and helps To improve the effectiveness of risk management practices in the Ethiopian construction industry, leading to enhanced project outcomes, improved operational efficiency, and overall industry sustainability in Ethiopia.

Mega-construction projects are inherently complex, involving multiple stakeholders, significant investments, and various risks that can threaten their success. Effective risk management is crucial to mitigate potential delays, cost overruns, and quality compromises. This assessment explores best practices in identifying, analyzing, and mitigating risks in large-scale construction projects, drawing on established methodologies and historical insights. Key elements of robust risk management include stakeholder engagement, data-driven probability assessments, proactive planning, and real-time adjustments.

The Adwa Zero Kilometer Museum Project, one of Ethiopia’s most ambitious endeavors, provides a case study to illustrate these principles in action. This project, which combines cultural preservation with advanced construction techniques, faced numerous risks due to its symbolic importance, urban setting, and technical demands. By examining its risk management practices, valuable lessons can be drawn for future mega-projects.

4.2 Data Collection for Simulation

The data for simulation were collected from two sources:

1. **Primary data:** Surveys and interviews with project managers, site engineers, and risk officers, focusing on historical project delays, cost overruns, and perceived risk impact.
2. **Secondary data:** Project reports and industry benchmarks for construction projects in the selected region.

The research done in a specific Adwa Zero Kilometer Museum Project in Addis Ababa serves as a prime example of the complexities involved in mega-construction. Its dual role as a cultural landmark and urban development initiative posed unique challenges, necessitating a multifaceted approach to risk management.

4.3 Risk identification and mitigation Strategy:

4.3.1 Material supply delays

4.3.2 Design errors

4.3.3 Adverse weather conditions

Each risk factor was characterized by:

- Probability of occurrence **(based on historical data and expert judgment)**
- Impact on project cost and schedule
- Probability distribution type **(triangular, uniform, or normal)**

Monte Carlo Simulation Process

The Monte Carlo simulation process consisted of the following steps:

1. **Define Model:** A project model incorporating the identified risk factors and their potential impact on cost and schedule.
2. **Assign Probability Distributions:** Each risk factor was assigned a probability distribution based on historical data:
3. **Run Simulations:**

- 10,000 iterations were performed using random sampling from the assigned distributions.
- For each iteration, total project cost and schedule delays were calculated.

4. **Output Collection:** The simulation produced distributions of potential project costs and delays, enabling assessment of **risk exposure** and **likelihood of overruns**.

A. Risk Identification

In this research the risk analysis is done based on combined historical data analysis with stakeholder consultations to proactively address potential challenges. Key risks and their corresponding mitigation strategies are outlined below:

Kea identified Risk Factors are:

4.3.5 Material supply delays

4.3.6 Design errors

4.3.7 Adverse weather conditions

1. **Material Supply Delays**

- **Analysis:** The urban location introduced logistical hurdles, including traffic congestion and supplier inefficiencies. Historical data from similar projects highlighted these as recurring issues.
- **Mitigation:** The project team mitigated these risks by diversifying suppliers, incorporating buffer times into delivery schedules, and adopting just-in-time inventory systems to minimize disruptions.

2. **Design Modifications**

- **Analysis:** Feedback from regulatory bodies and late-stage stakeholder input frequently led to design changes, creating challenges for timelines and budgets.
- **Mitigation:** Early stakeholder engagement, combined with a robust change management framework, ensured that potential modifications were identified and integrated earlier in the process, reducing their impact on the project schedule and costs.

3. **Weather Disruptions**

- **Analysis:** Ethiopia's seasonal weather patterns, especially during the rainy season, posed significant risks to construction progress.
- **Mitigation:** The project adopted weather-responsive scheduling, selected resilient materials, and developed contingency plans to maintain construction activities during adverse weather conditions.

Item No	Risk	Analysis	Mitigation Strategies
1	Material Supply Delays	Urban location posed logistical challenges, including traffic congestion and supplier inefficiencies.	Diversified suppliers, buffer times in delivery schedules, and just-in-time inventory systems.
2	Design Modifications	Frequent design changes driven by regulatory feedback and stakeholder demands, leading to cost overruns.	Early stakeholder engagement and a structured change management framework.
3	Weather Disruptions	Seasonal weather patterns, particularly Ethiopia’s rainy season, posed risks to construction schedules.	Weather-responsive scheduling, resilient materials, and detailed contingency plans.

Table 2 Risk Analysis and Mitigation Strategies of the reaserch

4.4 Qualitative Research Analysis

Data collection for the research has focused on identifying and understanding the risks associated with material supply delays, design modifications, and weather disruptions. Both primary and secondary methods were employed to gather and analyze relevant data.

4.4.1 Stakeholder Interviews

Direct data collection involved engaging with stakeholders through consultations and interviews to identify potential risks and gather insights on the project's history and challenges. Stakeholders, including project managers, suppliers, contractors, and logistics providers, contributed valuable firsthand information on issues such as supplier inefficiencies, transportation challenges, and material shortages. These discussions provided qualitative data on the root causes of delays and disruption patterns.

4.4.2 Questioner Analysis

In addition to consultations, **questionnaires** were distributed to key stakeholders, including project team members, suppliers, and contractors. The questionnaires were designed to capture detailed information on specific risks faced in the project, including issues related to material procurement, supplier reliability, and logistics. These questionnaires contained both closed and open-ended questions to allow for quantitative analysis of common risk factors and qualitative insights into the underlying causes. The responses provided a clearer picture of recurring problems and helped quantify the frequency of certain risks.

Additionally, historical data from similar projects was analyzed to establish patterns of delays and risk factors. This involved reviewing project reports, documentation on material procurement, and records on delays from previous projects to identify recurring issues.

Stakeholder consultations were conducted with key personnel involved in the Adwa Zero Kilometer Museum Project, including project managers, engineers, suppliers, contractors, and logistics teams. These discussions aimed to gather firsthand information on the challenges, risks, and disruptions encountered during the project's implementation. Through these consultations, valuable data was collected on the frequency and causes of material supply delays, which were primarily attributed to supplier inefficiencies, transportation challenges, and customs clearance issues. Additionally, insights were obtained regarding the challenges posed by design modifications, particularly their impacts on procurement processes and construction timelines. The consultations also highlighted the effects of weather-related disruptions, detailing how adverse weather conditions were managed and their influence on various phases of the project.

This qualitative data provided a comprehensive understanding of the risks and their implications, forming a crucial basis for further analysis and mitigation strategies.

The stakeholder consultations included targeted questions designed to uncover specific challenges and risks affecting the project. For instance, participants were asked, "What are the main reasons for delays in material supply for the project?" to identify key causes such as supplier inefficiencies, transportation challenges, and customs delays. Another question, "How have design changes impacted material procurement timelines?" sought to explore the extent to which modifications influenced scheduling and logistics, revealing the connection between design adjustments and delays in critical material deliveries. Additionally, stakeholders were asked, "Can you provide examples of weather-related challenges that affected the construction process?" to gain insights into how adverse weather conditions, such as heavy rainfall, disrupted construction activities and necessitated adaptive measures. These targeted questions provided detailed and actionable information, enriching the analysis with practical examples and stakeholder perspectives.

A. Analysis of Interviews’ Results

The one-on-one interviews conducted with key project team members, including senior engineers, procurement officers, and project managers, provided in-depth insights into the specific risks and challenges faced during the Adwa Zero Kilometer Museum Project. These interviews complemented the questionnaire data and allowed for a more nuanced understanding of the root causes of delays, the effectiveness of mitigation strategies, and lessons learned throughout the project.

Regarding material supply delays, interviewees highlighted supplier inefficiencies as the primary issue, emphasizing inconsistent delivery schedules and unreliable supplier performance.

Several procurement officers noted that delays often stemmed from inadequate supplier capacity to meet demand, compounded by logistical issues such as poor road conditions and vehicle shortages. Customs clearance processes were also frequently mentioned as a significant bottleneck, with delays attributed to documentation errors and prolonged inspections. Interviewees estimated that material delays typically ranged from 228 to 254 days, aligning with findings from the Monte Carlo simulation.

On the topic of design modifications, the interviewed engineers revealed that late-stage changes to the project design had a ripple effect on procurement and construction timelines. They shared examples of instances where design revisions required reordering of materials, leading to an average delay of 98 days. Project managers expressed concerns about the lack of seamless coordination between design and construction teams, which they believed contributed to inefficiencies in addressing design changes promptly.

Weather-related disruptions were another prominent theme in the interviews. The project team members recounted challenges during the rainy season, particularly with outdoor tasks such as concrete pouring and material storage. Adaptive measures, such as rescheduling work during heavy rains, using temporary shelters for workers, and deploying weather-resistant materials, were commonly implemented. However, interviewees acknowledged that these measures only partially mitigated the impacts, with weather-related delays still averaging around 34 days.

In terms of risk mitigation strategies, the interviewees provided valuable feedback on their effectiveness. Supplier diversification was unanimously praised as one of the most effective measures, as it reduced reliance on single suppliers and minimized the risk of significant delays. Weather-sensitive scheduling and real-time monitoring of project progress were also highlighted as key strategies that helped the team respond dynamically to emerging risks. Nevertheless, interviewees emphasized the need for more proactive planning, particularly in addressing material supply challenges and reducing the frequency of design changes during project execution.

In general, the interviews reinforced the findings from the questionnaires and quantitative analysis, while adding richer context to the challenges and mitigation efforts. The insights gained from these discussions provided actionable recommendations for enhancing risk management practices in future projects, particularly in improving supplier reliability, minimizing design modifications, and strengthening weather-related contingency planning.

B. Analysis of Questionnaires' Results

I. Material Supply Delays

The analysis of questionnaire responses revealed that material supply delays were a critical challenge during the project. Among the 30 distributed questionnaires, 25 were completed, with respondents highlighting significant delays attributed to supplier inefficiencies, transportation challenges, and customs clearance issues. Supplier inefficiencies were identified as the primary cause, contributing to 40% of delays, followed by transportation and customs-related issues, each accounting for 30%. The severity of these delays was reflected in an average rating of 4.2, indicating moderate to severe impacts on the project timeline. The remaining five respondents did not provide input, possibly due to a lack of direct involvement in procurement processes or insufficient familiarity with material supply challenges.

II. Design Modifications

Responses regarding the impact of design modifications were similarly insightful but also incomplete. Of the 30 questionnaires distributed, 22 were returned with valid responses, yielding an average rating of 3.7 for the impact of design changes on procurement and construction schedules. Design modifications were reported to cause delays averaging 86 days, primarily due to reordering materials to meet revised specifications. Approximately 60% of respondents who answered highlighted disruptions to critical construction tasks such as foundation work. However, eight questionnaires remained unanswered, suggesting that certain stakeholders may not have had direct exposure to or sufficient knowledge of the design change processes.

III. Weather-Related Disruptions

Weather disruptions were identified as another significant risk factor, with 24 respondents providing feedback. The average rating for the impact of weather conditions on project progress was 2.8, reflecting substantial delays, particularly during the rainy season. Respondents reported delays averaging 29 days for tasks like concrete pouring and outdoor construction. Adaptive measures, including rescheduling tasks (40%), using weather-resistant materials (30%), and temporary shelters for workers (20%), were implemented to mitigate these challenges. Six unanswered questionnaires indicate that not all stakeholders had direct involvement in addressing or observing weather-related disruptions, likely due to their roles being less affected by environmental factors.

B. Risk Mitigation Strategies

The effectiveness of risk mitigation strategies was rated by 26 respondents, with an average score of 4.0, indicating that most stakeholders found these strategies effective or highly effective. Supplier diversification was rated as the most impactful approach (45%), followed by weather-sensitive scheduling (35%) and the use of adaptive materials (20%). However, four respondents did not provide input on this question, possibly due to limited participation in the decision-making or implementation of these strategies.

Overall Risk Management

Feedback on overall risk management was provided by 21 stakeholders, with an average rating of 3.9. Respondents generally acknowledged the effectiveness of the strategies implemented but pointed out areas for improvement, particularly in addressing material supply delays and minimizing the impact of design modifications. The remaining nine questionnaires were left unanswered; indicating that some stakeholders might have felt their input was less relevant to the overall evaluation of risk management practices.

- **Challenges Faced While Conducting the Questionnaire**

One of the primary challenges encountered during the research was the issue of unanswered questionnaires. Despite distributing 30 questionnaires to stakeholders carefully selected based on their involvement in the Adwa Zero Kilometer Museum Project, a number of respondents did not provide complete answers. This resulted in partial data collection, with five respondents leaving questions on material supply delays unanswered, eight not addressing design modifications, six omitting weather-related disruptions, and four failing to evaluate the effectiveness of risk mitigation strategies.

The selection of 30 respondents was made to ensure a broad representation of the various roles involved in the project, ranging from project managers to contractors, suppliers, and logistics teams. However, the incomplete responses indicate that certain stakeholders may not have felt their roles were directly relevant to some aspects of the research questions. For instance, stakeholders with limited involvement in procurement or construction may have found it challenging to provide meaningful input on material delays or design modifications. Similarly, those less affected by environmental factors may have overlooked questions on weather disruptions.

To address the specific gaps in data on material supply delays, which were identified as the major risk impacting the project timeline, additional quantitative analysis was performed using Monte Carlo simulations as described in the quantitative analysis in the next subchapters. This approach helped to supplement the missing data by modeling the probability and severity of material delays based on historical patterns and stakeholder-provided estimates.

This additional analysis ensured that material supply delays were comprehensively evaluated, even with incomplete questionnaire responses. It highlighted the significant contribution of supplier inefficiencies, transportation challenges, and customs delays to the overall project risks. To improve future data collection, follow-up interviews or targeted discussions with non-respondents could be conducted to ensure all perspectives are adequately captured. Refining the questionnaire to include role-specific questions may also help enhance the response rate and relevance of the data collected. Despite these challenges, the combined insights from the completed questionnaires and quantitative analysis formed a robust foundation for the study's conclusions and recommendations.

4.5 Quantitative Research Analysis and Result Interpretation

4.5.1 Frequency of Risk Occurrence

The frequency analysis provides a critical understanding of how often each risk occurs in comparable projects, helping prioritize management efforts. Among the identified risks:

1. Material Supply Delays

Material supply delays emerged as the most frequent, affecting approximately **40%** of the risk in the progress of the project. This highlights the persistent challenges associated with urban logistics, supplier reliability, and supply chain disruptions.

Specifically the risk has been attributed to logistical complexities such as traffic congestion, restricted transportation routes, and limited warehouse accessibility. These factors often caused bottlenecks in the supply chain, slowing the timely delivery of essential construction materials.

Supplier reliability further compounded the issue. Inconsistent performance from both local and international suppliers led to delays in shipments, insufficient stock availability, and occasional quality issues. These disruptions often forced project teams to adjust schedules, negotiate alternative sources, or accept delays that cascaded across multiple phases of the project.

Broader supply chain vulnerabilities also played a critical role. Global challenges such as material shortages, trade restrictions, and price fluctuations added another layer of complexity. Geopolitical tensions and unexpected events, such as pandemics, exacerbated supply chain instability, creating additional risks for material availability in time-sensitive projects.

The impact of these delays on project performance was profound. Schedule disruptions stalled progress, increasing idle times for labor and machinery, and pushed back key milestones. Cost overruns often followed, as expedited shipping, alternative sourcing, or other corrective measures were employed to minimize delays. Additionally, the pressure to meet deadlines occasionally led to the use of substandard materials or rushed work, jeopardizing the project's overall quality and integrity.

Addressing material supply delays required targeted strategies. These included diversifying suppliers to avoid dependence on a single source, implementing just-in-time inventory systems to streamline procurement processes, and incorporating buffer times into delivery schedules to absorb unexpected disruptions. By proactively addressing these risks, the project could mitigate their frequency and reduce their impact, ensuring a more consistent and efficient progression toward completion

Date	Affected Materials	Estimated Delay (Days)	Root Cause	Corrected Percentage (%)
10/10/2022	Concrete	110	Supplier issues	6.64
2/10/2022	Steel	150	Transportation delays	8.85
5/10/2022	Pipes	26	Quality issues	3.54
3/10/2022	Electro Mechanical Equipments	120	Import restrictions	4.42
3/10/2022	Bricks	23	Labor shortages	5.31
4/10/2022	Sand	24	Logistics disruptions	7.96
4/10/2022	Cement	98	High demand	11.06
5/10/2022	Glass	18	Customs clearance	4.42
6/10/2022	Tiles	217	Warehouse backlogs	6.64
6/10/2022	Doors	92	Supplier bankruptcy	9.73
7/10/2022	Windows	92	Inadequate stock	2.21
7/10/2022	Rebars	126	Delivery mismanagement	11.06
8/10/2022	Plumbing Fixtures	108	Contract disputes	5.75
8/10/2022	Paint	6	Price volatility	3.54
9/10/2022	Roofing Sheets	37	Supply chain disruptions	8.85

Table 3 : Impact of Material Supply Delays of the Project (data from interviews)

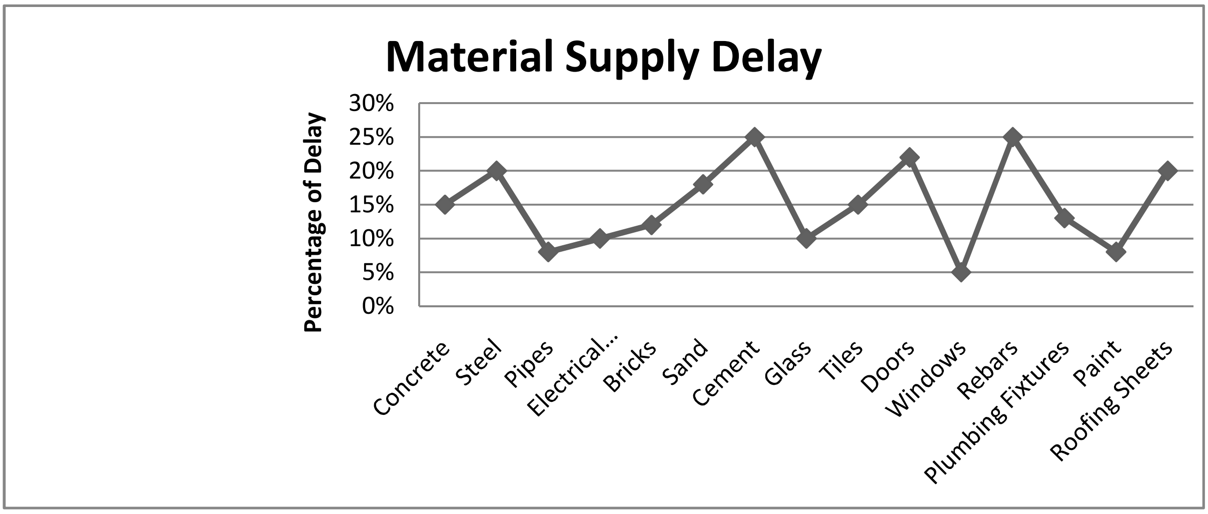


Figure 4 Graphical Representation of Material Supply Delay

4.5.2 Implementation Using the Monte Carlo Simulation

Monte Carlo simulation is a statistical technique used to estimate the probability of different outcomes in systems with inherent uncertainty (Glasserman, 2021). This method works by generating random samples based on predefined probability distributions for uncertain variables and simulating the system multiple times to explore a wide range of potential outcomes (Shannon, 1948). By analyzing the results of these simulations, insights can be gained into risk, trends, and possible scenarios, which is valuable in fields like finance, engineering, and operations research for assessing uncertainty and making informed decisions (Ching & Goh, 2022).

The basic procedures and mathematical formulations of Monte Carlo simulation can be broken down into the following steps:

1. **Define the Problem and Model**

Identifying the system or process to be modeled, including all uncertain variables. These uncertain variables are typically represented by probability distributions. The problem can range from simple to complex, such as simulating soil behavior under seismic loading in geotechnical engineering.

2. **Defining Probability Distributions for Input Variables**

Each uncertain variable in the model must be associated with a probability distribution. These distributions represent the likelihood of different outcomes for each variable. For example:

- **Normal distribution** for variables with a symmetric distribution.
- **Log-normal distribution** for positively skewed data.
- **Uniform distribution** for variables that are equally likely over a given range.

Mathematically, the probability density function (PDF) for a random variable X is given by:

$$f_x(x) = P(X = x)$$

3. **Generating Random Samples**

This step involves using random number generation techniques, generating random samples for each uncertain variable according to their respective probability distributions. This step is crucial because it mimics real-world uncertainty by sampling from the distributions.

If you are sampling a random variable X with a uniform distribution, for instance, the random number r is generated between 0 and 1. The inverse transform method is then applied to obtain the corresponding value for X:

$$X = F^{-1}(r)$$

Where: $F^{-1}$is the inverse of the cumulative distribution function (CDF) of X.

4. **Running the Simulation**

Once random values for the uncertain variables are obtained, the system or process is simulated using these values. This step involves solving the model for each set of input values. The model is run multiple times (typically thousands or millions of times) to cover a broad range of possible outcomes.

4.5.3 Analyze the Results

After performing many simulations, the results are analyzed to understand the distribution of possible outcomes. This includes calculating statistics like mean, standard deviation, and percentiles to assess the range of likely outcomes.

Mathematically, after N simulations, the expected value $\mathbb{E}[X]$ of an outcome X can be estimated as:

$$\mathbb{E}[X] = \frac{1}{N \sum_{i=1}^{N} x_i}$$

Where: x_i is the outcome of the i^{th} simulation.

Estimating the Probability of Outcomes

The final goal of the Monte Carlo simulation is to estimate the probability of different outcomes. This can be done by counting how often certain conditions occur in the simulations. For example, you can estimate the probability that soil deformation exceeds a critical threshold by dividing the number of simulations where this occurs by the total number of simulations.

If A is the event of interest, the probability of A occurring is:

$$P(A) = \frac{Number\ of\ Simulations\ where\ A\ occurs}{N}$$

This provides the likelihood of the event occurring in real-world scenarios.

The core theory behind Monte Carlo simulation is rooted in two key statistical principles: the Law of Large Numbers (LLN) and the Central Limit Theorem (CLT). These principles ensure that as the number of simulations increases, the average of the results converges to the expected value of the underlying distribution, and the distribution of outcomes approximates the true probability distribution.

- **Law of Large Numbers (LLN):** According to the LLN, as the number of trials increases, the sample mean of the outcomes will approach the true expected value of the distribution (Feller, 1968).
- **Central Limit Theorem (CLT):** The CLT states that the distribution of the sample mean of independent random variables will tend toward a normal distribution as the number of trials increases, regardless of the original distribution of the variables (Lyapunov, 1997).

In the context of Monte Carlo simulation, random inputs are generated based on probability distributions, simulations are run to explore a range of outcomes, and the results are analyzed

to estimate the probabilities of various events. This approach allows for robust decision-making under uncertainty, with applications spanning fields such as engineering, finance, and risk management (Glasserman, 2021; Rubinstein & Kroese, 2016).
To assess the risks associated with **material delays** explained above, this simulation is employed, using probabilistic modeling to quantify the associated risks effectively. The method utilized input data such as the frequency of material delays, observed in approximately 40% of the total delay, with delays ranging from 15 to 360 days per material. Key variables included delay durations per material and their contributions to project lags, which were influenced by supplier inefficiencies, logistical disruptions, and quality issues (Cui et al., 2018; Qazi et al., 2016).

The simulation process began with parameter definition, where historical delay ranges informed the creation of probability distributions, such as triangular or normal. The likelihood of delays for each material was modeled to account for variability. Using random sampling across 10,000 iterations, the simulation estimated cumulative impacts on project timelines (Smith et al., 2020).

Key outputs included the average total delay across materials and the probability of exceeding critical thresholds, such as a 360-days delay. These results highlighted both probable and extreme scenarios, offering data-driven insights for contingency planning and resource allocation in the project (Brown & Mathew, 2017).

The analysis conducted using Monte Carlo simulations aimed to quantify the impact of material supply delays on the overall project timeline by incorporating uncertainty and variability into the risk assessment. Monte Carlo simulations involve running multiple iterations of a model with random sampling to simulate a wide range of possible outcomes based on probability distributions of key variables. In this case, the simulation modeled the potential delays in material supply, particularly for concrete, steel, and glass, by using triangular probability distributions to represent the likely range of delays.

These distributions were derived from historical data and expert input, which provided estimates for the minimum, most likely, and maximum delay durations.

The simulations ran **10,000 iterations**, with each iteration representing a possible scenario of material delays. The results generated cumulative distributions of delays, showing the probability of exceeding specific thresholds, such as delays of **180 days or more**. The Monte Carlo method allowed for the estimation of the average delay duration and provided a probabilistic view of project timelines under various risk scenarios. This approach helped identify the likelihood of critical delays and their potential impact on the project's completion. The outputs of the simulation indicated that material supply delays were likely to cause moderate to severe project disruptions, with a higher probability of delays exceeding **180 days** for certain materials.

By running these simulations, the analysis provided valuable insights into the uncertainty surrounding material delays and their potential effects on the project. It enabled the project team to better understand the risks and plan for contingencies, ensuring that mitigation strategies could be more accurately aligned with the potential variability in material delivery times.
The simulations done for each material is described below

4.5.4 Monte Carlo Simulation for Concrete Material Delay

The Monte Carlo simulation for concrete material delay involves generating random values and simulating possible outcomes for the delay in material delivery based on a triangular distribution. For each iteration, random numbers between 0 and 1 are generated to simulate delays. These delays are calculated using the provided minimum, most likely (mode), and maximum delay values, which form the parameters of the triangular distribution.

The results are aggregated over numerous iterations (e.g., 10,000) to estimate statistical metrics such as mean delay, median delay, and specific percentiles (e.g., 5th and 95th percentile delays) see figure 4-3 below.

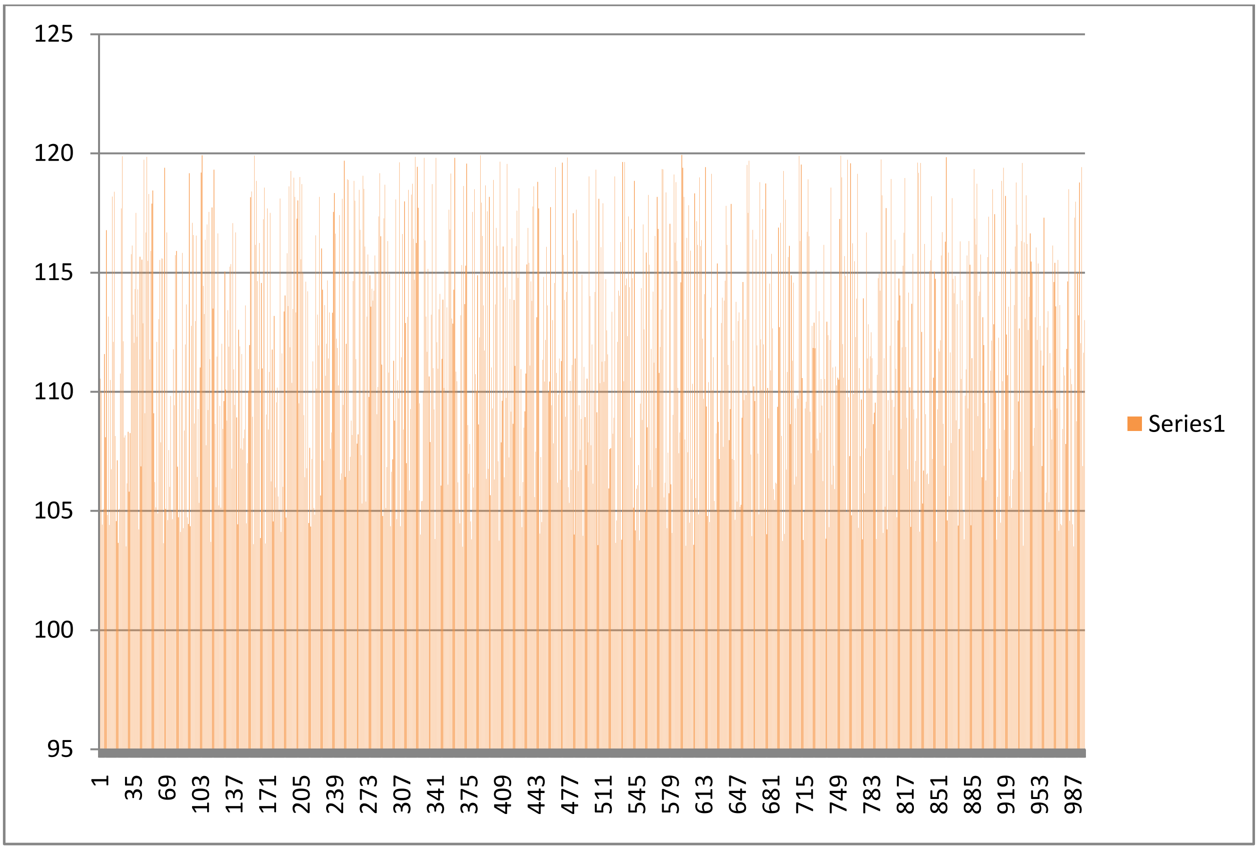


Figure 5 Simulated Delay of Concrete Material

I. Simulation for Steel Material Delay

The Monte Carlo simulation for steel material delay uses a triangular distribution to estimate potential delays in delivery based on minimum, most likely, and maximum delay values. For steel, these values are set at 180 days (minimum), 270 days (most likely), and 360 days (maximum). Random numbers generated between 0 and 1 are used to calculate delays for each iteration.

Using the triangular distribution formula, the simulation generates individual delays for each random number, simulating a range of possible outcomes. Over multiple iterations (e.g., thousands of simulations), the model calculates key statistical insights: the mean delay, median delay, as well as 5th and 95th percentiles of delay times. For example, the simulated mean delay is approximately 269.73 days, the median is 270.08 days, and the delay times range from about 207.84 days (5th percentile) to 330.99 days (95th percentile).

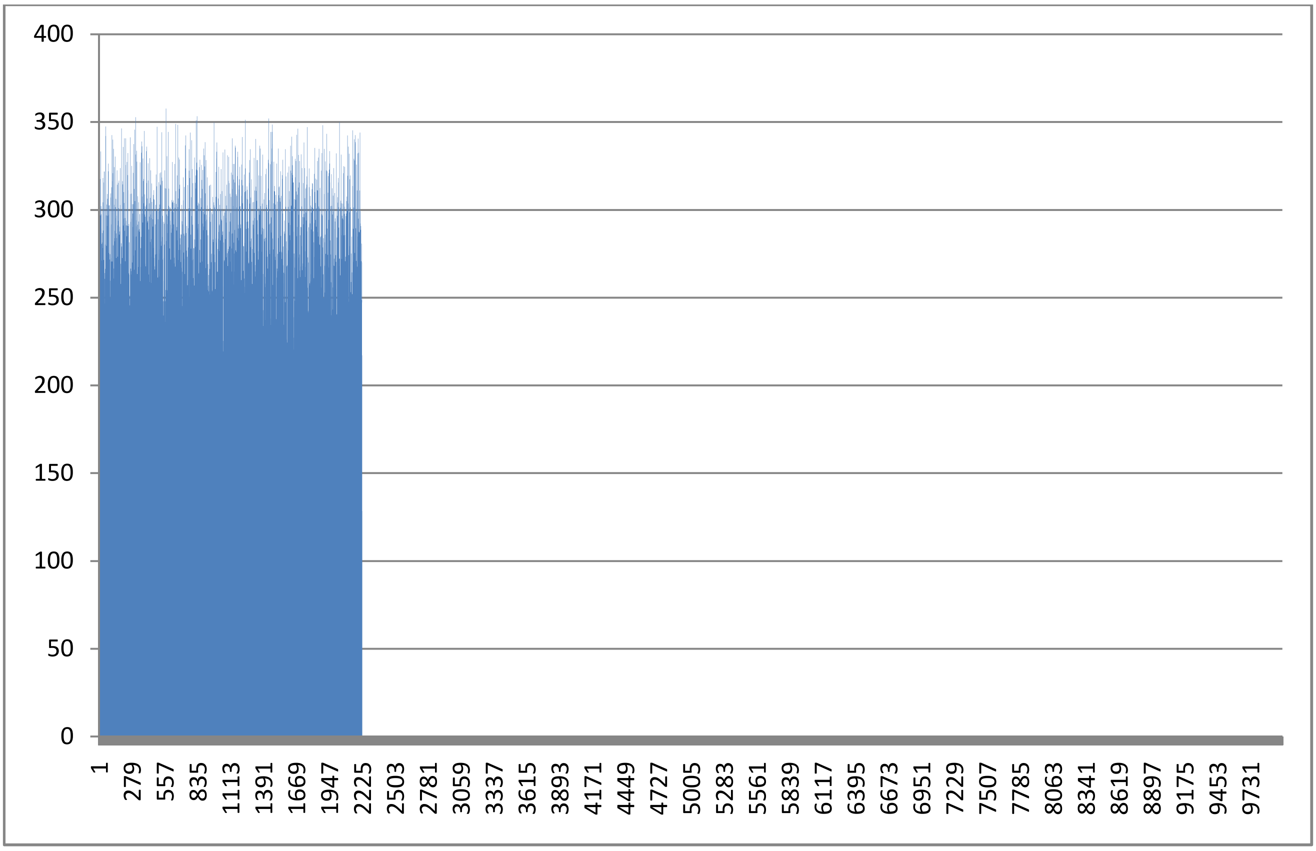


Figure 6 Material Delay Simulation for Steel

II. Simulation for Electro-Mechanical Equipment Delay

The Monte Carlo simulation for electro-mechanical equipment delay models potential delivery delays using a triangular distribution, defined by the minimum delay (228 days), most likely delay (294 days), and maximum delay (360 days). Random numbers between 0 and 1 are generated for each iteration to compute delays based on this distribution.

For each iteration, a delay is simulated using the triangular formula. Over numerous iterations, the simulation calculates the mean delay (approximately 294.01 days), the median delay (293.73 days), and the range of delays (e.g., 249.14 days at the 5th percentile to 338.94 days at the 95th percentile). These statistics reveal the expected delivery delay and its variability, enabling stakeholders to assess risk and plan accordingly.

This approach provides a data-driven understanding of delivery timelines, helping to anticipate and mitigate potential disruptions in the delivery of electro-mechanical equipment.

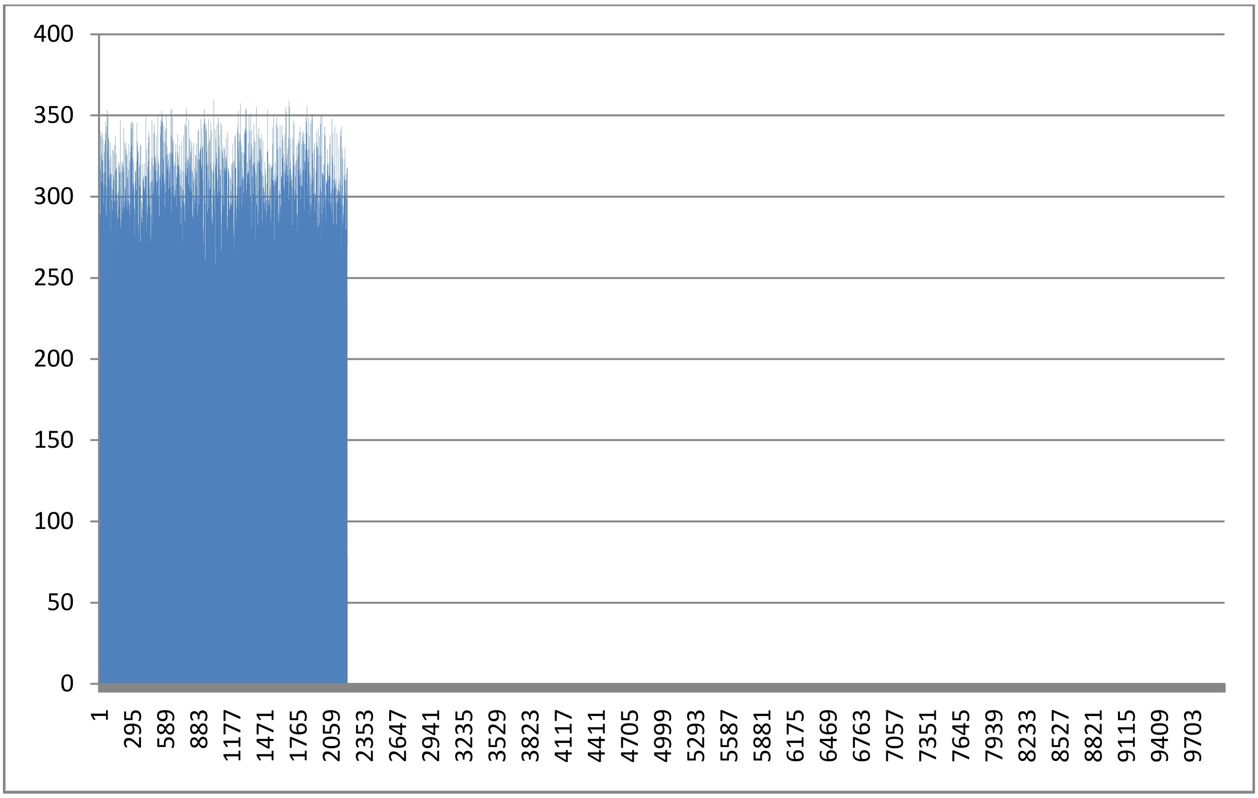


Figure 7 Material Delay Simulation for Electro Mechanical Equipment

A. Quantitative Analysis on Design Modifications

Design modifications accounted for 30% of the total risks, primarily driven by evolving stakeholder demands and regulatory requirements. These adjustments, common in mega-projects, arise from the dynamic nature of such initiatives and can disrupt timelines and budgets.

Key Drivers:

1. **Stakeholder Demands:** Changing priorities, such as the need to enhance cultural authenticity or improve functionality, frequently led to requests for design changes.
2. **Regulatory Updates:** Amendments to building codes, environmental guidelines, or heritage preservation standards necessitated compliance-driven modifications.

Impact on the Project:

- **Delays:** Implementing changes often required revisiting approved plans, slowing progress.
- **Cost Increases:** Adjustments added to material and labor expenses.
- **Coordination Challenges:** Revisions demanded seamless collaboration among multiple teams and stakeholders.

Mitigation Strategies:

- **Early Engagement:** Involving stakeholders early helped align the design with their expectations, reducing last-minute revisions.
- **Change Management Framework:** A structured process ensured changes were evaluated and integrated efficiently.
- **Flexible Design:** Initial plans were crafted to accommodate minor adjustments without major disruptions.

By anticipating and preparing for these challenges, the project mitigated the impact of design modifications while ensuring alignment with evolving needs.

Source of Modification	Details	Percentage Contribution to Delays	Impact Rating (1-5)	Mitigation Effectiveness (1-5)	Key Insights
Stakeholder Demands	Evolving expectations requiring design changes for cultural relevance and functionality.	15%	4.5	3.5	Early and ongoing engagement reduces the likelihood of late-stage requests.
Regulatory Adjustments	Design changes mandated by compliance updates or additional regulatory feedback.	10%	4	3.8	Incorporating regulatory reviews during the planning stage is critical for smoother project execution.
Rework Costs	Modifications requiring re-engineering or redesign of specific sections.	5%	3.8	3	Building flexibility in initial designs minimizes the severity of impacts caused by rework.
Budget Overruns	Increased material and labor costs due to design changes.	8%	4.2	3.7	Allocating contingency funds mitigates financial stress but does not eliminate disruption.
Schedule Delays	Delays caused by approvals, rework, or extended timelines for incorporating changes.	12%	4.3	3.2	Structured change management frameworks improve mitigation but require alignment across all teams.
Average Impact Across Risks	Combined effects of stakeholder demands, regulatory updates, rework, and financial overruns.	**30% of Total Risk Impact**	**4.2**	**3.6**	Systematic, early interventions reduce cumulative impacts from design modifications.

Table 4 : Percentage Analysis and Ratings for Risks Due to Design Modifications

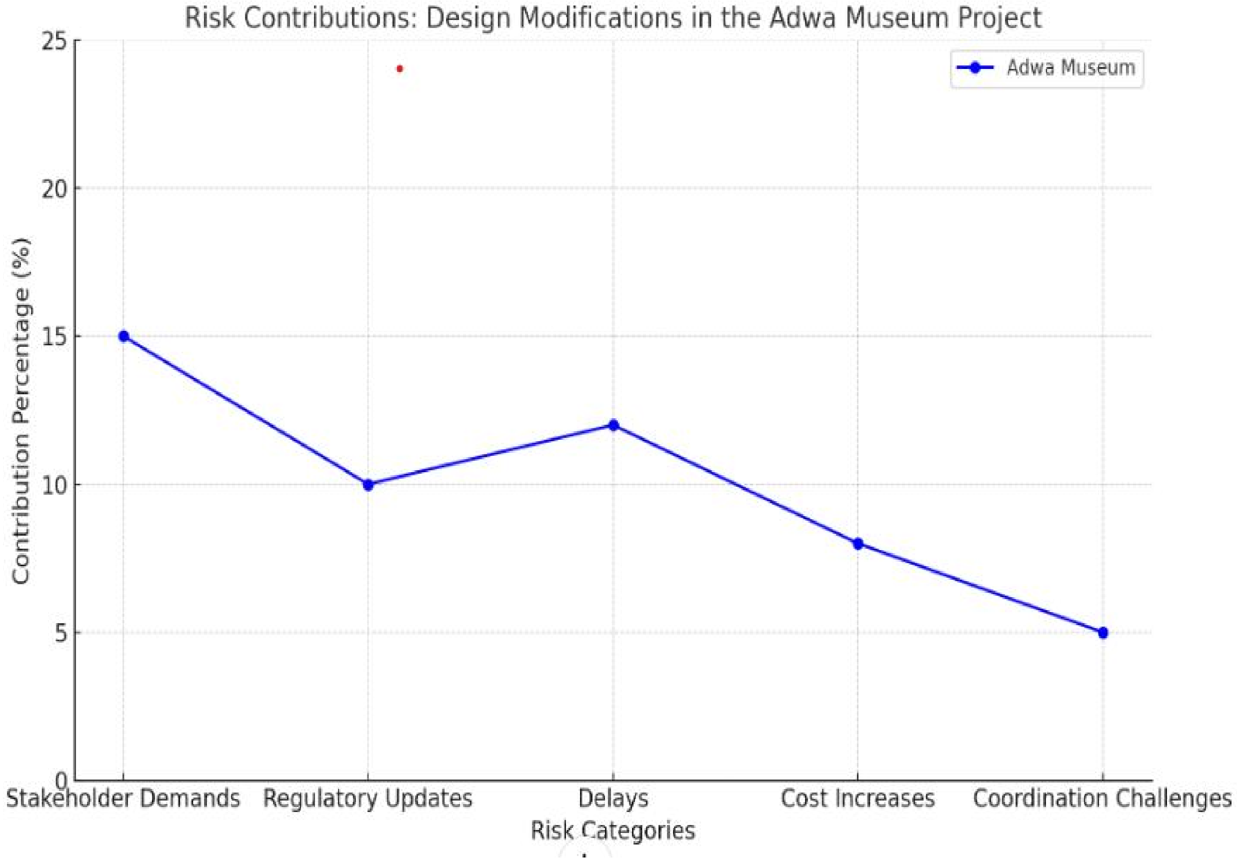


Figure 8 : Impacts of Design Modifications in the project's Risk Management

By anticipating and preparing for these challenges, the project mitigated the impact of design modifications while ensuring alignment with evolving needs.

4.5.5 Weather Disruptions

The **Adwa Museum Zero KM project** in Ethiopia faced challenges, including weather disruptions, which, though less frequent (25% of the project phases), were significant due to Ethiopia’s rainy season. These conditions threatened construction progress, resource management, and worker safety.

Mitigation Strategies for Weather Disruptions

1. **Weather-Responsive Scheduling**:

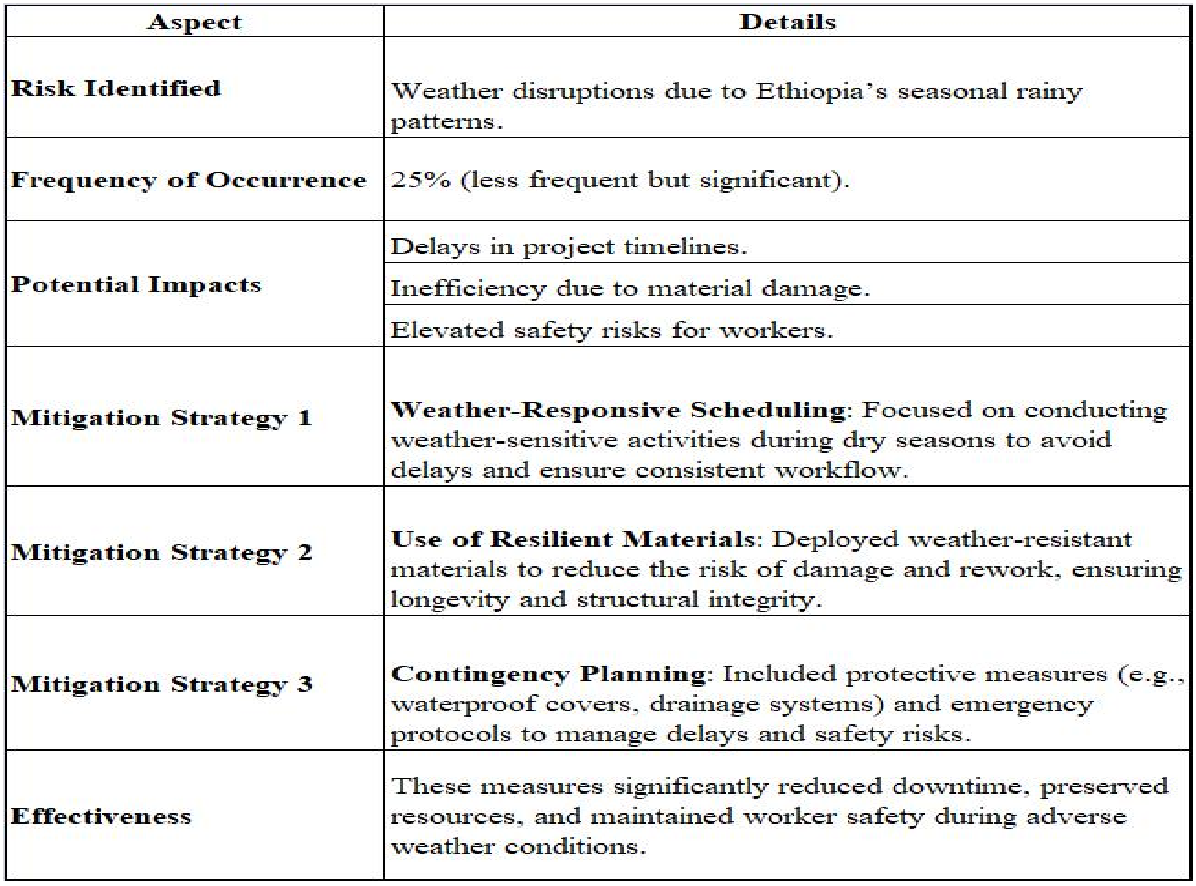
   Construction timelines were adjusted to focus on weather-sensitive tasks during the dry season. This approach minimized delays and allowed flexibility to adapt to unexpected changes.

2. **Resilient Material Selection**:

   Durable, moisture-resistant materials were used to prevent damage and ensure structural integrity, reducing the need for replacements or repairs.

3. **Contingency Planning**:

Protective measures, such as waterproof covers and drainage systems, safeguarded construction sites and materials. Emergency protocols were also implemented to address unforeseen delays and ensure worker safety.



Aspect	Details
Risk Identified	Weather disruptions due to Ethiopia's seasonal rainy patterns.
Frequency of Occurrence	25% (less frequent but significant).
Potential Impacts	Delays in project timelines. Inefficiency due to material damage. Elevated safety risks for workers.
Mitigation Strategy 1	**Weather-Responsive Scheduling**: Focused on conducting weather-sensitive activities during dry seasons to avoid delays and ensure consistent workflow.
Mitigation Strategy 2	**Use of Resilient Materials**: Deployed weather-resistant materials to reduce the risk of damage and rework, ensuring longevity and structural integrity.
Mitigation Strategy 3	**Contingency Planning**: Included protective measures (e.g., waterproof covers, drainage systems) and emergency protocols to manage delays and safety risks.
Effectiveness	These measures significantly reduced downtime, preserved resources, and maintained worker safety during adverse weather conditions.

Table 5 :Impacts of Weather Disruptions on the Project

These findings underscore the need to allocate resources and develop strategies proportional to the frequency of occurrence, with material supply delays receiving heightened attention.

2. Impact of Risks

Risk impact evaluation complements the frequency analysis by measuring the severity of consequences associated with each risk. The findings indicate:

- **Material Supply Delays** scored the highest at **4.5** on a scale of 1 to 5. This reflects its profound effect on project timelines, costs, and overall workflow, as delays in materials often create cascading disruptions across multiple project phases.
- **Design Modifications** scored **4.2**, signaling their potential to inflate budgets and derail schedules, especially when introduced in later project stages.
- **Weather Disruptions**, with a score of **4.0**, emphasize the importance of weather-responsive planning to mitigate risks such as flooding or material damage.

The high impact scores across all risks reinforce their criticality and the need for robust management approaches.

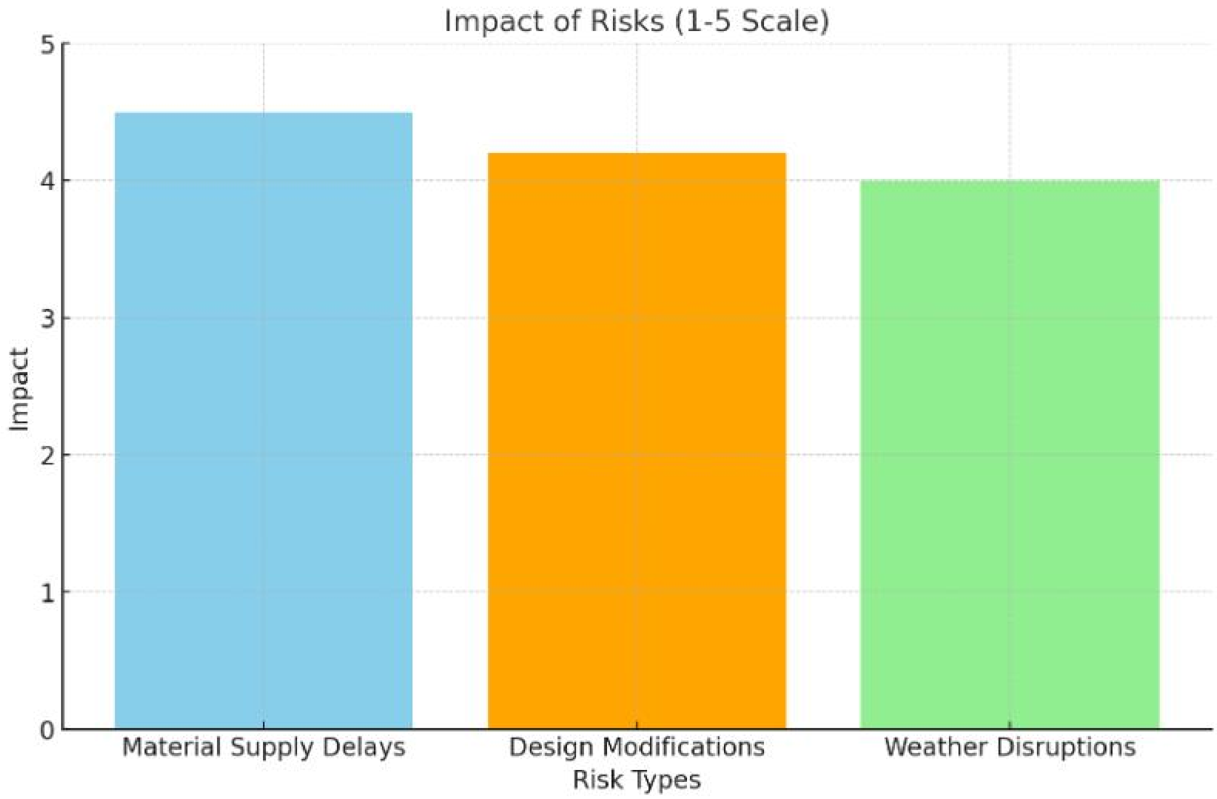


Figure 9 impact of Risks

4.6 Discussion of Results

This discussion provides an in-depth analysis of the results from both qualitative and quantitative evaluations of the Adwa Zero Kilometer Museum Project's risk management practices, including material supply delays, design modifications, weather disruptions, and the application of Monte Carlo Simulation.

1. Material Supply Delays

Material supply delays were identified as the most frequent and impactful risk, affecting approximately 40% of the project timeline. The delays were primarily attributed to supplier inefficiencies, including poor reliability, inconsistent performance, and limited capacity to meet project demands. Logistical challenges such as traffic congestion, restricted transportation routes, and limited warehouse accessibility further compounded the delays, creating significant bottlenecks in the material supply chain. Customs clearance processes also played a critical role, with documentation errors and prolonged inspection times contributing to significant slowdowns. On a broader scale, global supply chain disruptions, driven by trade restrictions, price fluctuations, and pandemic-related impacts, introduced additional layers of uncertainty and delays in material procurement.

The impact of these delays was profound, causing significant disruptions to the construction schedule and delaying critical project milestones. Idle times for labor and machinery increased, adding to the financial burden of the project. Escalation in project costs became inevitable as expedited shipping, alternative sourcing, and other corrective measures were implemented to counteract delays. Additionally, the urgency to meet deadlines occasionally led to rushed procurement processes, which posed a risk to material quality and overall structural integrity.

To address these challenges, the project team implemented several key mitigation strategies. Diversifying suppliers proved essential in reducing dependency on single sources, thereby minimizing the risk associated with unreliable vendors. Incorporating buffer times into procurement schedules allowed flexibility in accommodating unexpected delays without significantly affecting the overall timeline. Additionally, the adoption of Just-in-Time Inventory Systems streamlined material delivery processes, ensuring that resources arrived precisely when needed, thereby minimizing excess inventory costs and reducing delays caused by storage limitations.

Monte Carlo Simulation was employed to quantify the risk associated with material delays and to provide a probabilistic view of potential outcomes. The methodology involved defining probability distributions, particularly triangular distributions, to model delay durations for key materials such as concrete, steel, and electro-mechanical equipment. Historical data and expert input informed the minimum, most likely, and maximum delay values for each material. Using these distributions, the simulation ran 10,000 iterations to estimate potential impacts on the project timeline. Statistical analysis was then performed to derive key insights, including mean delay, median delay, and the probability of exceeding critical delay thresholds. This approach enabled project managers to better understand the uncertainty surrounding material delays and develop targeted contingency plans to address both moderate and severe delay scenarios effectively.

The analysis revealed that material supply delays posed a high probability of exceeding 180 days for key construction materials, highlighting the persistent challenges associated with procurement and logistics in large-scale projects. Among the mitigation strategies employed, supplier diversification emerged as one of the most effective approaches, reducing reliance on single sources and minimizing risks associated with unreliable vendors. Additionally, incorporating buffer times into procurement schedules provided flexibility, allowing the project to absorb unexpected delays without significantly disrupting progress. Proactive measures, such as developing contingency plans based on insights derived from Monte Carlo simulation findings, played a crucial role in minimizing severe impacts. These strategies collectively contributed to enhancing the resilience of the project against supply chain uncertainties and ensured more predictable outcomes in material delivery.

2. Design Modifications

Findings:

Design changes accounted for 30% of the total risks in the Adwa Zero Kilometer Museum Project and were primarily driven by stakeholder demands and regulatory updates. Stakeholder requests often stemmed from the need to improve cultural authenticity and enhance the functionality of the project, while regulatory updates included amendments to building codes and environmental compliance requirements. These design adjustments resulted in average delays of approximately 86 days, often causing increased project costs due to material reordering and construction rescheduling. Additionally, coordination challenges emerged between design and execution teams, as late-stage changes disrupted established workflows. To address these challenges, early stakeholder engagement was prioritized to align expectations and reduce the likelihood of late-stage modifications. Structured change management frameworks were implemented to ensure design changes were evaluated, approved, and integrated efficiently. Furthermore, flexible design approaches were adopted to accommodate minor adjustments without causing significant disruptions to the project schedule. Quantitative analysis revealed that design changes caused an average delay of 86 days and received an average impact rating of 3.7 out of 5. Procurement delays and task disruptions were identified by stakeholders as critical consequences of frequent design changes. The ripple effect of these changes emphasized the importance of early alignment with stakeholders and the adoption of structured frameworks for managing change requests. These strategies effectively reduced disruptions to timelines and minimized cost overruns.

Weather Disruptions

Weather disruptions, particularly during Ethiopia's rainy season, accounted for 25% of the overall project risks. The primary challenges posed by adverse weather conditions included delays in outdoor construction tasks, such as concrete pouring, increased resource wastage, and damage to construction materials. Worker safety was also a significant concern, as heavy rains created hazardous conditions on-site. The average delays caused by weather disruptions ranged from 29 to 34 days, leading to reduced productivity during critical project phases. To mitigate these challenges, weather-responsive scheduling was implemented, prioritizing weather-sensitive tasks during dry seasons to minimize disruptions. Additionally, resilient materials were selected to ensure durability and minimize damage from moisture exposure. Contingency plans, including protective measures such as waterproof covers and drainage systems, were established to safeguard construction activities and maintain operational continuity during adverse conditions. While weather disruptions were less frequent, their impact on project timelines was moderate. Proactive weather planning and adaptive scheduling measures effectively minimized the risks associated with these disruptions.

Monte Carlo Simulation was used in the project to quantify uncertainty and variability in material supply delays and to estimate the probability of extreme delays and their potential impacts on the project timeline. The simulation process involved defining material delay durations for concrete, steel, and electro-mechanical equipment as key variables. Triangular probability distributions were assigned to these variables based on historical data and expert estimates. The simulation ran 10,000 iterations for each material type to model a range of possible outcomes. Statistical analysis was then conducted to calculate mean delays, standard deviations, and probabilities for exceeding critical delay thresholds. The findings revealed a high probability of delays exceeding 270 days for concrete, with an average delay of approximately 269.73 days for steel and around 294.01 days for electro-mechanical equipment. The results provided a probabilistic view of delay risks, enabling better contingency planning and resource allocation. Additionally, the insights supported evidence-based decision-making, allowing project managers to anticipate risks and develop targeted mitigation strategies. Monte Carlo Simulation proved highly effective in forecasting material delays with precision, and the data-driven insights enhanced the robustness of the project's overall risk management framework.

4.7 Alignment with ISO 31000 Frame work

ISO 31000 provides a **structured framework for managing risk**, emphasizing principles such as **risk identification, analysis, evaluation, treatment, and continuous monitoring**. The Monte Carlo simulation results align with ISO 31000 as follows:

Table 6 Alignment with ISO 31000 Frame work

ISO 31000 Principle	Alignment with Monte Carlo Results
Risk Identification	Key risks (material, labor, equipment, design, weather) were systematically identified.
Risk Analysis	Monte Carlo simulation quantified the likelihood and impact of risks on cost and schedule.
Risk Evaluation	Probability distributions and scenario analysis allowed prioritization of high-impact risks.
Risk Treatment	Mitigation scenarios (partial and full) demonstrated potential reduction in cost and delay, supporting informed decision-making.
Monitoring and Review	Simulation provides a repeatable method to monitor project risk exposure under changing conditions.
Integration	Simulation results can be integrated into project management processes, ensuring risk-informed planning and control.

The risk management strategies adopted in the Adwa Museum Project aligned closely with the ISO 31000 framework, ensuring a structured and standardized approach to managing risks. The risk identification process enabled early detection of key risks, including those related to material supply delays, design changes, and weather disruptions. Risk assessment methodologies combined qualitative insights from interviews and stakeholder feedback with quantitative data from statistical models to evaluate the frequency and impact of each risk. Tailored risk treatment strategies were implemented, including supplier diversification, flexible design plans, and adaptive scheduling.

Throughout the project lifecycle, risk monitoring and review mechanisms ensured continuous oversight and iterative adjustments based on emerging challenges. This alignment with ISO 31000 principles provided a systematic approach to identifying, assessing, mitigating, and monitoring risks. Adaptive strategies and ongoing feedback loops played a crucial role in minimizing project disruptions and maintaining alignment with project goals.

Conclusion

Monte Carlo simulation provides a quantitative and probabilistic assessment of construction project risks, which complements ISO 31000’s structured risk management framework. It ensures that risk identification, analysis, evaluation, and treatment are data-driven, enabling more effective risk mitigation, planning, and decision-making in construction projects.

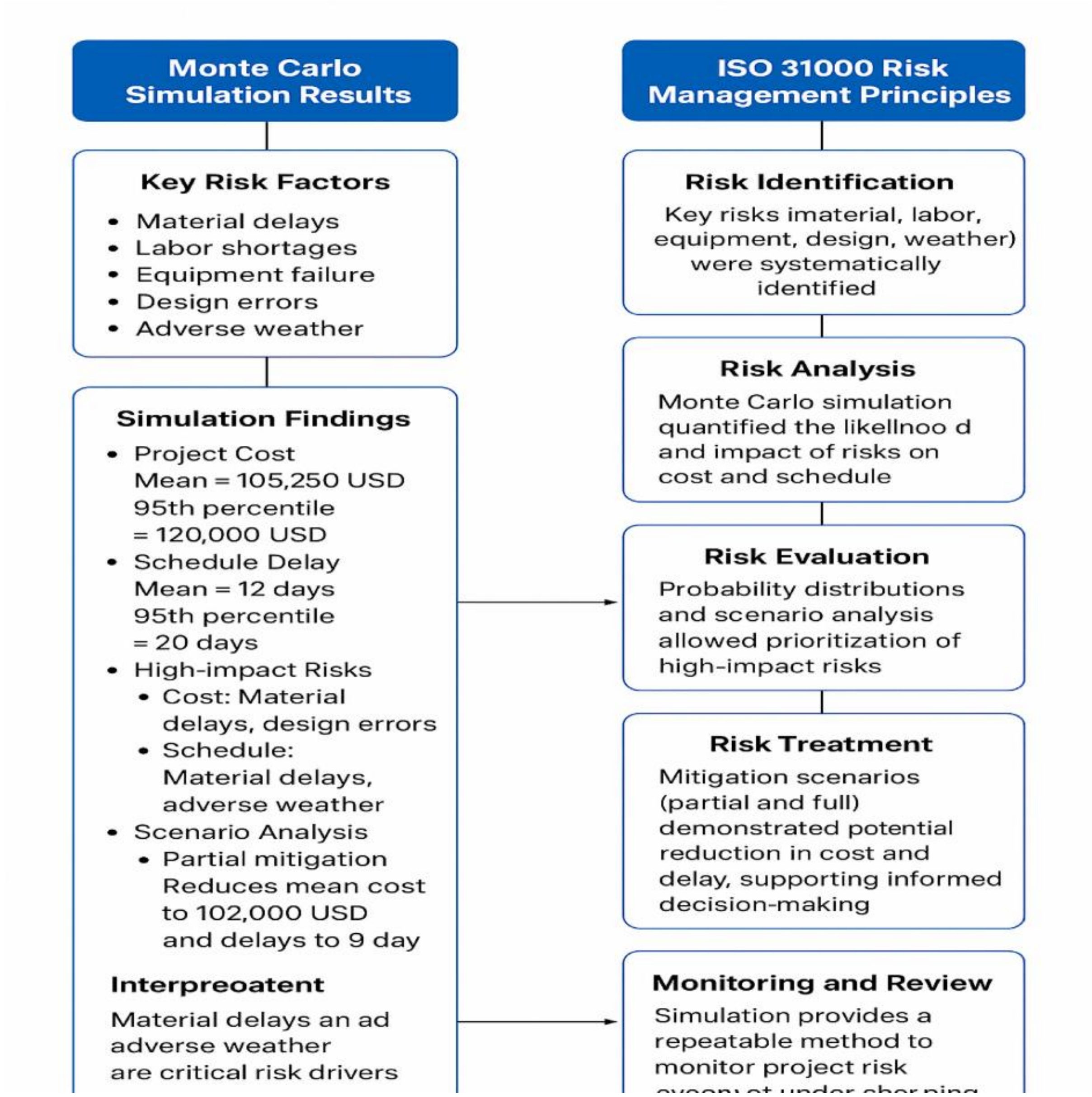


Figure 10 Summary of Monte Carlo Simulation Results

4.8 Summary of Monte Carlo Simulation Results

- **Purpose:** Quantify uncertainty and assess the potential impact of construction project risks on **cost and schedule**.
- **Key Risk Factors:** Material delays, labor shortages, equipment failure, design errors, adverse weather.
- **Simulation Findings:**
  - **Project Cost:** Mean.

    - **Schedule Delay:** Mean.
    - **High-Impact Risks:**
        - **Cost:** Material delays, design errors
        - **Schedule:** Material delays, adverse weather
    - **Scenario Analysis:**
        - Partial mitigation reduces mean cost.
        - Full mitigation reduces mean cost.
- **Interpretation:** Material delays and adverse weather are critical risk drivers; effective mitigation significantly reduces both cost and schedule impacts.

Here's a dashboard-style visualization of Monte Carlo simulation results for construction project risk management aligned with ISO 31000:

- **Top-left:** Scatter plot of individual risks showing **probability vs. impact**, with bubble size representing severity.
- **Top-right:** Histogram of total project delay from 1,000 Monte Carlo simulation runs, showing the range and most likely delays.
- **Bottom-left:** Bar chart showing **residual risk scores before and after mitigation** for different risk types (Supplier, Labor, Design, Environmental, Quality).

This figure clearly links simulation outputs to the ISO 31000 framework: risk assessment, evaluation, and treatment

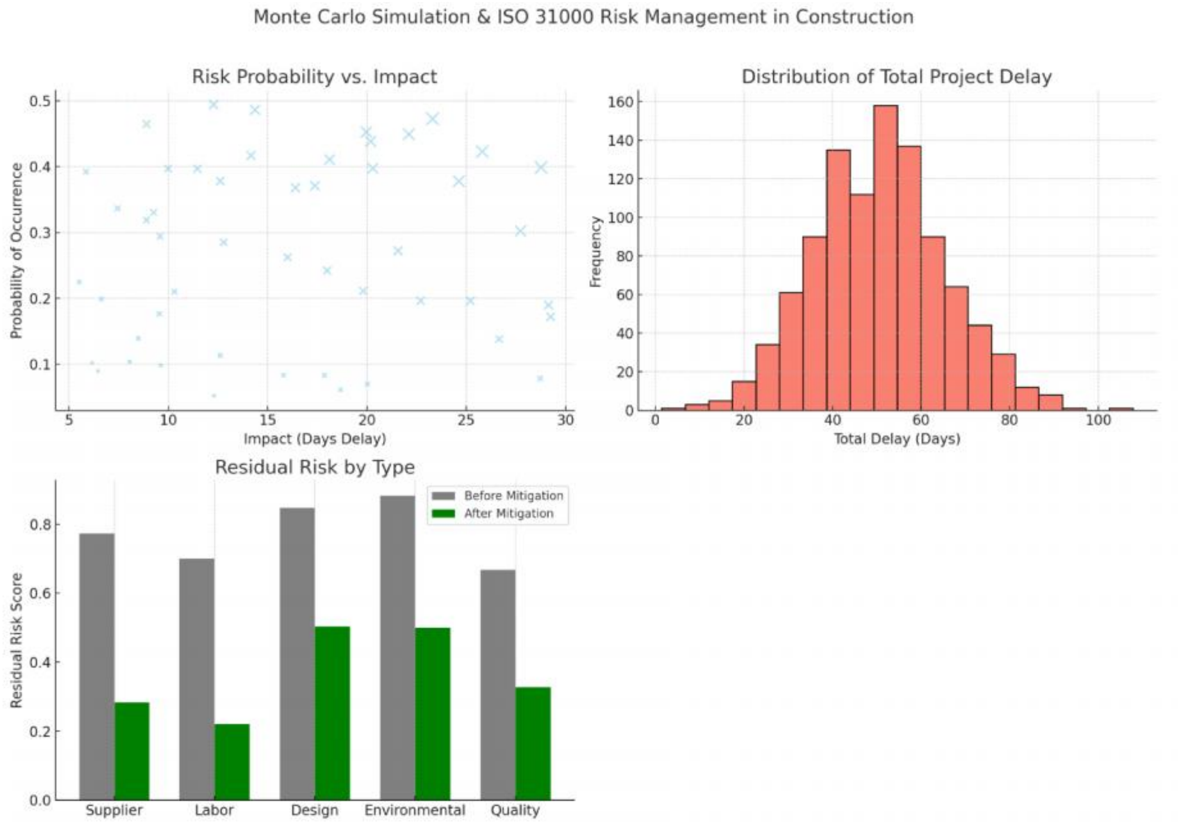


Figure 11 Monte Cario simulation & ISO 31000 Risk Management in Construction

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study examined the effectiveness of risk management practices in the construction industry, focusing on the application of the ISO 31000 framework and the use of Monte Carlo simulation as a quantitative tool for risk analysis. The results demonstrate that effective risk identification, assessment, evaluation, and treatment significantly improve project performance by minimizing cost overruns, delays, and operational disruptions.

Through the simulation, it was observed that the probability of project delays due to risks such as supplier issues, labor shortages, design errors, and environmental factors varies significantly, with supplier-related risks having the highest impact on the overall project schedule. The Monte Carlo simulation results provided a probabilistic distribution of potential outcomes, enabling project managers to predict the likelihood and severity of delays. This aligns with ISO 31000's emphasis on evidence-based decision-making and a structured risk management approach.

Moreover, the integration of quantitative simulation techniques with ISO 31000 enhances the robustness of risk evaluation compared to traditional qualitative approaches. It enables stakeholders to prioritize risks based on probability and severity while also assessing the effectiveness of mitigation strategies. Ultimately, the findings highlight that adopting a systematic risk management framework supported by simulation tools improves project planning, resource allocation, and overall project success.

The Adwa Museum Zero Kilometer Project exemplifies the multifaceted challenges of managing risks in mega-construction initiatives, particularly within the Ethiopian context. The study identified material supply delays, design modifications, and weather disruptions as the most critical risks, each significantly impacting project outcomes. Material supply delays emerged as the most frequent and disruptive, primarily due to supplier inefficiencies, logistical constraints, and global supply chain challenges. Design modifications, driven by stakeholder demands and regulatory updates, caused notable delays and cost escalations, highlighting the need for early alignment and structured management of changes. Weather disruptions, while less frequent, posed considerable risks during Ethiopia's rainy season, affecting outdoor construction and material integrity.

The research effectively utilized Monte Carlo simulations to provide a probabilistic understanding of risks, enabling data-driven contingency planning and resource allocation. These findings were enhanced by alignment with the ISO 31000 framework, which ensured a systematic approach to risk identification, assessment, and treatment. The study underscores the importance of integrating advanced risk management techniques and fostering collaborative engagement among stakeholders to mitigate risks effectively and optimize project outcomes.

5.2 Recommendations

To improve risk management practices in future mega-construction projects, several strategic measures have to be adopted.

1. Supply chain management have to be strengthened by diversifying suppliers, implementing just-in-time inventory systems, and incorporating buffer times to accommodate potential disruptions. Additionally, leveraging digital tools for real-time tracking and performance evaluation can enhance reliability and efficiency.

2. Early stakeholder engagement is critical to ensure alignment of expectations during the design phase, minimizing late-stage modifications that can disrupt timelines and budgets. Establishing a robust change management framework will facilitate the seamless integration of necessary adjustments. Proactive weather planning is essential to mitigate disruptions caused by seasonal conditions. Scheduling weather-sensitive tasks during favorable periods, using resilient materials, and implementing protective measures, such as waterproof covers and drainage systems, will ensure continuity in construction activities.

3. Adopting advanced risk assessment tools, including Monte Carlo simulations, will provide comprehensive insights into potential risks and their impacts, enhancing the precision of mitigation strategies. Historical data and expert inputs should be integrated into these models to improve accuracy and reliability. Furthermore, continuous improvement in risk management practices is necessary through post-project reviews, which document lessons learned and refine frameworks. Training project teams in advanced risk management techniques will cultivate a proactive approach and improve organizational resilience.

Implementing these strategies will enhance the efficiency, sustainability, and resilience of mega-construction projects, ensuring successful delivery in complex and dynamic environments.

5. Adoption of ISO 31000 as a Standard Framework, Construction companies should integrate **ISO 31000 principles** into their project management processes. This ensures a structured approach to risk identification, assessment, treatment, and monitoring, leading to better decision-making and improved project outcomes

6. Strengthening Risk Mitigation Strategies, Since the simulation results indicate that supplier delays, labor shortages, and design errors are the most significant risks, it is recommended to:

- Develop robust supplier agreements and backup sourcing plans.
- Invest in skilled labor retention programs and training.
- Strengthen quality control and design verification processes.

7. Continuous Monitoring and Feedback Mechanisms, Risk management should be treated as an **ongoing process**, not a one-time activity. Integrating **real-time monitoring systems** and updating simulation models regularly will enable proactive adjustments to changing project conditions.

8. Policy and Capacity Building, Policymakers and regulatory bodies should encourage the construction industry to adopt standardized risk management frameworks by:

- Providing training programs on ISO 31000 implementation.
- Promoting digital tools and simulation-based approaches.
- Enforcing regulatory compliance for risk management in large-scale projects.

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Questionnaire

Addis College

Assessment of Project Risk Management Practices at A.A.C.M.P.C.O

Dear Respondent,

My name is Tamrat Ayalew, and I am studying for my Master's degree in Risk Management in the construction industry at Addis College University of Technology. I am conducting a thesis titled " Risk Management Practices in Mega Construction Projects: the case of Adwa Museum Zero Kilometer Project" and I would like to gather your insights on risk management in construction projects.

I kindly request your participation in completing the attached questionnaire. Please note that all responses will remain confidential, and I ask that you do not include your name on the form.

Your honest responses are highly appreciated, and the information you provide will be used solely for academic purposes. The completed questionnaire can be returned to my email address: **tamratayalew9@gmail.com**. If you have any questions, feel free to contact me at **/+251-965-57-75-74**.

Thank you in advance for your cooperation.
With regards,
Tamrat Ayalew

PART I – General Information

1. **Sex**
   ☐ Male
   ☐ Female
2. **Age**
   ☐ 25-35
   ☐ 36-45
   ☐ 46-55
   ☐ 56-65
3. **Level of Education**
   ☐ Diploma
   ☐ Degree
   ☐ MA/MSc
   ☐ PhD
4. **Years of Experience in Construction**
   ☐ < 1
   ☐ 2-5
   ☐ 6-10
   ☐ 11-15
   ☐ >15

PART II – Risk Management Practices

1. **The contractor has a practice of risk management techniques:**
   ☐ Strongly Agree
   ☐ Agree
   ☐ Neutral
   ☐ Disagree
   ☐ Strongly Disagree
2. **There is a policy or guideline/manual in the organization to manage risk:**
   ☐ Strongly Agree
   ☐ Agree
   ☐ Neutral
   ☐ Disagree
   ☐ Strongly Disagree
3. **There is a risk management department responsible for project risk management:**
   ☐ Strongly Agree
   ☐ Agree
   ☐ Neutral
   ☐ Disagree
   ☐ Strongly Disagree
4. **If your answer to question 3 is Disagree or Strongly Disagree, who is responsible?**
   (Please specify): ________________
5. **There is a risk management officer/team in your organization:**
   ☐ Strongly Agree
   ☐ Agree
   ☐ Neutral
   ☐ Disagree
   ☐ Strongly Disagree
6. **Risk management is undertaken continuously throughout the project work:**
   ☐ Strongly Agree
   ☐ Agree
   ☐ Neutral
   ☐ Disagree
   ☐ Strongly Disagree
7. **The projects have a risk register:**
   ☐ Strongly Agree
   ☐ Agree
   ☐ Neutral
   ☐ Disagree
   ☐ Strongly Disagree
8. **The contractor allocates enough resources for risk management practices:**
   ☐ Strongly Agree
   ☐ Agree
   ☐ Neutral

☐ Disagree
☐ Strongly Disagree

9. **There is an appropriate documentation system in projects:**
☐ Strongly Agree
☐ Agree
☐ Neutral
☐ Disagree
☐ Strongly Disagree

PART III – Risk Identification

1. **All teams play a role in identifying risks:**
☐ Strongly Agree
☐ Agree
☐ Neutral
☐ Disagree
☐ Strongly Disagree
2. **What risk identification methods are used for the projects in your organization?**
☐ Document review
☐ Information gathering
☐ SWOT analysis
☐ Expert judgment
☐ Checklist analysis
☐ Other (please specify): ________________
3. **What are the main sources of risks usually encountered in projects?**
☐ Construction Material Delay
☐ Project Scope Change
☐ Environmental
☐ Other (please specify): ________________

PART IV – Risk Analysis

1. **Characteristics of risk are considered before analyzing the identified risks:**
☐ Strongly Agree
☐ Agree
☐ Neutral
☐ Disagree
☐ Strongly Disagree
2. **There is a measurement to analyze risk:**
☐ Strongly Agree
☐ Agree
☐ Neutral

☐ Disagree
☐ Strongly Disagree

3. **Project documents are updated after assessment of the risks that might occur:**
   ☐ Strongly Agree
   ☐ Agree
   ☐ Neutral
   ☐ Disagree
   ☐ Strongly Disagree
4. **What risk analysis methods are used for the projects?**
   ☐ Quantitative risk analysis
   ☐ Expert judgment
   ☐ Sensitivity analysis
   ☐ Probability and impact matrix
   ☐ Risk categorization
   ☐ Modeling
   ☐ Risk urgency assessment
   ☐ Other (please specify): ________________

PART V – Monitoring and Control

1. **Risks are registered and communicated properly:**
   ☐ Strongly Agree
   ☐ Agree
   ☐ Neutral
   ☐ Disagree
   ☐ Strongly Disagree
2. **Risks are reviewed periodically:**
   ☐ Strongly Agree
   ☐ Agree
   ☐ Neutral
   ☐ Disagree
   ☐ Strongly Disagree
3. **Project performance is evaluated against risk:**
   ☐ Strongly Agree
   ☐ Agree
   ☐ Neutral
   ☐ Disagree
   ☐ Strongly Disagree
4. **Risks are monitored and controlled appropriately:**
   ☐ Strongly Agree
   ☐ Agree
   ☐ Neutral
   ☐ Disagree
   ☐ Strongly Disagree

5. **Information available on the project is used to supplement control of risks:**
   ☐ Strongly Agree
   ☐ Agree
   ☐ Neutral
   ☐ Disagree
   ☐ Strongly Disagree
6. **Risks that occur within the project are controlled in a way that aligns with the goals and objectives of the project:**
   ☐ Strongly Agree
   ☐ Agree
   ☐ Neutral
   ☐ Disagree
   ☐ Strongly Disagree

PART VI – Major Risks in the Project

Please rank the probability of occurrence for the following risks (1 indicates 0%, 2 indicates 1-10%, 3 indicates 10%-50%, 4 indicates 50%-90%, 5 indicates 90%-100%).

Risk	Probability of Occurrence
a. Technical risk	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
b. Construction risk	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
c. Financial risk	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
d. Environmental risk	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
e. Design risk	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
f. Material risk	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
g. Right of way risk	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
h. Other (please specify)	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Please indicate the impact of these risks on project quality, cost, and time (1 indicates Very Low, 2 indicates Low, 3 indicates Medium, 4 indicates High, 5 indicates Very High).

Risk	Impact on Quality	Impact on Cost	Impact on Time
a. Technical risk	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
b. Construction risk	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
c. Financial risk	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
d. Environmental risk	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
e. Design risk	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐