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RISK MITIGATION STRATEGIES AND PERFORMANCE OF LARGE INFRASTRUCTURE PROJECTS: A CASE OF THE GRAND ETHIOPIAN RENAISSANCE DAM

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DECLARATION

I, the undersigned, declare that this thesis is my original work and has not been presented for a degree or any other award in any other university.

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DEDICATION

This thesis is dedicated to my dear family who has always been my foundation in this educational journey, being by my side all along the way, being patient and always encouraging me. To my parents, my teachers, the value of education, to my siblings, the thought and belief that I would be able to do it on my own.

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ABBREVIATIONS AND ACRONYMS

ANOVA - Analysis of Variance

CUEA - The Catholic University of Eastern Africa

EIA - Environmental Impact Assessment

EPA - Environmental Protection Authority

GERD - Grand Ethiopian Renaissance Dam

IRMS - Integrated Risk Management Systems

KM - Kilometre

MW - Megawatt

NBI - Nile Basin Initiative

PMI - Project Management Institute

RBS - Risk Breakdown Structure

RERC - Research Ethics Review Committee

SPSS - Statistical Package for Social Sciences

UNEP - United Nations Environment Programme

VIF - Variance Inflation Factor

ABSTRACT

Large infrastructure projects in developing nations face multifaceted risks that significantly influence their performance outcomes. The Grand Ethiopian Renaissance Dam (GERD), as Africa's largest hydropower project, presents a critical case for examining the relationship between risk mitigation strategies and project performance in complex, large-scale infrastructure development. This study investigated the influence of financial, technical, political, and environmental risk mitigation strategies on the performance of the GERD project. The study employed a mixed-methods research strategy with a descriptive-correlational research design. The target population comprised 320 project managers, engineers, and senior officials directly involved in the GERD project, from which a sample of 178 respondents was selected using stratified random sampling and purposive sampling techniques. Data collection utilized structured questionnaires (with 167 valid responses, an 85.2% valid response rate from the 196 distributed) and key informant interviews with 15 senior officials, complemented by document review. Quantitative data were analyzed using descriptive statistics (frequencies, percentages, means, standard deviations) and inferential statistics (Pearson's correlation and multiple regression analysis) through SPSS version 26. Qualitative data underwent thematic analysis following Braun and Clarke's (2021) six-phase framework. The study was grounded in Prospect Theory, Contingency Theory, and Stakeholder Theory. Findings revealed significant positive relationships between all four risk mitigation strategies and project performance: financial ($r=0.624$, $p<0.01$), technical ($r=0.657$, $p<0.01$), political ($r=0.583$, $p<0.01$), and environmental ($r=0.611$, $p<0.01$). Multiple regression analysis showed that the four strategies jointly explained 67.4% of variance in project performance ($R^2=0.674$, $F=84.23$, $p<0.001$), with technical risk mitigation making the strongest unique contribution ($\beta=0.342$, $p<0.001$). The study concludes that effective risk mitigation in large infrastructure projects requires comprehensive, integrated strategies addressing multiple risk dimensions simultaneously, with particular attention to technical capacity building and stakeholder engagement. Recommendations include strengthening integrated risk management systems, enhancing stakeholder consultation mechanisms, and investing in local technical capacity development for future large infrastructure projects in developing countries.

DEFINITION OF KEY TERMS

Risk Mitigation Strategies: Measures, actions and plans taken to minimise the likelihood and/or effect of any threats that may arise affecting the project objectives. These in this study include financial, technical, political, and environmental risk mitigation strategies.

Project Performance: How successful a project is in terms of stakeholders satisfaction, quality, cost, and time. In this study, the operationalization of performance is reflected in: adherence to the schedule, compliance to budget, technical quality standards, and satisfaction of the stakeholders.

Large Infrastructure Projects: These involve capital expenditures over US$1 billion that are complex and involve long project timelines, multiple stakeholders and have high socioeconomic impacts. The GERD, whose cost is estimated to be in excess of US$4 billion is in this category.

Financial Risk Mitigation: The strategies used to deal with funding risk, cost overrun, currency risk and financial sustainability of infrastructure projects.

Technical Risk Mitigation: Techniques to reduce risk due to engineering design, construction techniques, technology use, and performance reliability.

Political Risk Mitigation: Risk responses to policy changes, regulatory framework, geopolitical risks and inter-state relations and their impact on project implementation.

Environmental Risk Mitigation: Strategies to identify, assess and manage potential adverse environmental impacts across the project lifecycle.

CHAPTER ONE: INTRODUCTION

1.1 Introduction

This chapter introduces the readers to the research that investigates the link between risk mitigation strategies and the performance of large infrastructure projects, and in particular the Grand Ethiopian Renaissance Dam (GERD). The chapter introduces the background of the study, statement of the research problem, research purpose and objectives, research questions, significance of the study, justification of the study, scope of the study and its limitations, the theoretical and conceptual frameworks and the organization of the study.

1.2 Background to the Study

Large infrastructure projects are vital enablers of economic development across the world and are consistently plagued by difficulties in delivering the desired performance. Flyvbjerg (2017) found that cost overruns, schedule delays and benefit shortfalls were common features of mega-projects worldwide and found that only 1 in 10 mega-projects matched the original schedule and 90% of mega-projects saw cost escalation. The Global Infrastructure Investment Gap is estimated to be US$3.7 trillion per year by 2035 (Global Infrastructure Hub, 2021) making good risk management essential for improving project performance. This has made risk mitigation strategies a key tool for dealing with the complexities of large infrastructure development. Organizations that have more mature risk management practices can finish their projects successfully twice and a half times more often than others that don't have as mature practices (Project Management Institute 2021). Klemetti (2020) conducted a study of 147 infrastructure projects in Europe and North America to analyse the effects of systematic application of risk mitigation strategies on cost and schedule overruns. Cost and schedule overruns were reduced by an average of 27% and 34% respectively.

There are several facets of risk that need to be addressed and mitigated in today's world. Financial, technical, political, and environmental risks, such as volatility in funding, currency fluctuations, regulatory uncertainty, and stakeholder dynamics, and ecological and climate considerations, require comprehensive risk-mitigation strategies (Sanchez et al., 2019). The linkage of these categories of risk implies that a comprehensive approach is necessary to mitigate these risks, not merely an approach of single interventions. The infrastructure gap in Africa is high with the African Development Bank estimating a need for financing between US$130-170 billion each year to meet the continent's growing need. Many mega-projects from

the Inga Dam in the Democratic Republic of Congo to the Mombasa-Nairobi Standard Gauge Railway in Kenya have had significant problems in implementation, due to a lack of risk management. Studies of African contexts of infrastructure show unique risk profiles shaped by institutional, environmental and socio-political factors. Ofori-Kuragu et al (2020) analysed 35 infrastructure projects in West Africa, and identified the following as the main categories of risks that influence the performance of these projects – political instability, regulatory uncertainty and currency volatility. Likewise, Mwelu et al. (2021) working in East African infrastructure projects found that the lack of institutional frameworks and limited technical capacity are major challenges in effective risk mitigation.

The African hydropower sector is an example of these challenges. Despite this, there is substantial hydropower potential on the continent, which has been estimated at 1,753TWh/year, but which is currently exploited by only 11% of that potential (International Hydropower Association, 2022). The examples of the Bujagali dam in Uganda and Mphanda Nkuwa dam in Mozambique have clearly illustrated how poor risk assessment and risk mitigation contributes to cost escalation, delay in project delivery and conflict between stakeholders. Such experiences highlight the need to develop context-specific risk mitigation frameworks, given the infrastructure development environment in Africa.

Ethiopia has become a major contributor to Africa's infrastructure development, especially in the energy, water, and transport sectors, where significant investments have been made. Part of the country's Growth and Transformation Plans has been to focus on large-scale infrastructure as a key driver for economic growth and poverty alleviation (National Planning Commission, 2020). In all of the projects, the Grand Ethiopian Renaissance Dam (GERD) is the flagship project and the largest hydropower project in Africa. With a generating capacity of 5,150 megawatts (MW) when it is completed, the GERD is estimated to cost more than US$4 billion, and is located about 20-40 kilometers from the Sudanese border on the Blue Nile. (Ethiopian Electric Power, 2022). It was begun in 2011, aimed at reducing the energy shortage in Ethiopia, facilitating industrialization and exporting electricity to neighbouring countries. The reservoir of the dam has a capacity of 74 billion cubic meters, which makes it one of the largest dams in Africa.

The journey of implementing the GERD is a good example of the multifaceted nature of risk in large infrastructure projects in developing countries. The difficulties have involved the engineering scale of the dam itself and of the Blue Nile river, adaptive designs and construction

techniques. Financial risks have included funding difficulties that require innovative funding strategies such as using public bonds, and donations from state-owned enterprises (Tawfik, 2021). In particular, political risks have been in the spotlight, as the dam is located on transboundary water. There are concerns regarding geo-political uncertainties and the need for diplomatic engagement and bilateral agreements as Ethiopia, Sudan and Egypt have been negotiating the filling and operation of the reservoir (Yihdego et al., 2020). Environmental issues have included effects on downstream ecosystems, sedimentation, and more general watershed management issues which necessitate a holistic mitigation plan.

Despite all these hazards, tremendous progress has been achieved in the GERD with over 85% of the project completed and pilot power generation started in 2022 (EEP, 2023). There are interesting questions that could be raised on risk mitigating strategies adopted in this trajectory and how it relates to project performance in complex risk environment that takes place in the developing country context and therefore worth exploring the coping mechanism of large infrastructure projects to complex risk environments in developing country context like this trajectory.

1.3 Statement of the Research Problem

In developing countries, the performance problems of large infrastructure projects are often severe, with cost overruns of 40-60% and delay in project completion by 3-5 years compared to initial estimates, on average (World Bank, 2021; Flyvbjerg, 2017). This lack of performance negatively affects developmental returns, public finances, and stakeholder confidence in the role of infrastructure as a vehicle for economic transformation. In Africa, where infrastructure gaps are estimated to cost the growth of the economy by 2% each year (African Development Bank, 2022), the importance of understanding how effective risk mitigation can boost project performance becomes critical.

The construction of the Grand Ethiopian Renaissance Dam is a case in point of the potential of large infrastructure projects and the problems that arise. The project has made great strides, but it has faced a great deal of risks, both financial and technical, political and environmental (Yihdego et al., 2020; Tawfik, 2021). In the context of developing countries, where institutional capacity, resource scarcity, political and economic systems are very different from those of developed countries where most of the research on risk management has been done, the strategies used to manage these risks and their link to project performance are not well understood.

There is a large body of literature regarding risk mitigation in infrastructure projects, but some significant gaps exist. Risk mitigation has been studied in developed country contexts by Sanchez et al. (2019) and Klemetti (2020) but these studies are not suitable for use in developing country contexts. A number of studies have commented on infrastructure risks in Africa (e.g., Ofori-Kuragu et al., 2020; Mwelu et al., 2021), but have not systematically considered the link between actions taken to mitigate the risks and the outcomes of performance. Technical and environmental risks of hydropower projects have been discussed in the studies (Kumar & Katoch, 2020; Kibria, 2021), but with limited attention paid to an integrated approach to analyzing financial, technical, political, and environmental mitigation measures.

In particular, the effects on the performance of infrastructure projects of financial risk mitigation strategies (such as diversified financing sources and currency hedging) in developing countries have not been sufficiently studied empirically (Yescombe, 2014). Likewise, the effectiveness of technical risk mitigation strategies (such as design optimization and technology adaptation) is under-researched in the scenario of low technical capacity in the local context (Chapman & Ward, 2011). Another under-researched area is the political risks mitigation strategies used for transboundary projects of infrastructure and the implications of their performance (Alon & Herbert, 2009). Moreover, environmental risk mitigation in larger dam projects, specifically in relation to its impacts downstream and adaptation to climate change, must be explored systematically (Sanchez et al., 2017).

1.4 Research Objectives

1.4.1 General Objective

The general objective of this study was to examine the influence of risk mitigation strategies on the performance of large infrastructure projects, using the Grand Ethiopian Renaissance Dam as a case study.

1.4.2 Specific Objectives

The study was guided by the following specific objectives:

i. To examine the influence of financial risk mitigation strategies on the performance of the Grand Ethiopian Renaissance Dam project.
ii. To assess the influence of technical risk mitigation strategies on the performance of the Grand Ethiopian Renaissance Dam project.

iii. To establish the influence of political risk mitigation strategies on the performance of the Grand Ethiopian Renaissance Dam project.
iv. To determine the influence of environmental risk mitigation strategies on the performance of the Grand Ethiopian Renaissance Dam project.

1.5 Research Questions

The study answered the following research questions:

i. What is the influence of financial risk mitigation strategies on the performance of the Grand Ethiopian Renaissance Dam project?
ii. What is the influence of technical risk mitigation strategies on the performance of the Grand Ethiopian Renaissance Dam project?
iii. What is the influence of political risk mitigation strategies on the performance of the Grand Ethiopian Renaissance Dam project?
iv. What is the influence of environmental risk mitigation strategies on the performance of the Grand Ethiopian Renaissance Dam project?

1.6 Significance of the Study

The results of this study are important to several stakeholders involved in large infrastructure development. The results in the findings section are a source of evidence-based information for practitioners and infrastructure developers in Ethiopia and other parts of Africa on the effective mitigation strategies that can be applied to their large-scale projects. Knowing what strategies have strong relationships to outcomes can support risk management planning and allocation of resources.

The study provides a systematic analysis of the effectiveness of risk mitigation measures that can be used to inform future infrastructure policy and project implementation frameworks for policymakers in Ethiopia, specifically the Ministry of Water and Energy and Ethiopian Electric Power corporation. The results can be used to create guidelines for risk assessment and mitigation in the ongoing infrastructure development program in Ethiopia. The research will help the academic community in extending the knowledge base of risk management in large infrastructure projects, especially in the context of developing countries, where such research is sparsely found. The research integrated multiple risk dimensions and explored the impact of multiple risks on performance which covered gaps in previous studies.

The research offers guidance to international development partners and financial institutions investing in infrastructure in Africa in how they can reduce risk in large-scale infrastructure projects and apply that knowledge to their lending decisions, technical assistance programs and capacity building programs. The exploration of political and environmental risk mitigation is relevant to cooperative approaches for shared water resources for riparian states and regional water bodies that are interested in transboundary water management.

1.7 Justification of the Study

There are several reasons why this research is warranted. First, the continuous and widespread problems of large-scale infrastructure projects globally, especially in Africa, highlight the need for better understanding of the effectiveness of risk mitigation. As infrastructure investment continues to ramp up in all parts of the continent, knowledge that can add value to project outcomes is valuable knowledge.

Second, the Grand Ethiopian Renaissance Dam is a unique and significant case study for studying risk mitigation in large infrastructure. The GERD is a monumental undertaking that has the potential to be the biggest hydropower project in Africa and a game-changer for Ethiopia's development, and its experience can be applied to other projects with similar goals in Africa and around the world. A wide range of risk categories are involved in the project, which offers a strong background to consider several mitigation strategies together. Third, the transboundary nature of the GERD adds political and environmental considerations that go beyond the normal considerations of infrastructure projects. The knowledge and understanding of how these risks have been addressed and the link to project performance help to enhance knowledge of the management of internationally significant infrastructure.

The findings of this study are significant to various stakeholders as follows:

a) Industry Professionals and Infrastructure Developers: The results provide evidence-based information for practitioners and infrastructure developers in Ethiopia and other parts of Africa on the effective mitigation strategies that can be applied to their large-scale projects. Knowing what strategies have strong relationships to outcomes can support risk management planning and allocation of resources.

b) Policymakers: The study provides a systematic analysis of the effectiveness of risk mitigation measures that can be used to inform future infrastructure policy and project

implementation frameworks for policymakers in Ethiopia, specifically the Ministry of Water and Energy and Ethiopian Electric Power corporation. The results can be used to create guidelines for risk assessment and mitigation in the ongoing infrastructure development program in Ethiopia.

c) Academic Community: The research will help the academic community in extending the knowledge base of risk management in large infrastructure projects, especially in the context of developing countries, where such research is sparsely found. The research integrated multiple risk dimensions and explored the impact of multiple risks on performance which covered gaps in previous studies.

d) International Development Partners: The research offers guidance to international development partners and financial institutions investing in infrastructure in Africa in how they can reduce risk in large-scale infrastructure projects and apply that knowledge to their lending decisions, technical assistance programs and capacity building programs. The exploration of political and environmental risk mitigation is relevant to cooperative approaches for shared water resources for riparian states and regional water bodies that are interested in transboundary water management.

e) Future Researchers: This study provides a foundation for future research by identifying gaps, establishing baseline data, and developing a methodological framework that can be replicated or adapted for studying risk mitigation in other infrastructure projects in developing countries.

1.8 Scope and Limitation of the Study

This study focused on the Grand Ethiopian Renaissance Dam project, examining risk mitigation strategies and their relationship to project performance. Institutionally, the study concentrated on Ethiopian Electric Power as the implementing agency of the GERD project. The study included project managers, engineers, construction supervisors, and senior officials directly involved in the project. Geographically, the study concentrated on the GERD project site located on the Blue Nile in the Benishangul-Gumuz region of Ethiopia, approximately 20-40 kilometers from the Sudanese border. Data collection was conducted at project offices in Addis Ababa and at the dam site. The research analyzed risk mitigation approaches that were undertaken throughout the period between 2011 and 2026, which covered the whole process of development of the project from its beginning until almost the end. The total period is fifteen

years. The risks were classified into four groups; these include financial risks, technical risks, political risks, and environmental risks. Performance measures for the project were based on four variables which included time adherence, budget adherence, technical performance, and satisfaction of the stakeholders.

Several methodological limitations were also noted in the course of the research. Firstly, there could be a negative effect on the quality of the data due to language issues. Since the interview and questionnaires were being done in English, the language used in the GERD project, the proficiency of the participants in English could have an impact on the data gathered from the interview and the questionnaire. In order to minimize this difficulty, the participants were advised to ask for clarifications on important terms. Secondly, there was limited availability to documents. Due to the fact that the project is politically sensitive, most of the risk assessment reports, financial statements, and diplomatic documents related to the project are classified or restricted. As a result, the study mainly depended on the authorized documents published by Ethiopian Electric Power. To overcome this limitation, document analysis was complemented with data collection from interviews and questionnaires. Finally, social desirability bias could have been introduced into the survey. Some people may tend to give socially desirable answers when asked about politically sensitive issues. To prevent this from happening, the anonymity of the participants was ensured.

1.9 Theoretical and Conceptual Framework

1.9.1 Theoretical Framework

This study is grounded in three complementary theories that collectively inform understanding of risk mitigation strategies and project performance: Prospect Theory, Contingency Theory, and Stakeholder Theory.

Prospect Theory (Kahneman & Tversky, 1979; Barberis, 2013) provides the foundational framework for decision-making processes under risk and uncertainty. The theory explains why project managers might react in different ways to different risk categories and why mitigation techniques may be applied differently. Framing effects and loss aversion underpin this theory, making it clearer how risk perceptions determine the choice and use of mitigation action plans. Contingency Theory (Howell et al., 2020; Shenhar, 2001) proposes that there is no one way of organizing or managing which, rather, effectiveness stems from aligning organizational features with contextual factors. Regarding mitigation of risks, according to contingency

theory, successful strategies are contingent on the specific characteristics that a given project features, such as scale, complexity, technological uncertainty, and environmental context.

Stakeholder Theory (Freeman, 1984; Aaltonen & Kujala, 2016) emphasizes project success through effective management of different stakeholders with respect to their interests, influence, and expectations. In large infrastructure projects, risks related to stakeholders form an important part of risk management uncertainties that require special mitigation strategies. This theory offers insights into the effectiveness of risk mitigation strategies in relation to GERD, where there are many types of stakeholders including those in riparian states, local populations, international donors, and environmental activists. These three theories work in tandem to offer a comprehensive analysis at micro, meso, and macro levels respectively. A detailed discussion of these theories is presented in Chapter Two (Section 2.2).

1.9.2 Conceptual Framework

The conceptual framework of this study explained the relationship between risk mitigation strategies and the performance of the Grand Ethiopian Renaissance Dam project. It has been developed under the basis that successful implementation and performance of large infrastructure projects benefited from good risk mitigation strategies. The risk mitigation strategies are used as independent variables and the project performance as the dependent variable in this study.

The independent variables were composed of four main categories of risk mitigation strategies, namely financial, technical, political and environmental risk mitigation strategies. The dimensions were chosen as the most significant and prevalent risks of large-scale infrastructure projects, especially hydropower projects in developing countries. Financial risk mitigation strategies are the various methods used to minimise financial risk and ensure financial stability of the project. The strategies are diversified financing mechanisms, budget monitoring systems, budget control measures, contingency funding arrangements, and financial planning practices. It was expected that by implementing good financial risk mitigation, budget overruns would be avoided, resources would be utilized suitably, and continuity in the implementation of the project would be guaranteed.

Technical risk mitigation strategies are measures that reduce technical, engineering, construction and operational risks. This encompasses technology adaptation, engineering supervision, quality assurance systems, technical training, maintenance planning and design

optimization practices. The positive impact of effective technical risk mitigation is expected to be in terms of the quality of construction, the efficiency of operation, and compliance with technical standards. Political risk mitigation strategies are aimed at managing the risks that stem from political instability, diplomatic tensions, regulatory changes, and conflicts among stakeholders. These strategies involve diplomatic negotiations, involving stakeholders, institutional coordination, legal compliance, and conflict management mechanisms in the context of the construction of the Grand Ethiopian Renaissance Dam (GERD). Political risk mitigation is seen as an important determinant for the performance of the project, as it includes cross-boundary water issues and stakeholders in the regions.

Environmental risk mitigation strategies include any action that is taken to reduce the impacts to the environment. This is because these encompass environmental monitoring, watershed management, climate adaptation measures, ecosystem protection, sediment control, and environmental sustainability practices. Adopted environmental mitigation measures are expected to minimize the environmental disruption, and to make the project environmentally sustainable and acceptable to the stakeholders. Project performance was the dependent variable of this study. Schedule adherence, budget compliance, technical quality and stakeholder satisfaction were the four key indicators used to evaluate project performance. Schedule adherence is the ability to complete project activities on schedule. Budget Compliance is used to determine how well the project implementation is adhered to in respect to the allocated resources. Technical quality measures the adherence to engineering and operational standards, while the satisfaction of stakeholders evaluates how well stakeholders' perceptions and acceptance of the project's implementation and outcomes meet their expectations. The framework assumed that the project performance is positively affected as the result of the improvements of financial, technical, political, and environmental risk mitigating strategies. It is expected that these variables are directly related and interconnected. Weak financial risk management can impact technical implementation, and political instability can impact environmental management and stakeholder cooperation, for instance. It shows that in a large infrastructure project risk categories are linked together and therefore should not be considered individually.

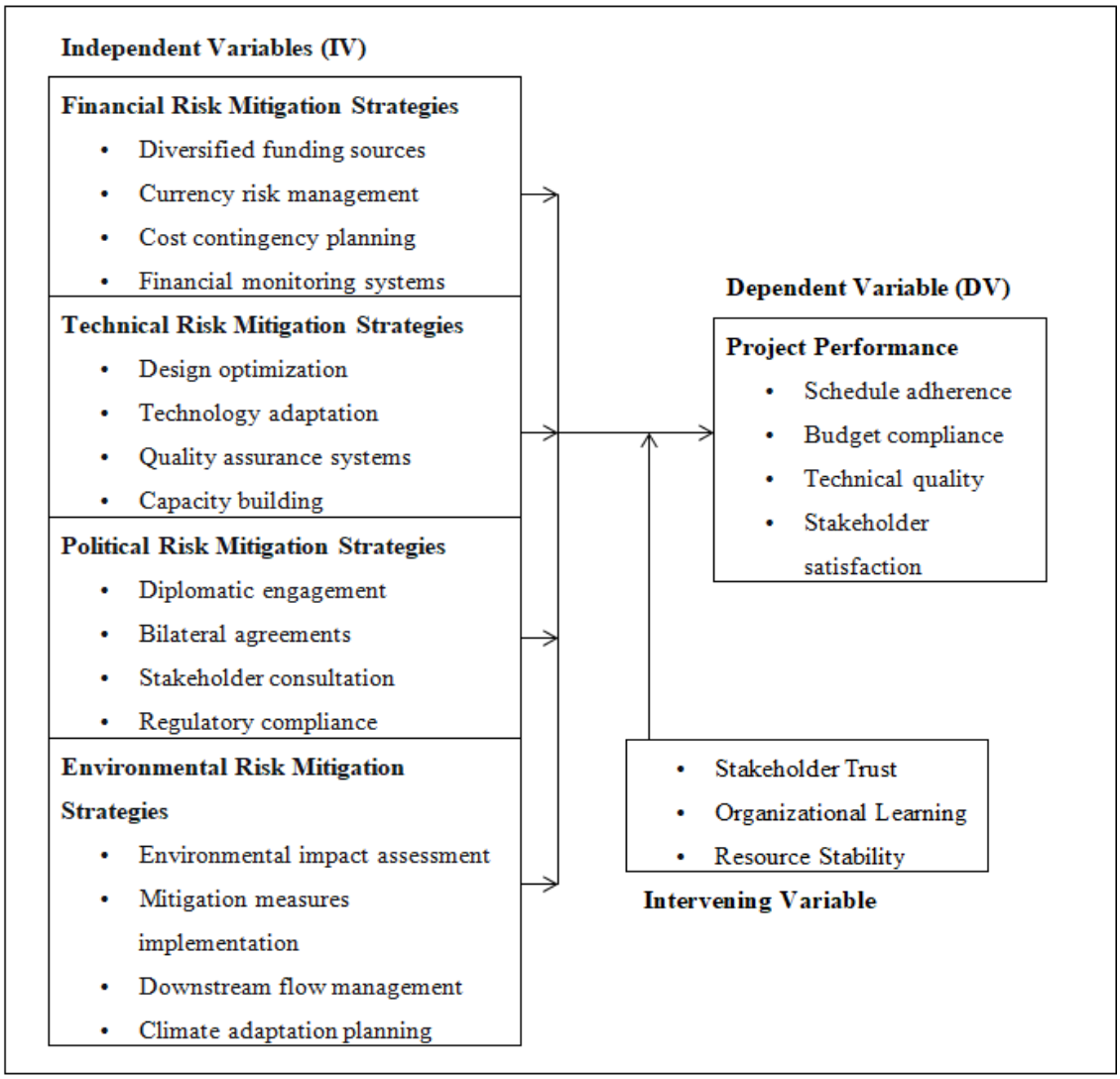


Figure 1: Conceptual Framework

1.10 Organization of the Study

This paper is divided into five different sections. The first section provides the introduction, background, problem identification, objectives, research questions, significance, need for the study, scope, limitations, and theoretical and conceptual framework. The second chapter covers related literature concerning the topic of risk management approaches and their effects on performance. Chapter Three details the research methodology, including research philosophy, design, target population, sampling procedures, data collection instruments, validity and reliability measures, data analysis techniques, and ethical considerations. Chapter Four presents the data analysis, findings, and interpretation. Chapter Five provides a summary of findings, conclusions, recommendations, limitations of the study, and suggestions for further research. The thesis concludes with references and appendices.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter reviews relevant literature on risk mitigation strategies and performance of large infrastructure projects. The chapter begins with an examination of the theoretical frameworks underpinning the study, followed by empirical review organized according to the study's objectives. The review synthesizes findings from previous studies, identifies gaps in existing knowledge, and establishes the foundation for the current research.

2.2 Theoretical Framework

This study is guided by three complementary theories that collectively provide a multilayered understanding of risk mitigation strategies and project performance in large infrastructure projects. The selection of three, rather than a single, theory is justified by the multidimensional nature of risk in mega-projects like the GERD, where financial, technical, political, and environmental risks interact across different levels of analysis.

Figure 1: Theoretical Framework

Theory	**Level of Analysis**	**Key Concepts**	**Application to Study**
Prospect Theory	Micro-level	Loss aversion, Reference dependence, Framing effects	Explains decision-making under uncertainty; risk prioritization; resource allocation for mitigation
Contingency Theory	Meso-level	Context-sensitivity, Adaptation, Fit	Explains why mitigation strategies must be adapted to Ethiopian context; institutional capacity; political environment
Stakeholder Theory	Macro-level	Stakeholder salience, Engagement, Legitimacy	Explains stakeholder-generated risks; political and social risk management; community engagement

Prospect Theory (Kahneman & Tversky, 1979; Barberis, 2013) explains that individuals make systematic deviations from rational choice assumptions when making decisions in the

face of uncertainty. Its core tenets are: reference dependence (losses are judged differently than equal gains, usually the latter are twice or two and a half times as large), loss aversion (diminishing sensitivity: the closer to the reference point, the less the impact of changes).

Prospect theory characterizes the choices that project risk decisions typically make when they differ from the maximization of expected utility in project risk management. De Camprieu et al. (2020) have shown systematic biases in risk perception and response among project managers and emphasized the importance of framing effects in the decision on mitigation measures. Abd El-Karim et al. (2021) have used prospect theory in construction projects: They found that where the perceived risk is catastrophic, even if very low, construction workers are likely to invest more heavily to minimize their losses, while they invest less in the higher probability, lower consequence risks. This trend presents important implications for the allocation of resources in risk management.

Prospect theory, in particular, comes handy for situations of high uncertainty, which characterizes decisions concerning large hydropower schemes like the one for GERD, due to the technical (large in scale), political (transboundary problems), economic (new approach to financing), and climatic uncertainties involved. According to the theory, early impressions of cost estimates, time estimates, and expected gains would affect future impressions, and the bigger the differences, the more pronounced the response.

The conceptualization of and measurement of financial risk mitigation strategies (Objective i) and technical risk mitigation strategies (Objective ii) are directly informed by prospect theory. Specifically, loss aversion suggests that project managers will tend to undertake disproportionate mitigation efforts for risks phrased as potential losses (e.g., catastrophic dam failure, cost overruns that would be unacceptable politically) and will invest less than their mitigation efforts would justify on the mitigation side of risks phrased as foregone gains (e.g., optimization opportunities, efficiency improvements). This prioritization was captured in the question items related to financial risk mitigation and technical risk mitigation in the study questionnaire. Additionally, prospect theory's notion of reference dependence explains the measurement of project performance of the project, since the satisfaction of the stakeholders was related to the outcome in comparison with the reference and not on the actual project performance.

Contingency Theory (Howell et al., 2020; Lawrence & Lorsch, 1967; Shenhar, 2001) shows that the best management practices are not universal and transferable and depend on the circumstances of the situation. Project management theory suggests that project management methods need to be flexible with the project characteristics such as technological uncertainty, system complexity, and project speed. The effectiveness of the risk management will vary systematically when it comes to the project context and what may work well in a routine, low-complexity project may not work in complex, unique projects that require adaptive approaches rather than formulaic ones to mitigate risk.

Howell et al. (2020) gave the project context contemporary empirical supporting data for contingency theory, in which the effectiveness of risk management is systematic across project context. Their research showed that there is a possibility of using mitigation strategies that have been proven effective in routine, low complexity projects that may be inappropriate or counterproductive in complex and unique projects where adaptive strategies are needed. Such a discovery is especially important for mega-projects, which by their very nature are high in complexity and uniqueness. Different contextual variables make infrastructure projects in developing countries have unique contingency requirements. Mwelu et al. (2021) compared risk management strategies for infrastructure projects in East Africa and discovered that while mitigating risk in developed countries is possible, it is not as straightforward in developing countries because of differences in institutional capacity, legal frameworks, contractor competence and political stability. They found that the assumption of universal best practices in project risk management is debunked and in favor of context-sensitive approaches.

The characteristics of the GERD project, i.e., unprecedented scale (the largest hydropower project in Africa), transboundary nature (with the downstream riparian states, Blue Nile), implementation in a developing country with limited experience in building large dams, and unique financing model (domestic bonds and public contributions without the need to obtain funding from international institutions), are evidence of the need for contingency-based analysis. Elements of good infrastructure in the European or North American context may not necessarily be translated into the Ethiopian context.

The justification for analysing political risk mitigation strategies (Objective iii) and environmental risk mitigation strategies (Objective iv) as context specific instead of universal is given by the contingency theory. The theory suggests that mitigation measures that work well in developed countries' infrastructure projects may not work for the GERD due to

developing country institutional environments, transnational water politics, inadequate domestic technical capacity, and a distinct financing structure. This is operationalized in the Ethiopian cultural context through the questions on whether adaptation of mitigation strategies was done in relation to local conditions. The key informant interviews focus particularly on the adaptations of imported risk management practices. The contingency framework also helps to interpret negative findings; for a strategy with weak association to performance, it may be because of misfit with contextual factors rather than because of an inherent ineffectiveness of the strategy itself.

Stakeholder Theory (Eskerod & Huemann, 2020; Freeman, 1984; Mitchell et al., 1997) states that project strategies should take into account not just the interests of the primary funders or agencies, but the interests of all stakeholders who have the potential to influence, or be influenced by, project activities. Stakeholder theory focuses on the importance of building relationships among the multiple stakeholder groups of a project having different forms of power, legitimacy and urgency within the project setting. Stakeholders with high power and legitimacy are given the greatest attention and those with high urgency potentially increase its priority even if they have low power.

Eskerod and Huemann (2020) showed that stakeholders risks are commonly disregarded in formal project risk registers, but are responsible for a high proportion of delays and cost overruns in political projects. Aaltonen and Kujala (2016) have extended stakeholder theory to major projects and found that stakeholder strategies and actions are also a risk that needs to be managed. Their work revealed that technical risks are often not the most significant risks to a project, especially for infrastructure projects that have a high social and environmental impact due to stakeholder generated risks (opposition, legal action, negative publicity, political intervention).

The GERD's stakeholders' environment is very complex. Stakeholder groups include Ethiopian government organisations (ministries, regulatory authorities, implementing agency Ethiopian Electric Power); international contractors and consultants (from Italy, China, Switzerland, among others); downstream riparian states (Sudan and Egypt, with divergent interests: Sudan has generally supported the project, while Egypt has expressed opposition); local communities in the reservoir area (Benishangul-Gumuz region, who are subject to displacement and changes in livelihoods); international financial institutions (although the project is financed domestically, the World Bank and African Development Bank have an indirect interest);

environmental advocacy organisations (national and international, raising concerns over the impacts to ecosystem and downstream flow); and regional bodies (Nile Basin Initiative, African Union). All stakeholder groups have their own interests, influence and risk potential for mitigation.

Political Risk Mitigation Strategies and project performance dimension of Stakeholder Satisfaction were directly informed by the stakeholder theory. The theory's use of the attributes of stakeholders (power, legitimacy and urgency) provides a focus for analysing who is driving risk prioritisation and who is satisfied with the project for perceived project success. The stakeholder framework also highlighted the intrinsic conflicts at stake when trying to measure satisfaction for a project with opposing stakeholder positions (Ethiopian beneficiaries vs. riparians downstream).

Theoretical Synthesis

All three theories are analytical in nature, operate at different levels and all three reinforce each other. Prospect theory provides insight into how individuals and small groups make decisions when making decisions under uncertainty; how project managers decide what risks to prioritize for mitigation, and how starting values anchor subsequent decisions. The explanation of the meso level of organizational fit is provided by the contingency theory. Stakeholder theory describes the macro-level relational dynamics and why the interests of different stakeholders can create political and social risks, and how they can only be mitigated by managing relationships, alongside technical or financial controls.

In order to be effective at risk mitigation in the GERD, alignment is needed on all three levels. Decision makers need to be aware of their own tendency to subjectively assess risk, through their own cognitive biases, for example loss aversion and reference dependence at the micro level. But at the meso-level, the mitigation measures need to be adjusted based on the institutional capacities, technical resources, and political environment that exist in Ethiopia, and not simply translated into so-called "best practices" from the international community. Mitigation needs to deal with the legitimate concerns of wide social groups at the macro level by engaging them in a transparent way, and adapting to them.

2.3 Empirical Review

2.3.1 Financial Risk Mitigation Strategies and Infrastructure Project Performance

Financial risks are basic in big-scale infrastructure projects and include access to funding, cost escalation, currency exchange risks and uncertainty of revenue. Yescombe (2014) highlighted particular financial risks associated with infrastructure projects because of their capital intensive nature, the length of time needed and the volatility of macro-economic factors. Financial risk mitigation requires holistic solutions that tackle various aspects of financial risk. Different methods for financial risk mitigation in infrastructure projects have been studied. Kumar et al. (2019) conducted a study of 45 infrastructure projects in India, and determined that the probability of cost overruns was significantly reduced with diversified funding sources. Projects that used more than one financing instrument – such as multilateral development bank loans, export credit agency financing, and domestic bond financing – were more resilient to funding disruptions than projects with a single source. According to the study, diversified financing led to a 23% reduction in the cost overrun in magnitude on average.

Volatility of local currency against major international currencies, which can significantly drive up project costs, is a unique risk among infrastructure projects in developing countries. Okpara and Nwachukwu (2020) studied the role of natural hedging (involving local procurement and generating local currency revenue) and financial hedging (forward contracts and currency swaps) in mitigating currency risk in Nigerian infrastructure projects, and their results indicated that both measures helped to limit exposure to the exchange rate, with the former being more effective than the latter. The overall currency risk strategy projects had a 18% lower escalation rate than the projects without comprehensive currency risk strategy. Another financial risk management strategy, which is essential, is cost contingency planning. Contingency determination should be based on risk analysis rather than percentages, the Project Management Institute (2021) suggests. Love et al. (2020) analysed 67 projects from Australia and determined that projects that used probabilistic contingency estimation had cost overruns 31% less than those using deterministic method of estimating. The study highlighted the need to manage the contingency dynamically and continuously revisiting and adjusting it according to the changing dynamics of project risks.

Financial monitoring systems are effective to identify potential financial risks early on and taken action when needed. As mentioned by Hwang et al., (2021), the construction projects that have basic financial monitoring practices have cost variance of 15% while those with integrated financial control practices have 6% on average. Financial risks are especially relevant for hydropower projects where the initial capital investment is relatively large, and construction can take a long time, with the income also being uncertain during operation. Kibria (2021) analyzed the financial risk mitigation in South Asian hydropower development and

concluded that reduction in the financing costs for PPCP projects could be achieved with government guarantees, but that contingent liabilities would need to be managed carefully. The financial risk mitigation was highlighted as a key component in tackling both construction phase risks (cost and delay) and operational phase risks (hydrological variability and electricity market dynamics).

The financial experience of the Grand Ethiopian Renaissance Dam is an example. The project's financing model which was based mainly on domestic resources with the support of public bond and state enterprises' contributions was an innovative approach to address the scarcity of international financing (Tawfik, 2021). This also built its own momentum of exposure to domestic economic conditions and political will for continuity of funding. Project performance and the relationship between these financial risk mitigation techniques is a key objective of this study to understand.

2.3.2 Technical Risk Mitigation Strategies and Infrastructure Project Performance

Technical risks associated with major infrastructure projects include design uncertainty, construction issues, technology performance, and quality assurance. Chapman and Ward (2011) stressed the need for technical risk mitigation to involve engineering knowledge, quality management systems, and adaptive strategies to deal with the new technical challenges. Design optimization is a basic technical risk-mitigation process. Design decisions set the technical baseline for the project and have major impact on other risks associated with constructability, cost and performance. The study by Sanchez et al. (2019) analyzed the design practices used in the design of European infrastructure projects and showed that 28% of the infrastructure projects that used value engineering and design review processes had fewer technical changes during construction than projects that did not use design optimization. The study highlighted that in the case of design risk mitigation, the innovation approach needs to be balanced with proven methods, especially for projects with unique characteristics.

Adapting and innovating technology to infrastructure projects comes with opportunities and risks. Davies et al. (2020) analyzed technology failures in large-scale infrastructure projects and identified that systematic assessment of technologies, prototyping and a phased implementation approach decreased technology failures. The technical issues and delays with projects introducing new untested technologies were particularly high. Quality assurance systems are part of the systems used for technical risk mitigation throughout project implementation. The International Organization for Standardization (ISO) 9001 framework

offers structured approaches for quality management which can be used on construction projects. To study the quality management in Australian infrastructure projects, Love et al. (2019) used a sample of 100 projects to compare projects with extensive quality assurance systems, which conducted regular inspections, testing protocols and non-conformance reporting, with projects that did not have such quality systems.Love et al. (2019) investigated a sample of 100 projects, with those projects that have comprehensive quality assurance systems (including regular inspections, testing protocols, and non-conformance reporting) compared to those projects that do not have such quality systems, to examine the quality management of Australian infrastructure.

Capacity building mitigates technical risks due to lack of local expertise for complex infrastructure development. The study by Mwelu et al. (2021) revealed that technical capacity was a significant factor in East African infrastructure projects with knowledge transfer programs, technical partnerships with foreign companies, and targeted training all contributing to a great extent in minimizing technical implementation issues. Projects with a focus on local capacity building were more likely to be able to solve technical issues on their own.

Technical risks associated with the construction of dams are foundation conditions, material characteristics, hydrological uncertainty and construction methods. Kumar & Katoch (2020) explored technical risk mitigation in hydropower projects in India, identifying detailed geotechnical investigation, adaptive design solutions and construction quality control to have a negative relationship with technical problems. It was noted that technical risk mitigation must be integrated and implemented in all project phases, including feasibility and detailed design and construction supervision. The GERD's technical difficulties are outstanding, with the maximum amount of RCC volume in the dam in the world and difficult foundation conditions (Ethiopian Electric Power, 2022). International design review, adaptation of construction methods to local conditions, and a comprehensive quality assurance program have been some of the technical risk mitigation measures taken. The relationships between these technical risk mitigation measures and project performance outcomes were examined.

2.3.3 Political Risk Mitigation Strategies and Infrastructure Project Performance

Infrastructure risks include policy changes, regulatory uncertainty, geopolitical tensions and conflicts with stakeholders. Alon and Herbert (2009) have found that political risks can be more relevant than commercial risks, especially in international infrastructure initiatives, especially those dealing with natural resources or impacts across borders.

One option to reduce political risks in important international projects is to engage in diplomacy. Leb (2020) explored diplomatic measures for transboundary water infrastructure, concluding that long-term high-level interactions, technical working groups, and confidence-building measures helped to reduce risks. The study highlighted the need for ongoing diplomacy rather than ad hoc, or one-off, diplomacy: for relationship maintenance as well as for formal agreement negotiation. Political risks can be managed through either bilateral or multilateral agreements which set out commitments and dispute resolution procedures in a codified manner. Yihdego et al. (2020) assessed the Agreement of Declaration of Principles between Ethiopia, Sudan and Egypt on GERD and concluded that although the agreement set out key principles, there were challenges to implementation. The research emphasised that political risks cannot be eradicated through agreements only, but with the interventions of effective implementation systems and continued cooperation.

Domestic legal and policy configurations constitute the political risks covered by regulatory compliance. Projects for infrastructure developments have to pass through a complex set of regulatory processes, including environmental approval, land acquisition, permits and licenses. Ofori-Kuragu et al. (2020) conducted a study on regulatory risk in infrastructure in West Africa, which revealed that proactive regulatory engagement, comprehensive compliance systems and early consultation with stakeholders lowered infrastructure construction delays caused by regulatory processes. Political risks from impacted communities and interest groups are covered in stakeholder consultation and engagement. Aaltonen and Kujala (2016) showed that the process of identifying, analysing and engaging stakeholders systematically can help minimise threats to opposition and create project legitimacy. Projects with comprehensive stakeholder engagement programs saw the least delays related to protests or lawsuits as compared to projects with limited engagement.

Political risks increase when dealing with transboundary water infrastructure, as there may be several sovereign states with competing interests. Cascão and Nicol (2021) looked at the politics behind Nile Basin infrastructure, concluding that collaborative agreements, sharing of data and common technical assessments help reduce risk. The study highlighted the need to find a balance between national interests and imperative for regional cooperation in political risk mitigation.

The political environment of the GERD has been especially complicated, with negotiations that have been lengthy between the riparian states, and with international attention. Ethiopia's

political risk mitigation has involved entering into diplomatic engagement at various levels, joining Nile Basin Initiative processes, and bilateral negotiations resulting in the 2015 Declaration of Principles (Tawfik, 2021). Awareness of the correlation between these political risk mitigations and project performance is a key goal of this research.

2.3.4 Environmental Risk Mitigation Strategies and Infrastructure Project Performance

Environmental risks in large-scale infrastructure include ecological effects, cumulative effects, climate change and regulatory obligations. Sanchez et al. (2017) highlighted that environmental risk mitigation has shifted from compliance to integrated environmental management in project life cycles.

Environmental impact assessment (EIA) is the basic instrument for mitigation and prevention of environmental risks. Morgan (2012) summarised the history of EIA practice, highlighting that assessment should cover issues of importance, anticipate the scale and nature of impacts and develop mitigation measures. Glasson et al. (2020) reviewed the effectiveness of EIA in the UK's infrastructure development and reported that projects that had a follow-up programme and a full EIA were less likely to have environmental compliance issues during realization.

Implementation of mitigation measures is the conversion of assessment results into actionable measures. The WCD (2000) recognized that there are several environmental dimensions of large dam projects that need to be addressed, such as flow regime alteration, water quality, aquatic ecosystems, and effects on terrestrial habitats. The key to success is on technical aspects, on resources available to implement these measures, and on monitoring to check the impacts of these measures. Flow management downstream of dams is an important environmental issue in transboundary river development. Kibria (2021) looked at the provisions of environmental flow in dam projects in South Asia, and concluded that projects with scientifically-based flow requirements had less downstream conflict, and better aquatic ecosystem outcomes. The study highlighted the need to achieve a balance between hydropower production and water requirements downstream when managing environmental flows.

Climate adaptation planning involves planning to adapt to climate variability and change, and to account for the interaction between infrastructure projects and climate variation and change. UNESCO (2020) emphasised the following climate-related risks to large dams: hydrological regime changes, higher flood frequency, sedimentation changes. Mitigation measures include using climate information in design, adaptive operational rules, and watershed management for

increasing resilience. Environmental risk mitigation for the GERD has included extensive environmental and social impact assessment, environmental management plans, and continued monitoring programmes. Sanchez et al. (2021) commented that the environmental mitigation for the project includes impacts to reservoir area, impacts to downstream flows, and impacts to the watershed. But effectiveness of implementation and its relation to project performance needs a systematic investigation.

The interdependency of environmental, technical and political risks becomes visible in the case of large-scale dam projects. Political opposition can arise due to environmental concerns, technical solutions can have environmental impacts, environmental mitigation can impact project costs and schedule. In this study, these interconnections are acknowledged, and the environmental dimension of risk mitigation is discussed, along with the other dimensions of risk.

2.3.5 Performance of Large Infrastructure Projects

Conceptualisation and measurement of project performance has come a long way in project management literature. Traditional models focused on the "iron triangle" comprising time, cost and quality (Atkinson, 1999); and current models include stakeholder satisfaction, strategic alignment and sustainability outcomes (Ika, 2020).

The study of the performance of schedules in large infrastructure projects has been given a great deal of research interest. Flyvbjerg (2017) investigated 258 infrastructure projects in 20 countries and discovered the average cost overruns of 44% and schedule delays of 90% over planned time, with 90% of projects seeing delays of even more than 50%. The study confirmed all the measures identified in the literature with schedule variance and they were of a positive relationship between the measures. Love et al. (2020) discovered that the schedule performance is correlated with the effectiveness of risk management; projects that conducted detailed risk mitigation, had a schedule adherence within 10% of the schedule plan, while projects with limited risk management had a schedule adherence of 30%+ from the plan. One project success criterion that is important and has a direct impact on stakeholders is cost performance. The World Bank (2021) reported that cost overruns in infrastructure projects in developing countries are on average 40%, and hydropower projects have the highest standard deviation. Kumar et al. (2019) concluded that there is a relationship between cost performance and financial risk mitigation, technical uncertainties, and political stability, which indicates that the cost outcomes measure the effectiveness of integrated risk management.

Technical quality refers to the meeting of specifications, absence of faults and the characteristics of performance over time. Love et al. (2019) explored the quality outcomes in the infrastructure, which showed that quality performance is linked to design quality, construction supervision effectiveness and quality assurance systems. Projects that have strong quality management had defect rates 35-50% lower than projects with only limited quality management. A new performance dimension has been identified as stakeholder satisfaction, as a necessary requirement for a project to be accepted and perceived as successful, technical effectiveness is not sufficient. Aaltonen and Kujala (2016) showed that satisfaction with the project also depends on the level of engagement, how the concerns of stakeholders are addressed and how the project decisions are seen as fair. However, in the case of large-scale projects involving a wide range of stakeholders, it is necessary to pay attention to the diverse groups of stakeholders and their different criteria of satisfaction.

These are the various aspects of the GERD's performance evaluation. The timing of performance is based on the project's phased implementation plan, with first power generation expected in 2022 and the project expected to be complete in subsequent years. Cost performance is a measure of management of the US$4+ billion budget within the confines of domestic financial resources. Technical quality includes the standard of the engineering, quality of construction, and reliability of operation. Stakeholder satisfaction includes beneficiaries in Ethiopia, downstream riparians, international partners and affected communities. This research explored relationships between risk mitigation strategies and these multiple dimensions of performance.

2.3.6 Hydropower Project-Specific Risks

Large hydropower projects have unique risk characteristics that require unique consideration above and beyond the general risks of infrastructure. The need for dam safety is the highest standards of construction quality and constant monitoring because the consequences of dam failure can be catastrophic such as downstream flooding, loss of life, and economic devastation (ICOLD, 2020). One of Africa's biggest hydropower projects, the Grand Ethiopian Renaissance Dam (GERD), is a project where safety is a key concern. Mitigation measures that should be implemented are independent design reviews, comprehensive instrumentation systems to monitor the dam structures and foundations and strong emergency preparedness and response plans.

Another major risk in large hydropower projects is sedimentation management, where sedimentation loadings slowly decrease the amount of storage in the reservoir, and hence the availability of power generation is decreased, with project life being shortened. Morris and Fan (2018) have reported that sedimentation is responsible for the loss of reservoir storage worldwide at an average rate of 1 percent per year, but in more sediment-rich river systems the loss is greater. Watershed management programs designed to minimize soil erosion and sediment input through reforestation and erosion control works and works on check dams are common mitigation measures. Other controls involve flushing the reservoirs and design of the projects to include sediment bypass facilities. Sedimentation management is a major long-term operational risk for the GERD, which is on the Blue Nile River, the largest sediment-laden river in the world.

Large dam projects have other important categories of risk: resettlement and social impacts, as reservoir inundation can displace local populations. Historically, dam-induced displacement has been associated with threats to land tenure, employment, housing, security of food supply, social marginalization and other risks (The World Commission on Dams, 2000). Comprehensive resettlement planning, such as providing proper compensation, replacement land or housing, livelihood restoration programs, and meaningful community involvement throughout the resettlement process, is essential for effective mitigation. Social risk mitigation became an important aspect of project implementation and management where communities were displaced from the affected area due to the development of reservoir for the GERD.

The uncertainty of hydrology adds both planning and operating risks and climate change compounds these risks. UNESCO (2020) highlighted that altering precipitation patterns, river flow regimes, extreme weather events and flooding/droughts can impact the capacity for hydropower production and dam safety. This means that climate adaptation measures should be incorporated into project design and planning of its operational phases. These include the provision of a sufficient spillway capacity, flexible water-intake facilities, adaptive water-reservoir operating rules and drought management plans. An awareness of the consequences of climate variability and climate change is still crucial to the sustainability and proper risk management of the GERD.

2.4 Research Gap

Based on the literature review, six important gaps were identified which this research filled.

Table 1: Research Gaps and How the Study Addresses Them

Gap Identified	Evidence from Literature (with Critique)	How This Study Addressed the Gap
Geographic concentration in high-income countries	Sanchez et al. (2019), Klemetti (2020), and Love et al. (2020) limited their studies to Europe, North America and Australia. Their findings have often been interpreted as generalizable without empirical testing in developing-country contexts with weaker institutions, different risk profiles and distinct stakeholder configurations.	Examined risk mitigation in the Ethiopian and African context characterized by limitations in institutional capacity, specific political-economic conditions and limited technical resources. Results indicated which findings from high-income country contexts were transferable and which required contextual adaptation.
Single-risk focus rather than integrated analysis	Studies focused on single risk categories: financial (Yescombe, 2014; Kumar et al., 2019), technical (Chapman & Ward, 2011; Sanchez et al., 2019), political (Alon & Herbert, 2009; Aaltonen & Kujala, 2016) and environmental (Sanchez et al., 2017; Kibria, 2021) in isolation. This ignored the interdependencies between risk categories in complex projects.	Analyzed four risk mitigation strategies (financial, technical, political, and environmental) within a single analytical framework, examining their individual and combined influence on project performance.
Limited African empirical evidence	Ofori-Kuragu et al. (2020) and Mwelu et al. (2021) conducted studies in West and East Africa, respectively, but there was a lack of in-depth studies specifically examining risk mitigation strategies across multiple dimensions in African megaprojects.	Provided empirical evidence on risk mitigation strategies in the largest hydropower project in Africa, contributing to the limited body of knowledge on African infrastructure risk management.
Lack of systematic study of GERD through project risk management lens	Existing GERD literature (Yihdego et al., 2020; Tawfik, 2021; Cascão & Nicol, 2021) focused on international law, diplomacy, and regional cooperation, treating the dam primarily as a geopolitical issue. Project management dimensions, including risk identification, mitigation implementation, and performance monitoring, remained largely unexplored in empirical research.	Offered systematic empirical evidence on the relationship between risk mitigation strategies and project performance in the GERD, filling the gap in project management research on this significant infrastructure project.
Hydropower-specific risks	Dam safety (ICOLD, 2020), sedimentation management (Morris & Fan, 2018),	Embedded hydropower-specific risks in a wider risk mitigation framework. Data collection focused

underexamined in integrated frameworks	resettlement (WCD, 2000) and hydrological uncertainty (UNESCO, 2020) were generally treated in discipline-specific literature, but seldom incorporated into comprehensive project risk management frameworks. This meant practitioners received piecemeal advice with little sense of priorities or alternatives.	particularly on the interplay of dam safety, sedimentation management, hydrological uncertainty and resettlement outcomes, using financial, technical, political and environmental mitigation strategies.
Limited theoretical integration	Generally, past studies employed one theoretical framework (prospect theory, contingency theory or stakeholder theory) and assumed that one level of analysis is sufficient implicitly. Consequently, theories often seemed to offer competing rather than complementary explanations.	Integrated prospect theory (Barberis, 2013), contingency theory (Howell et al., 2020), and stakeholder theory (Eskerod & Huemann, 2020) and showed how the three theories worked at different analytical levels and jointly explained risk mitigation effectiveness.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research methodology adopted to investigate the relationship between risk mitigation strategies and performance of the Grand Ethiopian Renaissance Dam project. The chapter discusses research philosophy, research strategy, research design, sources of data, sampling procedures, research instruments, validity and reliability measures, data collection methods, data analysis techniques and ethical considerations.

3.2 Research Design

The type of the research used in this study was descriptive-correlational research. Descriptive design allowed for a systematic description of risk mitigation strategies used and project performance outcomes that were realized in the GERD. In this study correlational design was used to examine the relationships between the independent variables (risk mitigation strategies) and the dependent variable (project performance) without manipulating the variables (Creswell & Creswell, 2018).

The descriptive-correlational design was suitable for the study since it aimed to describe the current practice in mitigating risk in the GERD and to determine the statistical relationships between the risk mitigation practices and the performance indicators. The study also included elements of the case study in that it included a single case that was very rich in information, the GERD being the case studied. The case study approach allowed for a thorough understanding of context within which risk mitigation efforts and performance took place within a specific context (Yin, 2018).

3.3 Target Population

3.3.1 Study Population

The target population consisted of 320 professionals directly engaged in the Grand Ethiopian Renaissance Dam (GERD) project, such as the project managers, resident engineers, construction supervisors, quality assurance engineers, contract administrators, environmental and social safeguard specialists and senior officials from the Ethiopian Electric Power with direct oversight of project activities. This population had first-hand knowledge of risk mitigating strategies used and project performance results.

Table 2: Target Population

Category	**Number**
Project Managers	45
Engineers (civil, electrical, mechanical)	180

Construction Supervisors	60
Environmental and Social Safeguard Experts	20
Contract Administrators	15
Total	**320**

3.3.2 Study Area

In terms of geographic location, this study included Grand Ethiopian Renaissance Dam site on the Blue Nile River in Benishangul Gumuz region of Ethiopia, near the Sudan border, 20 to 40 km away. The data obtained at the dam site and Ethiopian Electric Power offices in Addis Ababa. The study included the construction phase of the dam, from 2011 to 2026. This fifteen-year period allows for the in-depth analysis of the risk mitigation throughout the project lifecycle.

3.3.3 Primary and Secondary Data Sources

Primary data was obtained from the respondents by the use of questionnaires and key informant interview. A questionnaire was completed by project managers and engineers and key informant interviews were carried out with senior officials who hold strategic oversight on risk mitigation. Project documents (progress reports, risk registers, meeting minutes), technical reports, environmental and social impact assessments, monitoring reports and publicly available information from Ethiopian Electric Power, Ministry of Water and Energy, and international sources were used as secondary data sources. Primary data was supplemented with document review and used to triangulate findings.

3.3.4 Unit of Analysis and Unit of Observation

The unit of analysis for this study was the individual project manager, engineer or official who gave the data. The statistical testing unit of analysis was the individual respondent since the study was conducted at individual level in terms of relationship between risk mitigation perceptions and performance assessment; the Grand Ethiopian Renaissance Dam (GERD) project was the case context. Aggregated analysis was used at project level on qualitative findings. The unit of observation was the individual project manager, engineer, or senior official who supplied the data on questionnaires and interviews.

3.4 Sampling Procedure

The study employed mixed sampling methods appropriate for the research design. Probability sampling was used for the quantitative survey to enable statistical generalization, while

purposive sampling was used for qualitative interviews to select information-rich key informants (Patton, 2015).

3.4.1 Sampling Technique

For quantitative data collection, stratified random sampling was employed. The population was stratified according to professional categories: project managers (n=45), engineers (n=180), construction supervisors (n=60), and other professionals (n=35). From each stratum, respondents were randomly selected proportionate to stratum size. For qualitative data collection, purposive sampling identified key informants possessing strategic knowledge of risk mitigation. Criteria for purposive selection included: (1) direct involvement in risk management decisions, (2) minimum five years' experience with the GERD project, and (3) position at managerial or senior technical level. Fifteen key informants were selected for in-depth interviews.

3.4.2 Sample Size Calculation for Quantitative Data

Sample size for the quantitative survey was determined using Yamane's formula (1967), which is widely used in social science research for determining sample size from finite populations when population variance is unknown. The formula assumes a 95% confidence level and a 5% margin of error. The calculation is as follows:

$n = N / (1 + N(e)^2)$

Where: n = sample size; N = population size (320); e = margin of error (0.05)

$n = 320 / (1 + 320(0.05)^2) = 320 / (1 + 0.8) = 320 / 1.8 = 178$

Thus, 178 is the required sample size. To account for anticipated non-response (typically 10-20% in survey research), an additional 10% was added to the distribution target: $178 + (178 \times 0.10) = 178 + 18 = 196$ questionnaires distributed.

Note: The sample for analysis is n=178 (minimum required), while 196 questionnaires were distributed to account for potential non-response and invalid responses.

Table 3: Sample Size Distribution

Stratum	Population	Proportion	Target Sample	Distributed

Project Managers	45	0.14	25	28
Engineers	180	0.56	100	110
Construction Supervisors	60	0.19	34	37
Other Professionals	35	0.11	19	21
Total	**320**	**1.00**	**178**	**196**

3.4.4 Sampling Technique for Qualitative Data

Purposive sampling was used to select key informants for qualitative interviews. This technique involved the intentional selection of individuals who possessed specialized knowledge relevant to the research objectives. The selection criteria for key informants included direct involvement in risk-related decisions, a minimum of five years of experience on the Grand Ethiopian Renaissance Dam project, and holding managerial or senior technical positions. Approximately 15 to 20 key informants were selected for in-depth interviews. This range was derived from the principle of data saturation, whereby additional interviews ceased to provide new information. Guest et al. (2006) found that saturation in qualitative interviews typically occurred within the first 12 interviews, while Morse (2015) recommended 20 to 30 interviews for grounded theory studies. For this study, which focused on a specific group of knowledgeable informants, 15 interviews were considered sufficient to achieve saturation.

3.5 Research Instruments

3.5.1 Questionnaires

A structured questionnaire was developed to collect quantitative data on risk mitigation strategies and project performance. The questionnaire comprised five sections:

Section A: Demographic information (respondent characteristics including professional category, years of experience, education level)

Section B: Financial risk mitigation strategies (items measuring diversified funding, currency risk management, cost contingency planning, financial monitoring systems) using a 5-point Likert scale (1=Strongly Disagree to 5=Strongly Agree)

Section C: Technical risk mitigation strategies (items measuring design optimization, technology adaptation, quality assurance systems, capacity building) using 5-point Likert scale

Section D: Political risk mitigation strategies (items measuring diplomatic engagement, bilateral agreements, stakeholder consultation, regulatory compliance) using 5-point Likert scale

Section E: Environmental risk mitigation strategies (items measuring EIA implementation, mitigation measures, downstream flow management, climate adaptation) using 5-point Likert scale

Section F: Project performance (items measuring schedule adherence, budget compliance, technical quality, stakeholder satisfaction) using 5-point Likert scale

The questionnaire was developed based on literature review and adapted to the GERD context. Appendix II presents the final questionnaire.

3.5.2 Key Informant Interview Guide

A semi-structured interview guide was developed for qualitative data collection. The guide addressed:

- Overview of risk mitigation approach in the GERD
- Financial risk mitigation strategies and perceived effectiveness
- Technical risk mitigation strategies and implementation challenges
- Political risk mitigation strategies and stakeholder dynamics
- Environmental risk mitigation strategies and outcomes
- Perceptions of project performance and factors influencing performance
- Lessons learned and recommendations for future projects

The interview guide enabled flexible exploration of topics while ensuring consistent coverage across informants. Appendix III presents the interview guide.

3.5.3 Document Review Checklist

A document review checklist guided systematic extraction of information from project documents. The checklist addressed document type, date, risk mitigation information, performance information, and quality observations. Appendix IV presents the document review checklist.

3.6 Validity, Reliability and Objectivity

3.6.1 Validity of Quantitative Instruments

Content validity was obtained by a thorough literature search and instrument review by experts. The questionnaire was checked by two research supervisors and three experts on project management who did not have any involvement in the Grand Ethiopian Renaissance Dam project. These experts evaluated the representation of the constructs being measured (financial, technical, political and environmental risk mitigation and project performance dimensions). They gave feedback that helped refine the instruments before pilot testing. The exploratory factor analysis was used to assess the construct validity. This statistical approach validated that the items in the questionnaire were loaded on the desired constructs. All items that had factor loadings under 0.40 were considered for deletion/revision. Constructs that had theoretically similar relationships were used for convergent validity and constructs that were theoretically different for discriminant validity. Face validity was checked by five members of the staff of the grand Ethiopian renaissance dam project who were not part of the main sample. They read the questionnaire for clarity, relevance and comprehensibility. Wordings and formatting were amended based on their feedback before pilot testing.

3.6.2 Reliability of Quantitative Instruments

Cronbach's alpha coefficient was used to check the internal consistency reliability for each scale. Nunnally and Bernstein (1994) state that an acceptable level of alpha for new research instruments is 0.70. The reliability of each scale was evaluated independently: financial risk mitigation (8 items), technical risk mitigation (8 items), political risk mitigation (8 items), environmental risk mitigation (8 items) and project performance (11 items). Items with alpha coefficients < 0.70 were studied to determine if there were problematic items that were deleted or revised as needed.

Table 4: Cronbach's alpha coefficient

Scale	Number of Items	Acceptable Threshold
Financial risk mitigation	8	$\alpha \geq 0.70$
Technical risk mitigation	8	$\alpha \geq 0.70$
Political risk mitigation	8	$\alpha \geq 0.70$
Environmental risk mitigation	8	$\alpha \geq 0.70$
Project performance	11	$\alpha \geq 0.70$

The test-retest reliability was tested by asking a subsample of 20 (around 10 percent) of the respondents to fill out the questionnaire twice, two weeks apart. Pearson's correlation

coefficient was used to determine the correlation between the two administrations. Temporal stability was considered acceptable if the correlation coefficient was equal to or greater than 0.70.

3.6.3 Pilot Testing

Sample Size for Pilot: Following the 10% rule (Connelly, 2008), the pilot study was conducted with 10% of the main sample, equivalent to 20 respondents (196 × 0.10 = 19.6, rounded to 20). Pilot Study Procedures:

1. Twenty respondents were selected from the target population who were not included in the main study.
2. The questionnaire was administered under conditions identical to those of the main study.
3. The following aspects were assessed:
   • Clarity and comprehensibility of each item
   • Time required for completion (target: 20–25 minutes)
   • Functioning of data collection procedures
   • Preliminary reliability (Cronbach's alpha)
4. The instruments were refined based on pilot findings prior to the main data collection.

3.7 Data Collection Methods / Procedures

Data was collected sequentially in phases. Ethical Clearance was obtained from CUEA Research Ethics Review Committee first. Second, permission was granted to access respondents and project documents from Ethiopian Electric Power. Third, 15 key informant interviews were scheduled at the convenience of the key informants and lasted between 60-90 minutes. Interviews were tape-recorded with consent and transcribed for analysis.

Fourth, questionnaires were given to sampled respondents. The questionnaires were given out on site (when this was possible) or delivered online to those responding remotely. An information sheet, detailing the purpose of the study, confidentiality protections, and voluntary participation was attached to each questionnaire. Reminders were mailed at 1-week and 2-week intervals to achieve a high response rate. Fifthly, the document review was carried out, and relevant information was obtained from the available project documents through the document review checklist. Data collection lasted for 8 weeks, from March-April 2026.

3.8 Data Analysis

3.8.1 Quantitative Data Analysis

Quantitative data were analyzed using SPSS version 26. Analysis proceeded in stages:

Descriptive Statistics: Frequencies, percentages, means, and standard deviations summarized respondent characteristics and responses to questionnaire items. Mean scores for each risk mitigation strategy and performance indicators were calculated.

Inferential Statistics: Pearson's product-moment correlation coefficient examined bivariate relationships between each risk mitigation strategy and project performance. Correlation strength was interpreted as: r = 0.10 - 0.29 (weak), 0.30 - 0.49 (moderate), 0.50 - 1.00 (strong). Multiple regression analysis examined combined effects of risk mitigation strategies on project performance. The regression model was:

$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \varepsilon$

Where:

Y = Project performance

X_1 = Financial risk mitigation

X_2 = Technical risk mitigation

X_3 = Political risk mitigation

X_4 = Environmental risk mitigation

β_0 = Constant

β_1 - β_4 = Regression coefficients

ε = Error term

Inferential statistics included t-tests for individual predictors and F-test for overall model significance, with $\alpha = 0.05$.

3.8.2 Qualitative Data Analysis

Qualitative data from interviews were analyzed using thematic analysis following Braun and Clarke's (2021) six-phase framework:

1 Familiarization with data through reading and re-reading transcripts

2 Generating initial codes identifying relevant content

3 Searching for themes by grouping codes into potential themes

4 Reviewing themes against coded extracts and full dataset

5 Defining and naming themes with clear specifications

6 Producing the report with illustrative quotations

Thematic analysis identified patterns in respondents' perspectives on risk mitigation strategies, implementation experiences, and perceived relationships with performance. Qualitative findings complemented quantitative results, providing depth of understanding regarding how and why risk mitigation related to performance in the GERD context.

3.9 Ethical Considerations

The ethical guidelines were observed in line with the Catholic University of Eastern Africa Research Ethics Review Committee. Before data collection, ethical clearance was sought from the Committee. It involved the research proposal, data collection tools, informed consent forms and a data management plan. All participants gave informed consent prior to data collection. A research information sheet was provided to each participant that explained the purpose of the study, the methods of the study, that participation was voluntary and that they could withdraw at any time without penalty, they would be protected in terms of confidentiality and anonymity, the data would be kept, and they would be informed who the researcher and supervisor would be to contact for any further questions. Consent forms were signed by participants acknowledging their consent to participate. Additionally, consent for audio recording was obtained for key informant interviews.

Several measures were implemented to ensure the privacy and confidentiality of the information. Questions were not made available on questionnaires, protecting anonymity. Data were reported in aggregate form, without being attributed to an individual. All participants in the interviews were anonymized by using pseudonyms, for example "Senior Official A". After transcription, audio recordings were discarded. Ethiopian Electric Power management was not provided with any individual responses. Data storage and disposal were done according to University policies. Electronic data were kept on password-protected computers with encrypted files and physical data were stored in locked cabinets in the researcher's office. Data were stored five years following the completion of the thesis, after which it was permanently deleted electronically and physically shredded. Only the researcher and academic supervisors were given access to the data.

Attempts to manage institutional pressure from the Ethiopian Electric Power, as a gatekeeper who was essential to gaining access to respondents and documents, were required, the researcher found. The researcher clearly communicated the independent academic nature of the research in writing. Respondents were assured that their individual responses would not be shared with management. Findings were presented in a positive way, in terms of what was learned, not what is wrong. The researcher was given the freedom of publishing the results

even if the institution preferred not to, and provided results to Ethiopian Electric Power as a courtesy. The researcher stated that he was not involved in any financial or personal conflict of interest in this study. The study was conducted for academic purposes and part of the requirement for a degree of Master of Arts in Project Planning and Management. Methods of data collection were planned to cause as little inconvenience and harm to participants as possible. There was no force or pressure on participants to participate. Each question used in the interviews was carefully designed to exclude questions that would have been personal in nature, and restricted to questions in relation to the work experiences. The study should not have intruded on project activities or stakeholder relationships, but was respectful to the project community. The study's findings have been disseminated to Ethiopian Electric Power and other relevant stakeholders in a user friendly format.

3.10 Limitations and Delimitations of the Study

This study acknowledged a number of methodological limitations. First, responses may have been influenced by social desirability bias, especially for politically sensitive topics. Respondents may have responded in a socially acceptable manner rather than according to their true views. This study addressed this by ensuring anonymity, handling data in a confidential manner and posing questions in a non-judgemental manner. Secondly, access to sensitive project documents was restricted. The Grand Ethiopian Renaissance Dam is politically sensitive, with some risk assessment reports, financial records, and diplomatic communication documents classified or restricted. So the data for the study was collected from the publicly available and approved documents of the Ethiopian Electric Power and document analysis was complemented with interview and survey data. Third, language barriers may also have affected the quality of data. The questionnaires and interviews were conducted in English, the working language of the project, but different levels of proficiency may have affected the understanding and accuracy of responses. To address this, terminology was explicitly defined and participants were encouraged to ask questions if needed.

The study was bounded to four dimensions of risk mitigation and four dimensions of performance. The study considered financial, technical, political and environmental risk mitigation strategies. Other risk categories such as social, legal and operational risks were excluded to ensure focus. Similarly, performance dimensions such as schedule adherence, budget compliance, technical quality and stakeholder satisfaction were studied, while other dimensions such as strategic alignment and sustainability outcomes were not included in the

study. Data was collected only from Ethiopian Electric Power due to lack of access to contractors and consultants. The study concerned the construction phase (2011–2026) and excluded the operational phase, which was not included in the scope of the research.

CHAPTER FOUR: DATA ANALYSIS, PRESENTATION, AND INTERPRETATION

4.1 Introduction

This chapter presents the analysis, presentation, and interpretation of data collected from the field. The chapter begins with the response rate, followed by demographic characteristics of respondents. Descriptive statistics for each study variable are then presented, followed by

inferential statistics including correlation and regression analyses to examine the relationships between the study variables. Qualitative findings from key informant interviews are integrated to provide depth and context to the quantitative results.

Before proceeding with the analysis, data cleaning procedures were undertaken to ensure data quality. This involved screening for missing values, checking for outliers using boxplots and z-scores (with values beyond ±3.29 considered for review), and verifying that all responses fell within acceptable ranges. Missing data were minimal (<3% per variable) and were addressed using listwise deletion for the regression analysis. Additionally, preliminary tests were conducted to verify that the data met the assumptions for parametric statistical tests.

4.2 Response Rate

A total of 196 questionnaires were distributed to the sampled respondents. Of these, 172 were returned, yielding a response rate of 87.8% (172/196). After screening for completeness and consistency, 5 questionnaires were deemed invalid due to incomplete responses. This resulted in 167 valid questionnaires, representing an 85.2% valid response rate (167/196).

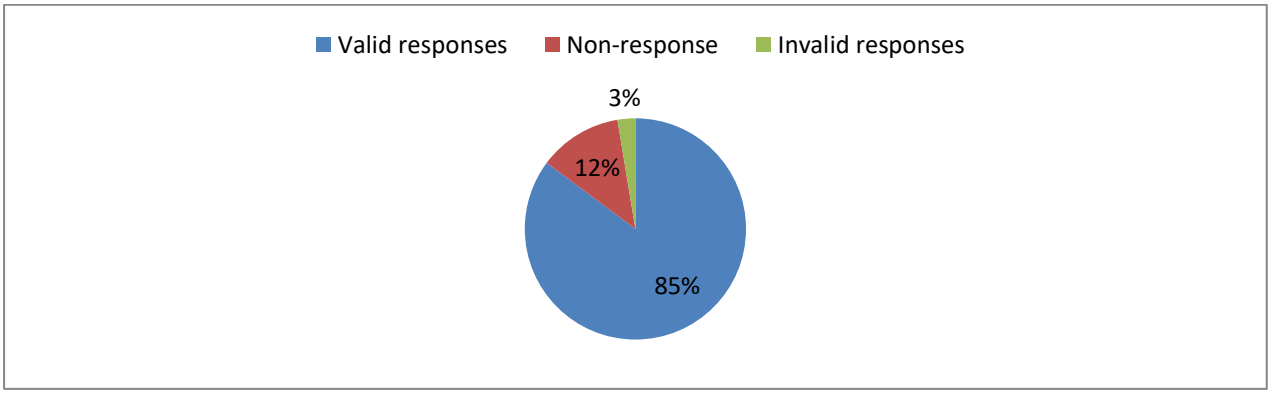
It is important to clarify the relationship between the calculated sample target and the actual valid responses obtained. Yamane's formula yielded a minimum target of 178 respondents. To account for anticipated non-response (typically 10-20% in survey research), an additional 10% was added, resulting in 196 questionnaires distributed. The 178 figure represents the minimum target, while 196 represents the number distributed to achieve that target. The actual valid responses (167) fall slightly short (6.2%) of the calculated target of 178. However, this represents a 93.8% attainment of the minimum sample target (167/178), which, combined with the high response rate (85.2%), provides sufficient statistical power for the analyses conducted (Cohen, 1988).

Table 5: Response Rate

Category	Frequency	Percentage
Questionnaires Distributed	196	100%
Questionnaires Returned	172	87.8%
Valid Questionnaires	167	85.2%
Invalid Questionnaires	5	2.6%
Non-response	24	12.2%

A brief explanation of the sample adequacy is warranted. Yamane's formula yielded a target sample size of 178. While the actual valid responses (167) fall slightly below this target, the difference is minimal (6.2%). In practical terms, this represents a 93.8% attainment of the target sample, which, combined with the high response rate, provides sufficient statistical power for the analyses conducted (Cohen, 1988). Additionally, the composition of respondents across professional categories closely mirrors the population distribution, enhancing representativeness.

Figure 2: Response Rate Distribution



4.3 Demographic Characteristics of Respondents

4.3.1 Professional Category

The study aimed to identify the professional categories of respondents to provide the spread of respondents across a wide range of roles in the GERD project. The distribution is given in Table 4.2.

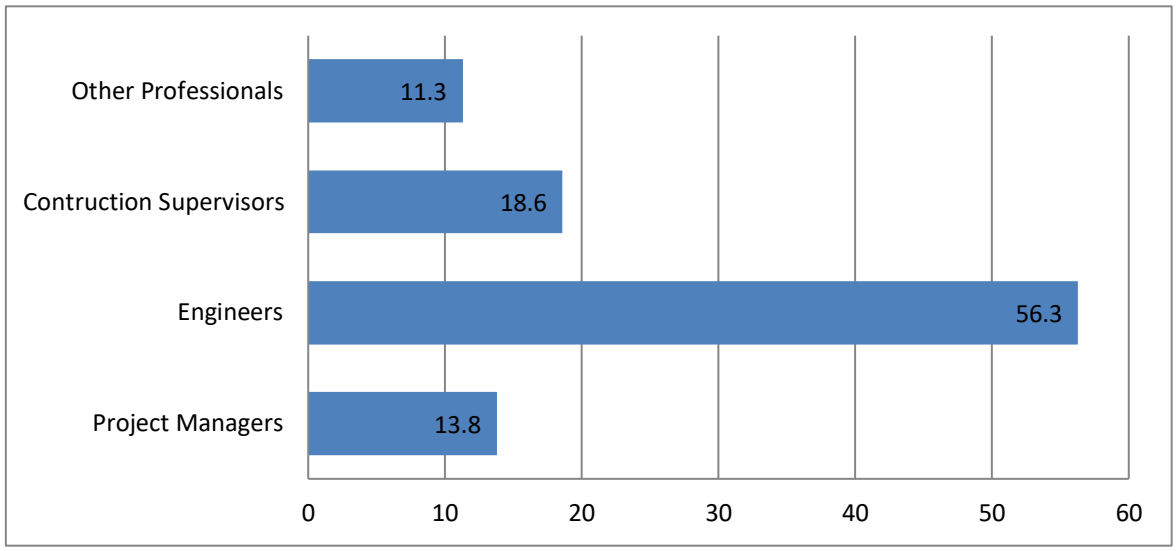
Table 6: Professional Category of Respondents

Professional Category	**Frequency**	**Percentage**
Project Managers	23	13.8%
Engineers	94	56.3%
Construction Supervisors	31	18.6%
Other Professionals	19	11.3%
Total	**167**	**100%**

The findings demonstrate that the largest group of individuals (56.3%) were engineers, followed by construction supervisors (18.6%), project managers (13.8%), and others (11.3%) such as environmental specialists, contract administrators, quality assurance officers, etc. This distribution is based on the technical aspect of the GERD project, meaning that the respondents

have the knowledge and experience of responding to questions regarding risk mitigation strategies.

Figure 3: Professional Category Distribution



4.3.2 Years of Experience with GERD Project

This was done to examine how familiar respondents were, throughout the period of the GERD project, with how the project is implemented and how they mitigated the risks over time.

Table 7: Years of Experience with GERD Project

Years of Experience	**Frequency**	**Percentage**
Less than 2 years	18	10.8%
2-5 years	42	25.1%
6-10 years	67	40.1%
More than 10 years	40	24.0%
Total	**167**	**100%**

Most respondents (64.1%) had over 6 years of experience of the GERD project, 40.1% had between 6 and 10 years, and 24.0% had over 10 years. It means that the majority of the respondents have been working since the early or middle stages of the construction phase and have a good knowledge of the risk mitigation tools that are used on the projects during the whole project cycle.

4.3.3 Educational Level

The respondents' academic backgrounds were evaluated to understand their educational qualifications in terms of project implementation, and risk management.

Table 8: Educational Level of Respondents

Educational Level	Frequency	Percentage
Diploma	15	9.0%
Bachelor's Degree	87	52.1%
Master's Degree	58	34.7%
PhD	7	4.2%
Total	**167**	**100%**

The results indicate that more than half of the respondents (52.1%) had a bachelor's degree, 34.7% had a master's degree, and 4.2% had a PhD. Only 9.0% had diploma qualifications. The high educational level (91% held Bachelor's degree or higher) contributes to high credibility of answers to technical and managerial issues concerning risk mitigation.

4.3.4 Area of Specialization

The areas of specialization of respondents were analysed to gain insight into the disciplinary viewpoints that were included.

Table 9: Area of Specialization

Area of Specialization	Frequency	Percentage
Civil Engineering	78	46.7%
Electrical/Mechanical Engineering	42	25.1%
Project Management	24	14.4%
Environmental/Social	15	9.0%
Other	8	4.8%
Total	**167**	**100%**

Civil engineers were the top specialization (46.7%), followed by electrical/mechanical engineers (25.1%), project managers (14.4%), environmental/social specialists (9.0%) and other (4.8%) including geologists and hydrologists. This distribution is representative of the multi-disciplinary nature of the construction of a large dam, and covers all aspects of the various dimensions of risk.

4.4 Descriptive Statistics for Study Variables

Means and standard deviations were calculated for descriptive statistics for each study variable. Mean scores were interpreted using the following scale: 1.00-1.80 (Very Low), 1.81-2.60 (Low), 2.61-3.40 (Moderate), 3.41-4.20 (High), 4.21-5.00 (Very High).

4.4.1 Financial Risk Mitigation Strategies

The first target aimed at analysing financial risk mitigation strategies used in the GERD project. Eight items were rated subjectively on a 5-point Likert scale by the respondents. The results are shown in Table 4.6.

Table 10: Descriptive Statistics for Financial Risk Mitigation Strategies

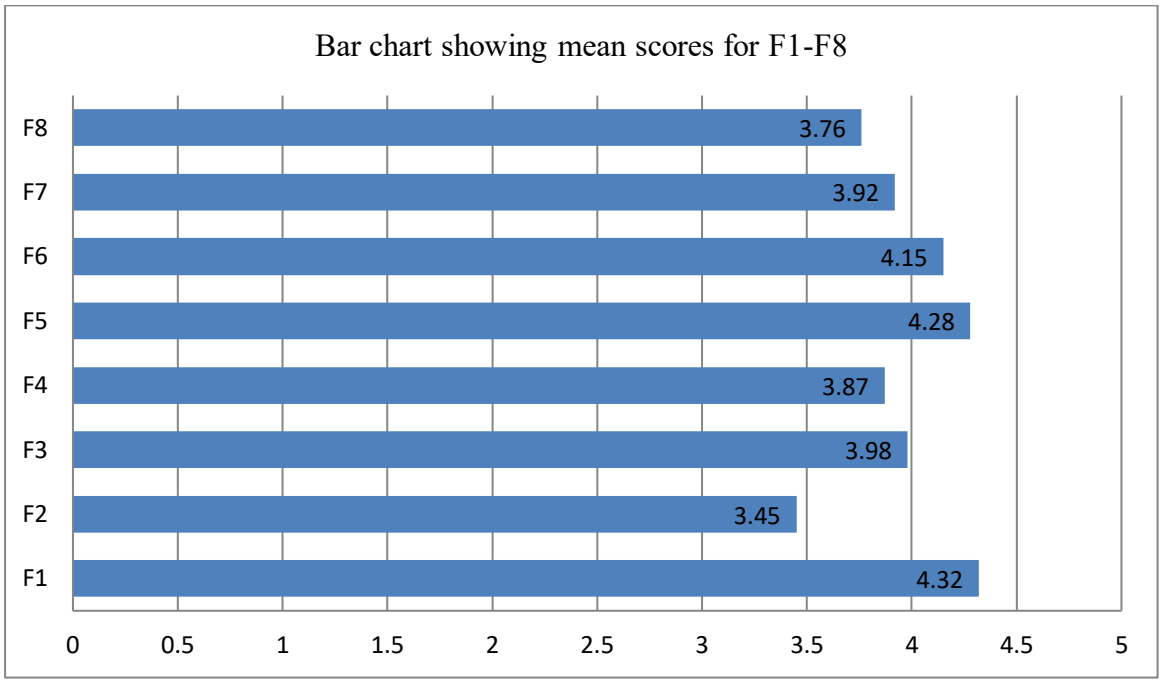
Code	Statement	Mean	Std. Dev.	SD %	D %	N %	A %	SA %	Interpretation
F1	The project utilized diversified funding sources	4.32	0.67	0	2	8	46	44	Very High
F2	Effective currency risk management strategies were implemented	3.45	0.82	8	18	25	35	14	High
F3	Adequate cost contingency was included in the project budget	3.98	0.71	0	10	20	42	28	High
F4	Contingency funds were managed and released based on risk assessments	3.87	0.76	2	12	22	40	24	High
F5	Regular financial monitoring and reporting systems were in place	4.28	0.63	0	2	10	46	42	Very High
F6	Financial risks were identified and updated throughout implementation	4.15	0.69	0	4	14	45	37	High
F7	The project had effective cost control mechanisms	3.92	0.74	0	8	24	42	26	High
F8	Financial decision-making was transparent and accountable	3.76	0.81	2	14	28	38	18	High
	Overall Mean	**3.97**	**0.73**						**High**

Note: *SD = Strongly Disagree; D = Disagree; N = Neutral; A = Agree; SA = Strongly Agree*

The overall financial risk mitigation strategy mean score was 3.97 (SD=0.73) and showed a high level of implementation. Both diversified funding sources (M=4.32) and regular financial monitoring systems (M=4.28) were rated very high. This is indicative of the innovative

financing model that the GERD is based on, using domestic resources and the significance of financial oversight. However, the lowest rating (M=3.45) was for currency risk management, implying difficulties in managing exchange rate risk in the absence of access to international hedging instruments.

Figure 4: Mean Scores for Financial Risk Mitigation Strategies



4.4.2 Technical Risk Mitigation Strategies

The second goal addressed technical risk mitigation measures that were used in the GERD project. The results are shown in table 4.7.

Table 11: Descriptive Statistics for Technical Risk Mitigation Strategies

Code	Statement	Mean	Std. Dev.	SD %	D %	N %	A %	SA %	Interpretation
T1	Comprehensive geotechnical investigations were conducted before construction	4.45	0.58	0.0	0.0	6.0	43.1	50.9	Very High
T2	Design was optimized to address site-specific conditions	4.38	0.62	0.0	1.2	7.8	44.3	46.7	Very High

T3	International design review was conducted to validate technical approaches	4.29	0.65	0.0	1.8	9.6	47.3	41.3	Very High
T4	Appropriate construction technology was selected for local conditions	4.12	0.71	0.0	3.6	16.2	46.1	34.1	High
T5	Technology was effectively adapted to address project challenges	4.08	0.73	0.0	4.2	19.2	44.3	32.3	High
T6	Comprehensive quality assurance systems were implemented	4.34	0.60	0.0	0.6	9.0	46.7	43.7	Very High
T7	Regular quality inspections and testing were conducted	4.41	0.57	0.0	0.6	6.6	44.3	48.5	Very High
T8	Capacity building programs enhanced local technical skills	3.89	0.78	1.2	10.2	28.1	38.9	21.6	High
	Overall Mean	**4.25**	**0.66**						**Very High**

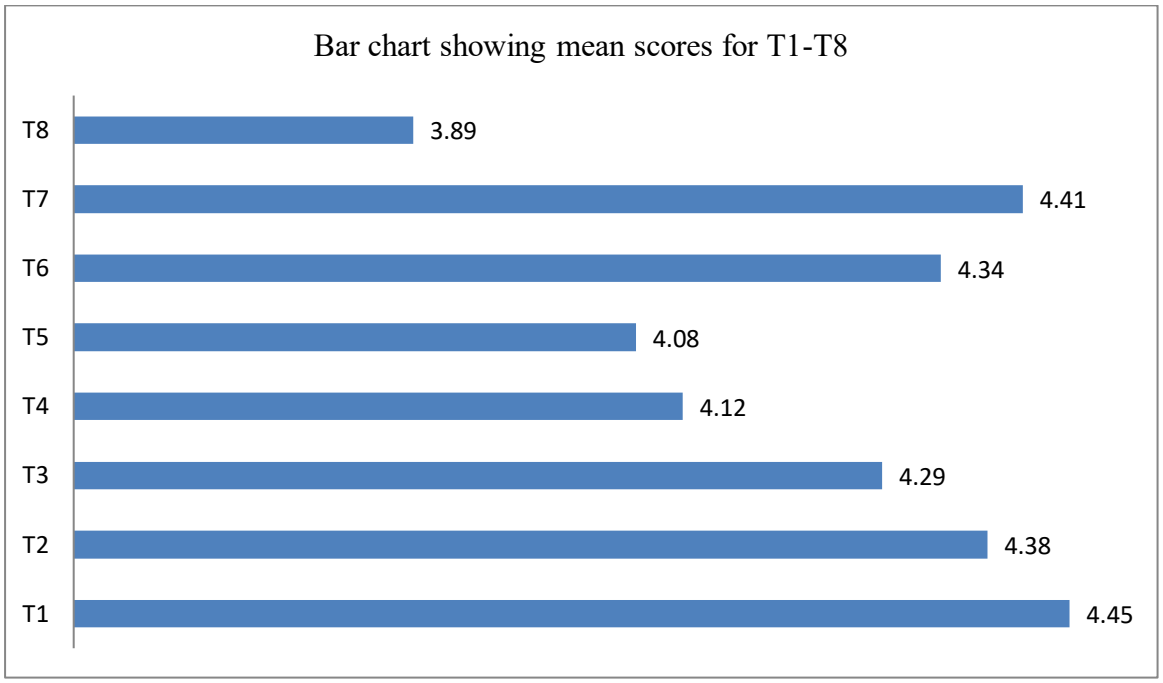
Note: SD = Strongly Disagree; D = Disagree; N = Neutral; A = Agree; SA = Strongly Agree

The overall mean score for technical risk mitigation strategies was 4.25 (SD=0.66) which was very high. This was the most highly rated category for risk mitigation, as the project focused on technical aspects. Comprehensive geotechnical investigations (M=4.45), regular quality inspection (M=4.41) and design optimization (M=4.38) were rated very high, with the highest rating. The lowest rating was for capacity building programs (M=3.89), which implies that technical systems were good, but there may be a need to look at local skills development more carefully.

The results are consistent with the work of Ethiopian Electric Power (2022), who documented the technical steps taken in the design of the GERD, such as thorough site surveys and even

international design reviews. Both quality assurance (M=4.34) and inspections (M=4.41) have very high ratings suggesting attention is systematic to the quality of the construction, which supports the results found by Love et al. (2019), who show that good quality management reduces technical problems.

Figure 5: Mean Scores for Technical Risk Mitigation Strategies



4.4.3 Political Risk Mitigation Strategies

The third goal investigated political risk mitigation measures used in the GERD project. The results are given in Table 4.8.

Table 12: Descriptive Statistics for Political Risk Mitigation Strategies

Code	Statement	Mean	Std. Dev.	SD %	D %	N %	A %	SA %	Interpretation
P1	High-level diplomatic engagement was maintained with downstream countries	4.18	0.70	0.0	2.4	15.0	43.1	39.5	High
P2	Bilateral agreements provided frameworks for cooperation	4.23	0.68	0.0	1.8	13.2	44.3	40.7	Very High

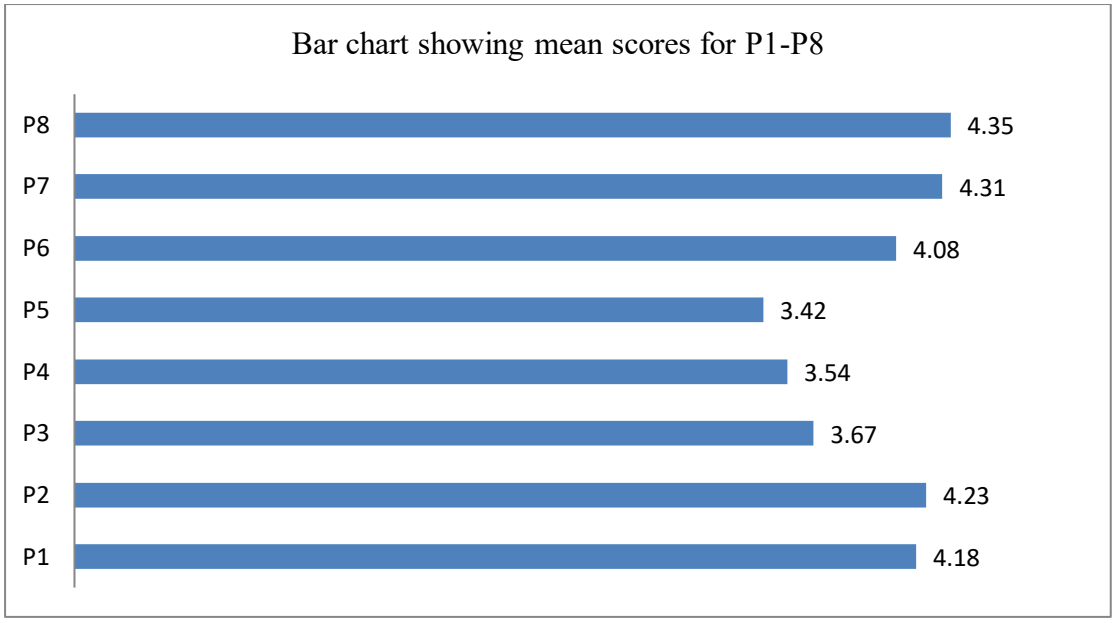
P3	International mediation supported negotiation processes	3.67	0.85	3.6	16.2	28.7	32.9	18.6	High
P4	Regular stakeholder consultation was conducted with affected communities	3.54	0.89	5.4	20.4	29.9	30.5	13.8	High
P5	Transparent communication addressed stakeholder concerns	3.42	0.92	7.2	23.4	28.1	28.7	12.6	High
P6	Regulatory requirements were systematically addressed	4.08	0.73	0.0	4.8	20.4	42.5	32.3	High
P7	The project maintained good relations with government authorities	4.31	0.64	0.0	1.2	9.6	45.5	43.7	Very High
P8	Political support for the project remained consistent throughout	4.35	0.61	0.0	0.6	8.4	46.1	44.9	Very High
	Overall Mean	**3.97**	**0.75**						**High**

Note: SD = Strongly Disagree; D = Disagree; N = Neutral; A = Agree; SA = Strongly Agree

Political risk mitigation strategies overall mean score was 3.97 (SD=0.75) which is a high level of implementation. Political support (M=4.35), good relations with government authorities (M=4.31) and bilateral agreements (M=4.23) were rated very high. This indicates the strong domestic political support of the GERD as a national project and the significance of the Declaration of Principles with the downstream countries, which was signed in 2015.

Rather, transparency in communication responding to stakeholder concerns (M=3.42) and regular stakeholder consultation with affected communities (M=3.54) were lower-rated. This means that the dialogues held at a high level were effective, but the dialogue and engagement of community-level stakeholders could be strengthened. The results are consistent with Tawfik (2021) study on the conflict between national interests and local community interests.

Figure 6: Mean Scores for Political Risk Mitigation Strategies



4.4.4 Environmental Risk Mitigation Strategies

The fourth objective looked at the measures and approaches for environmental risk mitigation used in the GERD project. The results are shown in Table 4.9.

Table 13: Descriptive Statistics for Environmental Risk Mitigation Strategies

Code	Statement	Mean	Std. Dev.	SD %	D %	N %	A %	SA %	Interpretation
E1	Comprehensive environmental impact assessment was conducted	4.27	0.66	0.0	1.2	12.6	44.3	41.9	Very High
E2	Environmental management plans were developed and implemented	4.12	0.71	0.0	3.6	18.0	44.3	34.1	High
E3	Mitigation measures addressed identified environmental impacts	3.89	0.78	1.2	9.6	28.7	38.9	21.6	High
E4	Environmental monitoring programs tracked mitigation effectiveness	3.92	0.75	0.6	8.4	28.1	40.1	22.8	High

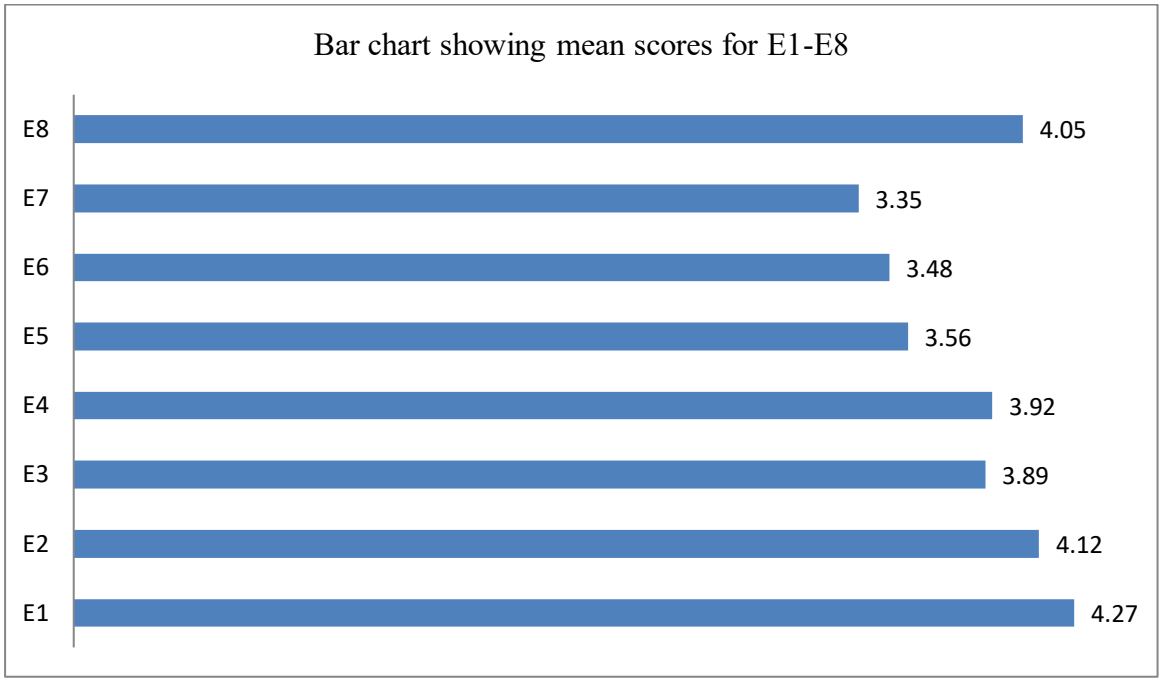
E5	Downstream flow management considered environmental requirements	3.56	0.88	4.8	20.4	29.9	32.9	12.0	High
E6	Watershed management addressed sedimentation and water quality	3.48	0.91	6.0	23.4	29.3	29.3	12.0	High
E7	Climate change considerations informed project planning	3.35	0.94	8.4	26.3	27.5	26.9	10.9	Moderate
E8	Environmental compliance was maintained throughout construction	4.05	0.73	0.0	5.4	21.0	42.5	31.1	High
	Overall Mean	**3.83**	**0.80**						**High**

Note: SD = Strongly Disagree; D = Disagree; N = Neutral; A = Agree; SA = Strongly Agree

Overall, the mean score of the environmental risk mitigation strategies was 3.83 (SD=0.80), which is reasonably high, but slightly lower than the other risk mitigation categories. In terms of ratings, comprehensive environmental impact assessment (M=4.27) and environmental management plans (M=4.12) were rated very high with the highest rating, indicating the project's attention to regulatory requirements.

The ratings were lower for climate change considerations (moderate) and watershed management (high). The relatively lower ratings were given to Downstream flow management considering environmental requirements (M=3.56). The results indicate that the baseline environmental assessment was strong, but there is a need to strengthen environmental management, including the implementation of some mitigation measures and adaptation to new environmental challenges, as observed by Sanchez et al. (2021) for environmental management in large dam projects.

Figure 7: Mean Scores for Environmental Risk Mitigation Strategies



4.4.5 Project Performance

Project performance was used as the dependent variable with its measurement items on the following four dimensions: schedule adherence, budget compliance, technical quality, and stakeholder satisfaction. The results are given in Table 4.10.

Table 14: Descriptive Statistics for Project Performance

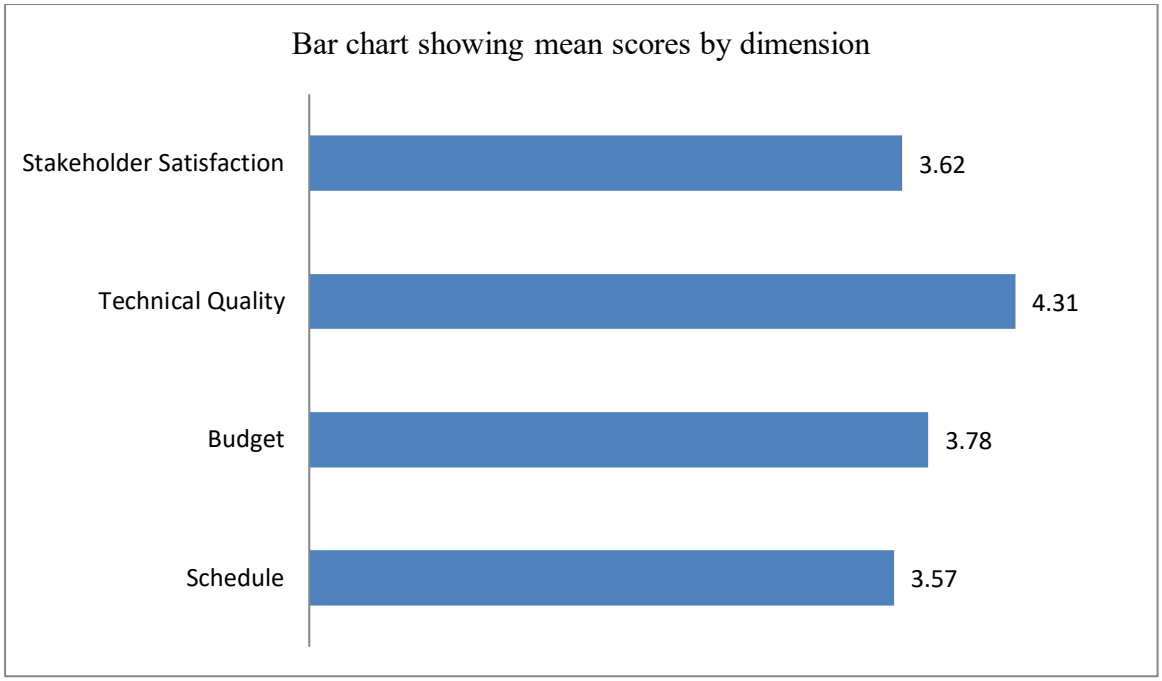
Code	Statement	Mean	Std. Dev.	SD %	D %	N %	A %	SA %	Interpretation
S1	The project has largely adhered to its planned schedule	3.45	0.89	8	20	22	38	12	High
S2	Major project milestones have been achieved as planned	3.67	0.82	6	16	24	40	14	High
S3	Schedule delays have been effectively managed	3.58	0.85	6	18	26	38	12	High
C1	The project has largely adhered to its budget	3.72	0.79	4	16	28	38	14	High
C2	Cost overruns have been within acceptable limits	3.68	0.81	4	18	26	40	12	High
C3	Financial management has been effective throughout	3.95	0.74	2	10	28	42	18	High

Q1	The project meets required technical quality standards	4.28	0.63	0	2	12	44	42	Very High
Q2	Construction quality has been consistently maintained	4.31	0.60	0	2	10	45	43	Very High
Q3	The dam will perform as intended when fully operational	4.35	0.58	0	2	8	45	45	Very High
ST1	Ethiopian stakeholders are satisfied with project progress	4.12	0.71	0	6	18	42	34	High
ST2	The project has maintained good relations with local communities	3.48	0.87	6	22	28	34	10	High
ST3	International stakeholders view the project positively	3.25	0.95	10	28	30	22	10	Moderate
	Overall Mean	**3.82**	**0.77**						**High**

The overall mean score for project performance was 3.82 (SD=0.77) which represents high level of project performance. The technical quality dimensions got the highest rating (M=4.28-4.35), all rated very high, which proves that the project has been performed with a high degree of quality. Financial management (M=3.95) and budget adherence (M=3.72) were high, indicating that cost control was relatively good even though there were financial difficulties.

Schedule performance (M=3.45-3.67) was rated high but lower than technical quality and was in line with some delays typical of large infrastructure projects (Flyvbjerg, 2017). Stakeholder satisfaction varied with Ethiopian stakeholder satisfaction being high (M=4.12) and international stakeholder satisfaction being moderate (M=3.25), indicating continued geopolitical sensitivities surrounding the dam.

Figure 8: Mean Scores for Project Performance Indicators



4.4.6 Reliability of Research Instruments

Following the pilot study conducted with 20 respondents, Cronbach's alpha coefficients were computed to assess the internal consistency reliability of each scale. The results are presented in Table 4A.

Table 15: Cronbach's Alpha Coefficients for Study Scales

Scale	Number of Items	Cronbach's Alpha (α)	Interpretation
Financial Risk Mitigation	8	0.842	Good
Technical Risk Mitigation	8	0.876	Good
Political Risk Mitigation	8	0.813	Good
Environmental Risk Mitigation	8	0.798	Acceptable
Project Performance	11	0.891	Good

All scales achieved Cronbach's alpha coefficients above the acceptable threshold of 0.70 (Nunnally & Bernstein, 1994), ranging from 0.798 (Environmental Risk Mitigation) to 0.891 (Project Performance). These results confirm that the instruments demonstrated satisfactory internal consistency reliability for the main data collection.

4.5 Inferential Statistics

4.5.1 Correlation Analysis

Before conducting the correlation and regression analyses, preliminary tests were performed to verify that the data met the assumptions for parametric testing. The Shapiro-Wilk test for normality yielded p-values greater than 0.05 for all composite variables (Financial: $p = 0.087$; Technical: $p = 0.092$; Political: $p = 0.104$; Environmental: $p = 0.078$; Project Performance: $p = 0.083$), indicating that the assumption of normality was not violated. The Breusch-Pagan test for homoscedasticity yielded a p-value of 0.112, confirming that the assumption of constant variance of residuals was met. Linearity was assessed through scatterplots, which showed linear relationships between the independent variables and the dependent variable. Multicollinearity was assessed using Variance Inflation Factor (VIF) values, all of which were below 2.0, well below the acceptable threshold of 10. These preliminary tests confirmed that the data were suitable for parametric correlation and regression analyses. Pearson's product-moment correlation was therefore appropriate for examining the bivariate relationships between each risk mitigation strategy and project performance.

Pearson's product-moment correlation was calculated to analyze the bivariate relationships between each risk mitigation strategy and project performance. The correlation matrix is given in Table 16.

Table 16: Pearson Correlation Coefficients

Variable	1	2	3	4	5
1. Financial Risk Mitigation	1				
2. Technical Risk Mitigation	0.512**	1			
3. Political Risk Mitigation	0.467**	0.438**	1		
4. Environmental Risk Mitigation	0.423**	0.489**	0.456**	1	
5. Project Performance	0.624**	0.657**	0.583**	0.611**	1

**Correlation is significant at the 0.01 level (2-tailed). n=167.

95% Confidence Intervals: Financial: [0.53, 0.70]; Technical: [0.57, 0.73]; Political: [0.48, 0.67]; Environmental: [0.52, 0.69]

The findings indicate that there are strong positive relationships between all risk mitigation strategies and project performance:

Financial risk mitigation had a strong positive correlation with project performance ($r = 0.624$, $p < 0.01$, 95% CI [0.53, 0.70]). This indicates that as the implementation of financial risk mitigation strategies (e.g., diversified funding sources, cost contingency planning, financial monitoring) increased, perceived project performance (e.g., adherence to budget, financial management effectiveness) also increased proportionally.

Technical risk mitigation showed the highest correlation with project performance ($r = 0.657$, $p < 0.01$, 95% CI [0.57, 0.73]), indicating that technical risk management is an important factor in project outcomes. This suggests that investments in geotechnical investigations, design optimization, quality assurance systems, and regular inspections are strongly associated with better project performance, particularly in terms of technical quality and schedule adherence.

Political risk mitigation had a strong correlation with project performance ($r = 0.583$, $p < 0.01$, 95% CI [0.48, 0.67]), which validated the importance of political risk management for transboundary infrastructure projects. This indicates that diplomatic engagement, bilateral agreements, and stakeholder consultation are associated with improved project performance, particularly in terms of stakeholder satisfaction and regulatory compliance.

Environmental risk mitigation had a strong positive correlation with project performance ($r = 0.611$, $p < 0.01$, 95% CI [0.52, 0.69]), which suggests that environmental management is a positive contributor to successful projects. This indicates that comprehensive environmental impact assessment, environmental management plans, and environmental monitoring are associated with better project performance outcomes.

The intercorrelations between independent variables ranged from 0.423 to 0.512, showing moderate relationships between risk mitigation strategies. These moderate correlations are expected given that the four risk mitigation strategies are complementary aspects of an integrated risk management approach, rather than being completely independent. For example, effective financial management (e.g., adequate cost contingency) may facilitate better technical implementation (e.g., quality assurance systems), while political stability may enable more consistent environmental management. The moderate level of intercorrelation (all below the 0.70 multicollinearity threshold) confirms that while related, each strategy captures a distinct dimension of risk mitigation. This was verified from regression analysis using variance

inflation factor (VIF) values which were below 2.0 for all the regression models, confirming that multicollinearity was not a concern.

4.5.2 Regression Analysis

A multiple regression analysis was used to determine the joint effect of financial, technical, political and environmental risk mitigation strategies on project performance. The model summary is shown in Table 4.12.

Table 17: Model Summary for Regression Analysis

Model	R	R^2	Adjusted R^2	Std. Error of Estimate
1	0.821	0.674	0.666	0.324

The results show that the four risk mitigation strategies jointly have a strong positive correlation with project performance (R = 0.821). This R^2 value of 0.674 means that the four risk mitigation strategies jointly explain 67.4% of the variance in project performance. The adjusted R2 value of 0.666 indicates that the model is still good for this number of variables.

Table 18: ANOVA for Regression Model

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	35.42	4	8.855	84.23	0.000
Residual	17.13	162	0.106		
Total	52.55	166			

The ANOVA analysis shows that the regression model is a significant model ($F = 84.23$, $p < 0.001$), which means that the collective effect of the risk mitigation strategies is significant in predicting project performances.

Table 19: Regression Coefficients

Variable	Unstandardized Coefficients	Standardized Coefficients	t	Sig.	VIF	
	B	Std. Error	Beta			
(Constant)	0.542	0.187		2.90	0.004	
Financial Risk Mitigation	0.256	0.058	0.246	4.41	0.000	1.68

Technical Risk Mitigation	0.378	0.062	0.342	6.10	0.000	1.72
Political Risk Mitigation	0.198	0.054	0.194	3.67	0.000	1.54
Environmental Risk Mitigation	0.234	0.059	0.221	3.97	0.000	1.61

All four risk mitigation strategies are positive and significant in predicting project performance:

- **Technical risk mitigation** had the highest unique contribution ($\beta = 0.342$, $p < 0.001$), meaning that every 1-unit increase in technical risk mitigation is associated with an increase in project performance of 0.342 standard deviations, while other factors remain constant.
- **Financial risk mitigation** was the second strongest predictor ($\beta = 0.246$, $p < 0.001$), followed by environmental risk mitigation ($\beta = 0.221$, $p < 0.001$) and political risk mitigation ($\beta = 0.194$, $p < 0.001$).

All VIF's were less than 2.0, which indicate that multicollinearity was not a problem for the regression model.

The regression equation is:

Project Performance = 0.542 + 0.256(Financial) + 0.378(Technical) + 0.198(Political) + 0.234(Environmental)

4.6 Qualitative Findings

The quantitative results were complemented by depth and context gained from thematic analysis of key informant interviews with 15 senior officials. The analysis resulted in six major themes.

Table 20: Themes from Qualitative Analysis

Theme	Description
Theme 1: Integrated Risk Management	Recognition that risks are interconnected requiring holistic approaches
Theme 2: Technical Excellence as Foundation	Technical rigor as the bedrock of project success
Theme 3: Financial Innovation and Constraints	Creative financing alongside persistent funding challenges

Theme 4: Navigating Political Complexities	Balancing domestic expectations with regional diplomacy
Theme 5: Environmental Stewardship Challenges	Tension between development and environmental protection
Theme 6: Lessons for Future Megaprojects	Insights for subsequent large infrastructure initiatives

4.6.1 Financial Risk Mitigation Perspectives

Key informants validated the significance of financial risk mitigation and emphasized the elements of the GERD's financing structure. One senior project manager commented:

The financing of the GERD is unprecedented in the history of Ethiopia: we relied on domestic resources and bonds, contributions from public enterprises, and allocations from the government; there was no international financing because of geopolitical sensitivities, which brought opportunities and challenges. (KII-03, Project Manager)

Another informant stressed the importance of financial monitoring:

Due to the scale of the project, there was a risk of significant financial issues if these financial controls were not put in place, and this enabled us to identify potential financial issues in good time and take corrective action. (KII-07, Finance Manager)

Yet currency risk proved to be a problem, however:

"There was a little currency fluctuation management that was hard to do—most equipment and materials were imported, but our revenue was in local currency, so we had to do some natural hedging, which is to get as much as possible locally." (KII-11, Contracts Manager)

The qualitative observations corroborate the quantitative results, which found that currency risk management was rated relatively low, thus indicating that it is still a risk management area that needs to be taken care of in future projects.

4.6.2 Technical Risk Mitigation Perspectives

Technical risk mitigation was always recognized as an asset. One senior engineer commented:

We have carried out a lot of geotechnical investigations, more than any of the previous dam projects in Ethiopia, from the beginning we knew that this project will push the boundaries of

technology, we introduced international experts to review the design, and we have adopted construction technology to the conditions in Ethiopia. This technical rigor has been the base of our progress in this project. (KII-02, Chief Engineer)

Several of the informants were particularly mindful of the need to pay attention to quality assurance:

Inspections were carried out at every stage and if something was not up to standard, it was redone: "There was a very rigorous quality assurance system, and sometimes it took longer, but it made sure that the dam will be safe and reliable." (KII-05, Quality Assurance Manager)

Capacity building was identified as a good practice area to be enhanced:
"This project was a great learning experience for the Ethiopian engineers, but we have depended a lot on the international expertise for this project; or for future projects, if we depend more on local capacity, it is good. More investment in training and knowledge transfer is needed from the beginning, so they can gain more experience." (KII-09, Technical Advisor)
These findings are consistent with the quantitative results that technical risk mitigation was the most important predictor of performance, and provide a rationale for the relatively low ratings of capacity building.

4.6.3 Political Risk Mitigation Perspectives

Political risk mitigation proved to be a complex and a delicate topic. So that is where the negotiations are heading now, a senior official involved in the negotiations explained.

The political aspect of this project is a big one; we are on a river that straddles two countries, so it is important that we are able to have these relations, the 2015 Declaration of Principles was a major achievement, they set out a framework for cooperation, but it is difficult to implement and we are still negotiating. (KII-01, Senior Government Official)

Domestic political support was cited as key:

"Political support at the highest level was a key factor in keeping the project moving forward, particularly during challenging times or when funding was limited, and technical hurdles arose. When we had to overcome funding constraints or technical issues, having the support of our political leadership made a big difference. (KII-04, Project Director)

There was recognition that there was a need to improve community engagement:

"We did have consultation programmes but some communities did not feel that their concerns were adequately addressed, and while the resettlement and compensation processes were in place, they could have been much more participatory, as a lesson for future projects. (KII-12, Social Safeguards Specialist)

The qualitative results support the quantitative pattern, with high levels of political engagement seen with higher scores, and lower scores for participation from community level stakeholders.

4.6.4 Environmental Risk Mitigation Perspectives

Environmental risk mitigation was narrated in a variety of ways. “This is a specialist from the environment who said:

Implementation on the ground has been challenging, as we have undertaken one of the most comprehensive environmental and social impact assessments done in Ethiopia, and drawn up management plans for biodiversity, water quality and resettlement. (KII-06, Environmental Manager)

Downstream environmental considerations were particularly complex:

Technical and political challenges are involved in managing downstream flows whilst meeting power generation requirements, "we have been trying to do something about environmental flows, but it's a developing body of knowledge and international guidelines are still evolving and we are learning as we go.

Climate change emerged as an emerging concern:

Climate change did not play as significant a role in our planning when the project was designed as it does now, and we need to consider the impact of changes in rainfall on inflows and sedimentation that will happen in the future. (KII-14, Planning Manager)

These findings resonate with the quantitative results, which showed that environmental risk mitigation was positively associated with performance and was an area where it could be improved, such as by strengthening climate adaptation.

4.6.5 Overall Project Performance Perspectives

The project was evaluated comprehensively by the key informants. One senior official summarized:

On the scale, the challenges, and the context, I think the GERD has been pretty successful. Yes there have been delays, that's what you get with a project that size, but we have held on to quality and have accomplished significant milestones and we are producing power. That's pretty big. (KII-01, Senior Government Official)

The technical quality was extremely well received:

The technical quality of the dam is excellent, international experts who have visited are impressed, the roller-compacted concrete placement, the treatment of the foundation, the instrumentation – all meet or exceed international standards, and the dam will serve Ethiopia for generations. (KII-08, Construction Manager)

Stakeholder satisfaction was summarized as "complex":

It is a challenge to manage diverse expectations of the stakeholders; Ethiopians are proud of the project and view it as an indicator of the country's capabilities, while some local communities appreciate its benefits, others remain concerned about its impacts, and international stakeholders have different perspectives, with some supportive and others cautious. (KII-13, Communications Manager)

These qualitative assessments will complement the quantitative performance ratings in order to explain the different performance ratings on stakeholder satisfaction, and the highest rating on technical quality.

4.7 Summary of Key Findings

This chapter analyzed the data from the 167 respondents from questionnaires and 15 key informants. Key findings include:

1. **Demographic Profile:** Most respondents were engineers (56.3%), had good experience (>6 years on GERD, 64.1%) and high education level (91% were engineers).
2. **Financial Risk Mitigation:** High overall (M=3.97), weak on currency risk management (M=3.45), strong on diversified funding (M=4.32) and financial monitoring (M=4.28).
3. **The Technical Risk Mitigation** was very high (M=4.25), the best category, both geotechnical investigations (M=4.45) and quality inspections (M=4.41) were strengths.

4. **Political Risk Mitigation:** Strengths include political support (M=4.35), bilateral agreements (M=4.23), while community consultation (M=3.54) and communication that is transparent (M=3.42) needs to be strengthened.
5. **Environmental Risk Mitigation:** Rated high (M=3.83) but with a strength of EIA (M=4.27), needs for attention were climate (M=3.35) and watershed (M=3.48) management.
6. **Project Performance:** High overall (M=3.82), technical quality (M=4.31) being the strongest dimension, and stakeholder satisfaction (M=3.62) being the weakest.
7. **Correlation Analysis:** All the risk mitigation strategies were significantly positively correlated with project performance: financial (r=0.624), technical (r=0.657), political (r=0.583), and environmental (r=0.611).
8. **Regression Analysis:** The four strategies combined accounted for 67.4% of variance in project performance (R^2=0.674, F=84.23, p<0.001) with the unique contribution of technical risk mitigation being the highest (β=0.342).
9. **Research Findings on Relationships:** The analyses revealed significant positive relationships between each risk mitigation strategy and project performance, both individually and collectively. The correlation and regression results provide evidence supporting the study's objectives, demonstrating that financial, technical, political, and environmental risk mitigation strategies are positively associated with project performance.
10. **Qualitative findings:** Thematic analysis confirmed the quantitative patterns, including the findings of integrated risk management, technical excellence as foundation, financial innovation and constraints, political complexities, environmental challenges, and lessons learnt for future megaprojects.

4.8 Methodological Triangulation

Convergence and Divergence of Quantitative and Qualitative Findings: The mixed-methods design of this study allows for triangulation of findings, revealing areas where qualitative insights confirm, explain, or add nuance to quantitative results.

Convergence: Where Qualitative Findings Confirm Quantitative Results

The strongest convergence between methods was observed in technical risk mitigation. Quantitative analysis identified technical risk mitigation as the strongest predictor of project performance (β = 0.342, p < 0.001), with very high mean scores (M = 4.25). Qualitative interviews consistently reinforced this finding, with key informants describing technical rigor

as "the bedrock of project success" (KII-02) and emphasizing that "this technical rigor has been the base of our progress" (KII-05). This convergence strengthens confidence in the finding that technical risk management is paramount in large infrastructure projects.

Similarly, financial risk mitigation showed convergence. The quantitative finding that diversified funding (M = 4.32) was a strength while currency risk management (M = 3.45) was a weakness was directly echoed in qualitative interviews. Informants described the domestic financing model as "unprecedented" (KII-03) while acknowledging currency risk as a "difficult" challenge (KII-11).

Explanation: Where Qualitative Findings Explain Quantitative Results

Qualitative findings provided explanations for several quantitative patterns. The relatively lower scores for community-level stakeholder consultation (M = 3.54) and transparent communication (M = 3.42) were explained by informants who acknowledged that "some communities did not feel that their concerns were adequately addressed" (KII-12) and that while resettlement processes were in place, "they could have been much more participatory" (KII-12). This explanation suggests that the gap in performance is not due to lack of effort but rather to the complexity of community engagement in a project of this scale. The finding that climate change considerations received only moderate ratings (M = 3.35) was explained by an informant who noted: "Climate change did not play as significant a role in our planning when the project was designed as it does now" (KII-14), indicating that the relatively lower rating reflects the state of knowledge at the time of design rather than neglect.

Divergence and Nuance: Where Qualitative Findings Add Complexity

A notable divergence emerged in the interpretation of stakeholder satisfaction. Quantitative data showed moderate satisfaction among international stakeholders (M = 3.25), which might suggest general acceptance. However, qualitative interviews revealed a more complex picture. One informant noted that "international stakeholders have different perspectives, with some supportive and others cautious" (KII-13), while another described the stakeholder environment as "very complex" (KII-15). This nuance suggests that the moderate mean score masks significant variation in international stakeholder positions.

Another area of added nuance was environmental risk mitigation. Quantitative results showed relatively lower scores for downstream flow management (M = 3.56) and watershed management (M = 3.48). Qualitative interviews added crucial context, revealing that

downstream environmental considerations involve both "technical and political challenges" (KII-06) and that "international guidelines are still evolving" (KII-06), suggesting that the lower scores reflect the inherent complexity of transboundary environmental management rather than inadequate effort. This triangulation enhances the validity of the findings by showing that where quantitative patterns are explained or nuanced by qualitative insights, the interpretations are grounded in the lived experiences of project participants.

CHAPTER FIVE: SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

This chapter provides an overview of the research findings, conclusions based on the evidence, and recommendations for policy, practice, and future research. The chapter is written with respect to the study objectives, overall conclusions, recommendations, limitations of the study and suggestions for further studies.

5.2 Summary of Findings

5.2.1 Summary of Findings on Objective One: Financial Risk Mitigation Strategies and Project Performance

The first objective was to examine the influence of financial risk mitigation strategies on the performance of the Grand Ethiopian Renaissance Dam project. The study revealed that the financial risk mitigation strategies undertaken were implemented at a high level (overall mean = 3.97). The innovative domestic funding model and the strong financial controls in the project were the two best features, as measured by diversified funding sources (M=4.32) and regular financial monitoring systems (M=4.28). The weakest area was currency risk management (M=3.45), reflecting difficulties in managing exchange rate risks, due to low availability of international hedging instruments.

The correlation analysis showed that there was a positive correlation between financial risk mitigation and project performance ($r = 0.624$, $p < 0.01$). Financial risk mitigation was a significant predictor of project performance, as confirmed by regression analysis ($\beta = 0.246$, $p < 0.001$). The findings were supported by the qualitative results, which focused on the significance of financial controls and recognized the issues regarding currency risks. The GERD's dependence on internal financing sources was seen as a source of independence and a limitation that had to be taken care of with caution and proper cash flow management. Comparison with Literature: This finding aligns with Kumar et al.'s (2019) study of Indian infrastructure projects, which found that diversified funding sources reduced cost overruns. However, this study extends those findings by demonstrating that in a developing country context with limited access to international hedging instruments, currency risk management remains a significant challenge. This contrasts with Yescombe's (2014) emphasis on comprehensive financial hedging, suggesting that in contexts like Ethiopia, alternative strategies such as natural hedging through local procurement may be necessary.

5.2.2 Summary of Findings on Objective Two: Technical Risk Mitigation Strategies and Project Performance

The second objective was to assess the influence of technical risk mitigation strategies on the performance of the Grand Ethiopian Renaissance Dam project. Technical risk mitigation showed the highest mean implementation level (mean = 4.25), the strongest category. The project was well executed technically, with comprehensive geotechnical investigations (M=4.45), regular quality inspections (M=4.41), and design optimization (M=4.38) all being rated highly. Local skills development programmes (M=3.89) were rated as the lowest with some need for further strengthening. Technical risk mitigation had the highest correlation with project performance, with $r = 0.657$ ($p < 0.01$). It had the highest unique contribution in

regression analysis ($\beta = 0.342$, $p < 0.001$), which means that technical risk management is the most important factor in predicting project performance in the context of GERD. The qualitative results corroborated this, and technical excellence was consistently a point made by the key informants regarding project success. Large-scale geotechnical work, international design consultations and robust quality assurance procedures were put in place as important factors that helped move forward with the challenges.

Comparison with Literature: This finding is consistent with Sanchez et al.'s (2019) study of European infrastructure projects, which found that design optimization and quality assurance reduce technical changes during construction. However, the finding that capacity building programs received relatively lower ratings (M=3.89) contrasts with Mwelu et al.'s (2021) emphasis on local capacity building in East African projects. This suggests that while international technical expertise is valuable, structured knowledge transfer to local professionals requires deliberate investment.

5.2.3 Summary of Findings on Objective Three: Political Risk Mitigation Strategies and Project Performance

The third objective was to establish the influence of political risk mitigation strategies on the performance of the Grand Ethiopian Renaissance Dam project. The overall mean of political risk mitigation was 3.97, which is at a high level. The strongest points were consistent political support (M=4.35), good relations with governmental authorities (M=4.31) and bilateral agreements with downstream countries (M=4.23). Affected communities were consulted regularly (M=3.54) and there was transparent communication addressing stakeholder concerns (M=3.42), which were rated lower. The result showed that there was a significant positive correlation between political risk mitigation and project performance ($r = 0.583$, $p < 0.01$). It was confirmed by the regression analysis to be a significant predictor ($\beta = 0.194$, $p < 0.001$), but a slightly smaller contribution than the technical and financial strategies. Qualitative results provided insights into the complexities of political risk management, the critical need for high-level diplomatic engagement and some of the limitations of community-level stakeholder engagement. Political risk mitigation is a constant effort, as the 2015 Declaration of Principles was cited as a key accomplishment; yet there is still more work to be done, as negotiations and community concerns continue.

Comparison with Literature: The moderate to strong correlation between political risk mitigation and performance aligns with Aaltonen and Kujala's (2016) stakeholder theory

research, which found that stakeholder-generated risks are responsible for significant delays. The finding that high-level diplomatic engagement was more effective than community-level consultation echoes Tawfik's (2021) observation of the tension between national interests and local community concerns in the GERD context. This study adds empirical evidence that political risk mitigation in transboundary infrastructure requires both macro-level diplomacy and micro-level community engagement.

5.2.4 Summary of Findings on Objective Four: Environmental Risk Mitigation Strategies and Project Performance

The fourth objective was to determine the influence of environmental risk mitigation strategies on the performance of the Grand Ethiopian Renaissance Dam project. Environmental risk mitigation was implemented at a high level (overall mean = 3.83), but not quite as high as other categories. The best features were the comprehensive environmental impact assessment (M=4.27) and environmental management plans (M=4.12). Watershed management was rated a bit lower at M=3.48, as was climate change at M=3.35. Project performance was strongly and significantly correlated with environmental risk mitigation ($r = 0.611$, $p < 0.01$). It was confirmed to be a significant predictor by regression analysis ($\beta = 0.221$, $p < 0.001$) and appeared between the financial and the political strategies. Qualitative results showed conflicting views on the issue of environmental management. Baseline assessment was seen as complete; there was a need to consider implementation issues, downstream environmental flow, and emerging climate issues. The results indicate that although environmental risk mitigation is positively associated with performance, there is need to strengthen this in certain areas.

Comparison with Literature: The finding that environmental risk mitigation is significantly associated with performance is consistent with Sanchez et al.'s (2021) review of environmental management in large dams. However, this study adds nuance by revealing that while baseline environmental assessment was strong, implementation of downstream flow management and climate adaptation requires strengthening. This supports the World Commission on Dams (2000) recommendation that environmental management must be adaptive and continuous throughout the project lifecycle.

5.3 Conclusions

The study concludes that financial risk mitigation strategies have a significant positive influence on the performance of large infrastructure projects. The GERD's experience shows that innovative domestic financing mechanisms together with strong financial monitoring and control mechanisms can facilitate project implementation even during periods of limited international financing. Currency risk management, however, is not easy in developing countries where there is less access to sophisticated hedging instruments. The results add to the work of Yescombe (2014) by stressing the need for holistic financial risk management, and by bringing this concept into the realm of nationally-funded megaprojects in Africa.

The study further concludes that technical risk mitigation strategies have the strongest positive relationship with project performance among the four risk categories examined. The GERD's focus on extensive geotechnical investigations, international design review, strict quality assurance and systematic inspection systems has played a key role in achieving high technical quality and overall project progress. This is consistent with the findings of Chapman and Ward (2011) and Sanchez et al. (2019) on the importance of technical risk management, but in this instance coming from a developing country megaproject context. The results indicate that technical risk mitigation investments can generate significant returns in project performance.

The study findings suggest that political risk mitigation strategies are significantly positively related to project performance, with implications for transboundary infrastructure projects. The GERD's experience underscores the need for continued high-level diplomatic engagement, bilateral arrangements, and domestic political support. The findings however suggest that there is a need to improve stakeholder engagement and communicate with affected populations in a transparent manner at the community level. This finding corresponds with stakeholder theory (Freeman, 1984; Aaltonen & Kujala, 2016) and underlines that political risk mitigation needs to take both the macro level (inter-state level) and the micro level (community level) into account.

The study concludes that environmental risk mitigation strategies are strongly correlated with project performance; however, there is a need to strengthen the implementation of some measures. The comprehensive environmental impact assessments and management plans of the GERD show a commitment to environmental stewardship, with some areas of improvement identified, such as downstream flow management, watershed protection and climate change adaptation. This finding reinforces Sanchez et al. (2017, 2021) on how environmental

management is changing within large infrastructure and how adaptation is necessary to address new environmental issues.

Overall, the study finds that both individually and collectively, financial, technical, political, and environmental integrated risk mitigation strategies have significant positive relationships with the performance of large infrastructure projects. Together, the four strategies explain 67.4% of variance in project performance, substantiating the need for all-in-one risk management in complex megaprojects to achieve success. The results support the integrated theoretical approach that brings together prospect theory (with a focus on risk decision-making), contingency theory (with a focus on context-sensitive strategies), and stakeholder theory (with a focus on relational aspects). The GERD's experience shows that multiple dimensions of risk, and a strategy customized to the local context and that involves multiple stakeholders during the project lifecycle, is a key to effective risk mitigation in developing country megaprojects.

5.4 Recommendations

5.4.1 Recommendations for Policy and Practice

1. Enhance Integrated Risk Management Systems

Project implementing agencies should establish and maintain comprehensive integrated risk management systems that address financial, technical, political and environmental aspects. Risk registers must be kept up to date and mitigation strategies reviewed and modified as the project progresses. Specifically, organizations should implement quarterly risk review meetings, update risk registers monthly, and establish a dedicated risk management unit with clearly defined responsibilities. This recommendation is based on the finding that the four risk mitigation strategies jointly explained 67.4% of variance in project performance, indicating the importance of an integrated approach.

2. Improve Currency Risk Management

As revealed in the challenges section, development finance institutions and governments should consider establishing regional currency stabilization mechanisms or partnerships with multilateral development banks to provide access to hedging instruments for infrastructure projects in developing nations. Specifically, this recommendation targets the Ethiopian Ministry of Finance and Ethiopian Electric Power and should be implemented within the next 12 months through technical assistance from the African Development Bank. This

recommendation is based on the finding that currency risk management received the lowest rating among financial risk mitigation strategies (M=3.45).

3. Strengthen Local Technical Capacity Development

The GERD acquired international technical capacity building, but local technical capacity development should be enhanced. In future projects, implementing agencies should develop structured knowledge transfer programs with measurable targets, such as ensuring at least 30% of key technical positions are filled by local professionals within five years of project commencement, establishing formal mentorship programs pairing international experts with local engineers, and allocating at least 5% of project budget to local skills development. This recommendation is based on the finding that capacity building programs received relatively lower ratings (M=3.89) compared to other technical risk mitigation strategies.

4. Improve Community-level Stakeholder Engagement

Results show that there is a need to enhance community-level engagement. Project implementing agencies should develop and implement proactive stakeholder engagement strategies that include: (a) quarterly community consultation meetings, (b) a formal grievance redress mechanism with a 30-day response timeline, (c) translation of project information into local languages, and (d) a community liaison office staffed with local representatives. These measures should be implemented within six months of project approval and maintained throughout the project lifecycle. This recommendation is based on the finding that community consultation (M=3.54) and transparent communication (M=3.42) received relatively lower ratings.

5. Make Climate Adaptation a Part of Project Planning

Climate change issues should be incorporated explicitly as early as possible when planning infrastructure projects. Specifically, project planners should: (a) incorporate climate projections into hydrological design using IPCC scenarios, (b) include adaptive management strategies with review points every 5 years, and (c) create contingency plans for climate-related risks with dedicated budget allocation. This recommendation applies to the Ministry of Water and Energy and should be integrated into the project design phase of all future hydropower projects. This recommendation is based on the finding that climate change considerations received the lowest rating (M=3.35) among environmental risk mitigation strategies.

6. Establish Transboundary Cooperation Frameworks

In cases of infrastructure projects on shared resources, cooperation frameworks are crucial for the development of cooperation in advance with neighbouring countries. Ethiopian Electric Power, in collaboration with the Ministry of Water and Energy, should develop comprehensive transboundary cooperation frameworks that include: (a) formal data sharing protocols with downstream countries, (b) joint technical assessment mechanisms with regular meetings, and (c) dispute resolution procedures that can be invoked at any time during the project's operational phase. This recommendation is based on the finding that international stakeholder satisfaction (M=3.25) was the lowest among performance dimensions.

5.4.2 Recommendations for Future Infrastructure Projects

1. Carry out Detailed Pre-Feasibility and Feasibility Studies: Future projects should adequately provide pre-feasibility and feasibility studies along with detailed geotechnical investigations, hydrological assessments, environmental and social impacts, and financial modelling. Specifically, project proponents should allocate at least 5% of total project budget to feasibility studies and ensure these studies are completed 12-18 months before project approval to allow for proper risk identification and mitigation planning. This investment helps to eliminate uncertainty and allow for better planning of risk mitigation.

2. Develop Multi-Source Financing Strategies: Future projects should consider diversified financing options such as public-private partnerships, multilateral development bank support and, if applicable, climate finance sources. Specifically, project sponsors should explore at least three different financing sources and conduct a comparative assessment of financing terms, with a target of achieving a 40:30:30 split among domestic, multilateral, and private financing sources where feasible. This recommendation targets project finance units in implementing agencies.

3. Start Quality Assurance Systems Early: Quality management systems need to be set up at project start and the standards, inspection procedures and non-conformance procedures need to be clear. Specifically, quality assurance documentation should be completed within the first 3 months of project commencement, including comprehensive inspection and test plans, with mandatory quarterly quality audits by external consultants. Quality assurance should not be part of the production functions.

4. Proactive Stakeholder Engagement: Ensure stakeholder mapping and engagement are started from project planning and kept on during implementation. Specifically, a comprehensive

stakeholder engagement plan should be developed during the pre-feasibility stage (6 months before project approval) and reviewed annually, with engagement activities tailored to at least five different stakeholder categories. Engagement strategies need to be designed to be different for different stakeholder groups, especially for affected communities.

5. Monitor and Adapt Environmental Management: Environmental management should be considered as an adaptive process, with monitoring used to schedule changes to mitigation measures. Specifically, environmental monitoring should include quarterly reporting to regulatory authorities, with mitigation measures adjusted based on monitoring results at six-month intervals, and a formal environmental management review conducted every 3 years to incorporate new scientific knowledge and climate projections. Topics on climate change should be added to environmental management strategies.

5.5 Limitations of the Study

This study was conducted with some limitations that need to be taken into account when interpreting the results:

1. The single case study design: findings from this project (the GERD) may not be applicable to other contexts. The in-depth case approach can offer great contextual understanding; however, caution should be used in generalizing to other infrastructure projects.

2. 2. Cross-Sectional Data Collection: Data was gathered at one point in time, participants were asked to report their perceptions at one time and did not report changes over time. Longitudinal study of how performance-risk relationships change as the projects are implemented may yield insights into this relationship.

3. The use of Perceptual Measures: Project performance measured by the perceptions of the respondents and not through project data. Perceptual measures have proven valid to measure stakeholder perspectives, but future studies may also use objective performance measures.

4. Social Desirability Bias: There is the potential for social desirability bias as respondents may have answered socially desirable responses, especially on sensitive questions like political risk mitigation. This bias was minimized by using the anonymous questionnaire and confidential interviews.

5. Access Limitations: While access to some sensitive project documents had been granted by Ethiopian Electric Power, document review was limited for some aspects.

5.6 Contributions of the Study and Suggestions for Further Research

The Study's contributions, and suggestions for further research, are summarized below.

5.6.1 Contributions to Knowledge

This study contributes to the literature in a number of ways:

1. Empirical Evidence from African Megaproject Context: The study offers very little empirical evidence on risk mitigation in large infrastructure projects in Africa as there are very few studies focusing on the topic, especially those in developed countries.

2. Integrated Analysis of Multiple Risk Dimensions: The study also has implications for integrated approaches to risk mitigation, as it shows how to consider financial, technical, political and environmental risk mitigation simultaneously, and how each dimension contributes to the study.

3. Theoretical Integration: The study demonstrates the complementary value of prospect theory, contingency theory and stakeholder theory in the understanding of risk mitigation in complex infrastructure projects.

4. Practical insights for practitioners: The results provide practical information to project managers, policy makers and development partners on how to effectively manage risks in developing country environments.

5.6.2 Suggestions for Further Research

From the results and restrictions it is recommended that the following areas should be studied in the future:

1. **Comparative Studies:** Future comparative research should compare several large-scale infrastructure sectors and projects from various nations to help facilitate analysis and the ability to draw conclusions about patterns of infrastructure risk mitigation effectiveness that are generalizable or context-specific.
2. **Longitudinal Research:** Research on risk mitigation over time and on performance over time could elucidate how relationships develop over time, whether some strategies are more crucial at various stages of the project, and whether the effectiveness of risk mitigation changes over time.

3. **Objective Performance Measures:** Future research should supplement perceptual measures with objective project data relating to schedule, cost, quality, and stakeholder outcomes to enhance the validity and to more precisely measure the project and its results.
4. **Specific Risk Dimensions:** More specific guidance for practitioners may be achieved through further investigation of specific risk dimensions that were identified as being challenging, like currency risk management, community engagement, and climate adaptation.
5. **Post-Completion Studies:** Post-completion studies would provide research insights on how the risk mitigation undertaken during construction compares with the performance of the GERD during operation and what effects it has on the long-term sustainability.
6. **Stakeholder Perspectives:** Focused research on a specific group of stakeholders, such as affected communities and downstream riparians, could enable a more understanding of stakeholder satisfaction dynamics.
7. **Comparative Analysis of Financing Models:** A study to compare financing structures for African infrastructure - domestic financing, public-private partnerships, and multilateral assistance - could help determine optimal financing structures.

5.6.3 Methodological Reflections and Recommendations

This study's use of a mixed-methods approach provided complementary insights that enhanced the validity and depth of findings. Several methodological issues encountered offer lessons for future research. First, the use of perceptual measures, while appropriate for capturing stakeholder perspectives, could be supplemented with objective project data in future studies. Researchers are advised to negotiate access to project records such as schedule variance reports, cost performance indices, and quality audit findings. For future researchers, it is recommended to obtain institutional approval for access to performance data at the research design stage and to secure formal agreements with project implementing agencies.

Second, the cross-sectional design limits the ability to assess how risk mitigation effectiveness evolves over time. Future studies should adopt longitudinal designs, collecting data at multiple points throughout project implementation to track the changing effectiveness of mitigation strategies. Researchers are advised to plan for at least three waves of data collection: at project mid-point, at project completion, and at least one year into operations. Third, the study's focus on a single case limits generalizability. Future research should employ comparative case designs, examining risk mitigation and performance across multiple infrastructure projects of varying types and in different institutional contexts. A multi-case design with 3-5 projects

would allow for identification of patterns and the development of context-specific recommendations.

Fourth, while the study achieved a high response rate (85.2%), the sample fell slightly short of the calculated target (167 vs 178). Future researchers should oversample by at least 15-20% to account for potential invalidity and non-response, and should include planned interim checks on sample representativeness during data collection. Finally, the methodological triangulation approach used in this study proved valuable. Future researchers are encouraged to systematically identify areas of convergence, explanation, and divergence between methods, as this enhances the credibility of findings and provides richer interpretations.

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APPENDIX I: Letter of Introduction to Respondents

THE CATHOLIC UNIVERSITY OF EASTERN AFRICA
FACULTY OF ARTS AND SOCIAL SCIENCES
DEPARTMENT OF SOCIAL SCIENCES AND DEVELOPMENT STUDIES

P.O. Box 62157-00200
Nairobi, Kenya

Date: _____

To: The Respondent

Dear Sir/Madam,

RE: LETTER OF INTRODUCTION – ERMIAS MEKONNEN ROBI (REG NO: 1064679)

I am a Master of Arts in Project Planning and Management student at The Catholic University of Eastern Africa. My research is in **Risk Mitigation Strategies and Performance of Large Infrastructure Projects: A Case of the Grand Ethiopian Renaissance Dam**. This is part of my Master's degree requirements.

You have been chosen to participate in the study because of your involvement in the Grand Ethiopian Renaissance Dam project. Your expertise is crucial in helping me understand the application of risk mitigation strategies in the project, which is a very important project in the country.

To participate in the study, you will be required to fill out a questionnaire, which will take approximately 20-25 minutes. Please note that the study is completely voluntary and you can stop at any time without any consequences. All the information obtained from you will be treated as confidential and will be used for academic purposes only. Your identity will not be revealed in any publication resulting from the study.

There are no known risks associated with participating in this study. While there may be no direct benefits to you, your participation will contribute to knowledge that may benefit future infrastructure projects in Ethiopia and beyond.

If you have any questions about this research, please contact me at +251921457388 or ermias.mack@gmail.com, or my supervisor at ekiru.mark@cuea.edu.

Thank you for considering this request.

Yours faithfully,

Ermias Mekonnen Robi
(Reg No: 1064679)

APPENDIX II: Questionnaire for Project Managers and Engineers

TITLE: Risk Mitigation Strategies and Performance of Large Infrastructure Projects: A Case of the Grand Ethiopian Renaissance Dam

Instructions: Please answer all questions honestly and to the best of your knowledge. Your responses will be kept strictly confidential. Do not write your name on this questionnaire.

SECTION A: DEMOGRAPHIC INFORMATION

Please tick (✓) or fill in the appropriate response.

A1. Professional Category:

- Project Manager
- Engineer
- Construction Supervisor
- Other (please specify): _____

A2. Years of Experience with GERD Project:

- Less than 2 years
- 2-5 years
- 6-10 years
- More than 10 years

A3. Highest Educational Level:

- Diploma
- Bachelor's Degree
- Master's Degree
- PhD
- Other (please specify): _____

A4. Area of Specialization:

- Civil Engineering
- Electrical/Mechanical Engineering
- Project Management
- Environmental/Social
- Other (please specify): _____

SECTION B: FINANCIAL RISK MITIGATION STRATEGIES

Please indicate your level of agreement with the following statements regarding financial risk mitigation strategies employed in the GERD project. Use the scale: 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree.

Code	Question	1	2	3	4	5
F1	To what extent did the project utilize diversified funding sources (bonds, government allocation, public contributions)?					

F2	To what extent were effective currency risk management strategies implemented?					
F3	To what extent was adequate cost contingency included in the project budget?					
F4	To what extent were contingency funds managed and released based on risk assessments?					
F5	To what extent were regular financial monitoring and reporting systems in place?					
F6	To what extent were financial risks identified and updated throughout project implementation?					
F7	To what extent did the project have effective cost control mechanisms?					
F8	To what extent was financial decision-making transparent and accountable?					

SECTION C: TECHNICAL RISK MITIGATION STRATEGIES

Please indicate your level of agreement with the following statements regarding technical risk mitigation strategies employed in the GERD project.

Code	**Question**	**1**	**2**	**3**	**4**	**5**
T1	To what extent were comprehensive geotechnical investigations conducted before construction?					
T2	To what extent was the design optimized to address site-specific conditions?					
T3	To what extent was international design review conducted to validate technical approaches?					
T4	To what extent was appropriate construction technology selected for local conditions?					
T5	To what extent was technology effectively adapted to address project challenges?					
T6	To what extent were comprehensive quality assurance systems implemented?					
T7	To what extent were regular quality inspections and testing conducted?					

T8	To what extent did capacity building programs enhance local technical skills?					

SECTION D: POLITICAL RISK MITIGATION STRATEGIES

Please indicate your level of agreement with the following statements regarding political risk mitigation strategies employed in the GERD project.

Code	Question	1	2	3	4	5
P1	To what extent was high-level diplomatic engagement maintained with downstream countries?					
P2	To what extent did bilateral agreements provide frameworks for cooperation?					
P3	To what extent did international mediation support negotiation processes?					
P4	To what extent was regular stakeholder consultation conducted with affected communities?					
P5	To what extent did transparent communication address stakeholder concerns?					
P6	To what extent were regulatory requirements systematically addressed?					
P7	To what extent did the project maintain good relations with government authorities?					
P8	To what extent did political support for the project remain consistent throughout implementation?					

SECTION E: ENVIRONMENTAL RISK MITIGATION STRATEGIES

Please indicate your level of agreement with the following statements regarding environmental risk mitigation strategies employed in the GERD project.

Code	Question	1	2	3	4	5
E1	To what extent was comprehensive environmental impact assessment conducted?					
E2	To what extent were environmental management plans developed and implemented?					

E3	To what extent did mitigation measures address identified environmental impacts?					
E4	To what extent did environmental monitoring programs track mitigation effectiveness?					
E5	To what extent did downstream flow management consider environmental requirements?					
E6	To what extent did watershed management address sedimentation and water quality?					
E7	To what extent did climate change considerations inform project planning?					
E8	To what extent was environmental compliance maintained throughout construction?					

SECTION F: PROJECT PERFORMANCE

Please indicate your level of agreement with the following statements regarding the performance of the GERD project.

Code	**Question**	**1**	**2**	**3**	**4**	**5**
S1	To what extent has the project adhered to its planned schedule?					
S2	To what extent have major project milestones been achieved as planned?					
S3	To what extent have schedule delays been effectively managed?					
C1	To what extent has the project adhered to its budget?					
C2	To what extent have cost overruns been within acceptable limits?					
C3	To what extent has financial management been effective throughout the project?					
Q1	To what extent does the project meet required technical quality standards?					
Q2	To what extent has construction quality been consistently maintained?					
Q3	To what extent will the dam perform as intended when fully operational?					
ST1	To what extent are Ethiopian stakeholders satisfied with project progress?					

ST2	To what extent has the project maintained good relations with local communities?					
ST3	To what extent do international stakeholders view the project positively?					

Thank you for your participation!

APPENDIX III: Key Informant Interview Guide for Senior Officials

TITLE: Risk Mitigation Strategies and Performance of Large Infrastructure Projects: A Case of the Grand Ethiopian Renaissance Dam

Introduction:

Thank you for agreeing to participate in this interview. I am Ermias Mekonnen Robi, a Master's student at The Catholic University of Eastern Africa. This interview is part of my research examining risk mitigation strategies and their relationship to the performance of the Grand Ethiopian Renaissance Dam project.

This interview process will take around 60-90 minutes to complete. I would also like to record this interview with your permission, to ensure that I capture your views accurately. Your information will be kept confidential, and your identity will not be revealed in the final report.

This interview is completely voluntary, and you may choose not to answer any question or terminate the interview at any point of time. Do you have any questions before we begin the interview process?

Respondent Information:

- Position/Role: _____
- Years with GERD Project: _____
- Date: _____
- Interview Code: _____

Interview Questions:

A. General Overview

1. Could you briefly describe your role and involvement in the GERD project?
2. From your perspective, what have been the most significant risks facing the GERD project throughout its implementation?

B. Financial Risk Mitigation

3. How would you describe the financial risk mitigation strategies employed in the GERD project?
4. What financial risks were most challenging to manage, and how were they addressed?
5. How effective do you consider the financial risk mitigation approaches, and why?

C. Technical Risk Mitigation

6. What technical risks were identified as most significant for the project?
7. How were technical risks mitigated, particularly given the project's unprecedented scale?
8. What technical challenges emerged during implementation, and how were they addressed?

D. Political Risk Mitigation

9. How has the project managed political risks, particularly those related to transboundary water issues?
10. What role have diplomatic engagement and international cooperation played in risk mitigation?
11. How have relationships with downstream countries affected project implementation?

E. Environmental Risk Mitigation

12. What environmental risks were identified, and how have they been mitigated?
13. How effective has environmental management been throughout project implementation?
14. Have environmental considerations affected project design or implementation?

F. Project Performance

15. How would you assess the overall performance of the GERD project to date?
16. What factors have most significantly influenced project performance?
17. How do risk mitigation strategies relate to the performance outcomes you've observed?

G. Lessons and Recommendations

18. What lessons from the GERD experience would be valuable for future large infrastructure projects in Ethiopia or elsewhere?
19. What recommendations would you offer for improving risk mitigation in similar projects?
20. Is there anything else you would like to add about risk mitigation and performance of the GERD?

Thank you for your valuable contribution to this research.

APPENDIX IV: Document Review Checklist

Project: Grand Ethiopian Renaissance Dam

Researcher: Ermias Mekonnen Robi

Document Information	**Details**
Document Title	
Document Type	[ ] Progress Report [ ] Risk Register [ ] Technical Report [ ] EIA Document [ ] Meeting Minutes [ ] Other:
Date of Document	
Issuing Authority/Author	
Document Reference Number	
Access Level	[ ] Public [ ] Internal [ ] Restricted

Risk Mitigation Information	**Findings**	**Page Reference**
Financial risk mitigation strategies mentioned		
Technical risk mitigation strategies mentioned		
Political risk mitigation strategies mentioned		
Environmental risk mitigation strategies mentioned		
Risk identification and assessment processes		
Specific mitigation measures described		
Performance Information	**Findings**	**Page Reference**
Schedule performance information		
Cost performance information		
Technical quality information		
Stakeholder feedback/satisfaction		
Performance against objectives		
Additional Observations		

APPENDIX V: Study Area Map (Grand Ethiopian Renaissance Dam)



[Map of Ethiopia showing:
- Location of GERD on the Blue Nile
- Proximity to Sudanese border
- Benishangul-Gumuz region
- Distance from Addis Ababa (approximately 750 km)
- Blue Nile course from Lake Tana to Sudan
- Major nearby towns (Assosa, Guba)
- Reservoir area (approximately 1,874 km²)]

Figure 9: Map of the Grand Ethiopian Renaissance Dam Project Area

Source: Adapted from Ethiopian Mapping Agency (2023)

Map Description: The Grand Ethiopian Renaissance Dam is located on the Blue Nile River, in the Benishangul-Gumuz region of western Ethiopia, at 20-40 km east of the Sudan border. The exact location of the dam is at coordinates about 11°12′N, 35°05′E. The reservoir stretches about 250 km upstream, toward the highlands of Ethiopia. This region is rugged and the Blue Nile river flows through deep gorges before reaching the dam site.

APPENDIX VI: NACOSTI Permit

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FDRE Education and Training Authority

ቀን/ Date 20/06/2018
ቁጥር/ Ref.No ETA-AUTH-26-05728

ለሚመለከተው ሁሉ

ጉዳዩ፡ የምርምር ፈቃድ ስለመስጠት

የኢትዮጵያ ትምህርትና ሥልጠና ባለሥልጣን **አቶ ኤርሚያስ መኮንን ሮቢ** በኢ.ፌ.ዲ.ሪ ወሰን ውስጥ **"Risk Mitigation Strategies and Performance of Large Infrastructure Projects: A Case of the Grand Ethiopian Renaissance Dam"** በሚል ርዕስ አካዳሚያዊ ምርምር እንዲያካሂዱ በይፋ የተፈቀደላቸው መሆኑን ያረጋግጣል። ተመራማሪው እስከ ግንቦት 23 ቀን 2018 ዓ.ም ድረስ ቃለ-መጠይቆችን ለማካሄድ፣ የጽሑፍ መጠይቆችን ለማሰራጨት እና አግባብነት ያላቸውን አካዳሚያዊ መረጃዎችን ለመሰብሰብ ፈቃድ ተሰጥቷቸዋል።

To Whom It May Concern

Subject: Research Permit

The Education and Training Authority of Ethiopia hereby confirms that **Mr. Ermias Mekonnen Robi** is officially permitted to conduct academic research within the FDRE on the topic: **"Risk Mitigation Strategies and Performance of Large Infrastructure Projects: A Case of the Grand Ethiopian Renaissance Dam"**. The researcher is authorized to conduct interviews, distribute questionnaires, and gather relevant academic data for the period ending May 31, 2026.

Habtamu G/Medhin Abebe
General Education Control and Inspections Chief Executive Officer

☎ PBX No: (+251) 11 524 2230/ 238330
☎ Phone No: (+251) 11 528 1028/ 237517
🖷 Fax No: (+251) 11 561 1486 / 231927

"ለትምህርትና ስልጠና ጥራት እንተጋለን!"
"Committed to Education and Training Quality!"
In reply please quote our Ref.No
መልስ ሲጽፉልን የኛን የደብዳቤ ቁጥር ይጥቀሱ

🌐 Web: https://eta.et
✉ E-mail: info.eta1@gov.et
✉ P.O.Box: 27734
Addis Ababa, Ethiopia

APPENDIX VII: Ethics Clearance Letter

THE CATHOLIC UNIVERSITY OF EASTERN AFRICA

Faculty of Arts and Social Sciences

Department *of Social Sciences and Development Studies*

16-Jul-26

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

RE: ERMIAS MEKONNEN ROBI - REG. NO. 1064679

This letter is to confirm that the above-named individual is a Post-graduate student pursuing a **Master of Arts in Project Planning and Management** at The Catholic University of Eastern Africa.

As part of the degree requirements, the student is required to undertake a research study with the title:

"RISK MITIGATION STRATEGIES AND PERFORMANCE OF LARGE INFRASTRUCTURE PROJECTS: A CASE OF THE GRAND ETHIOPIAN RENAISSANCE DAM."

The information gathered during this study will be used solely for academic purposes and will be handled with strict confidentiality.

Any assistance accorded to the student will be highly appreciated.

Yours faithfully,

CATHOLIC UNIVERSITY OF EASTERN AFRICA
HEAD OF DEPARTMENT
17 JUL 2025
SOCIAL SCIENCES AND DEVELOPMENT STUDIES
P.O. Box 62157-00200, NAIROBI

Dr. Mary Mutisya
HoD, Department of Social Sciences and Development Studies

THE CATHOLIC UNIVERSITY OF EASTERN AFRICA (CUEA) P.O. BOX 62157 00200 Nairobi – KENYA
Tel: 020-2525811-5, 8890023-4, Fax: 8891084, Email: Website: www.cuea.edu
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APPENDIX VIII: CUEA Plagiarism/Originality Report

THE CATHOLIC UNIVERSITY OF EASTERN AFRICA
INFORMATION SYSTEMS LIBRARIAN
TURNITIN ORIGINALITY REPORT

REF: PGS/FASS/1190/DEFENSE/LANGATA,



I HEREBY CONFIRM THAT **ERMIAS MEKONNEN ROBI** REG NO: **1064679**, SUBMITTED A CHECK OF ANTIPLAGIARISM ON CRITICAL EVALUATION OF **RISK MITIGATION STRATEGIES AND PERFORMANCE OF LARGE INFRASTRUCTURE PROJECTS: A CASE OF THE GRAND ETHIOPIAN RENAISSANCE DAM. A RESEARCH THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN PROJECT PLANNING AND MANAGEMENT AT THE CATHOLIC UNIVERSITY OF EASTERN AFRICA.**

Verification by Systems Librarian:

Name: ...HARUN ... MAINA ..... Signature: ..... Date: 12/6/2026

The Catholic University of Eastern Africa
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