School of Postgraduate Studies

EFFECT OF ADVANCED PROJECT MANAGEMENT TECHNOLOGIES ON ROAD PROJECT PERFORMANCE: A QUALITATIVE STUDY OF ROAD DEVELOPMENT AGENCY IN ZAMBIA

A Proposal Submitted to the School of Postgraduate Studies, University of Lusaka in Partial Fulfillment of the ward of the Master of Science in Project Management.

BY

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DECLARATION

Declaration by Candidate

I declare that this dissertation titled **Effect of Advanced Project Management Technologies on Road Project Performance: A Qualitative Study of Road Development Agency in Zambia** is my own original work and has not been submitted for any degree or examination in any other institution. It is being submitted in partial fulfilment of the degree of Masters of Project Management to the University of Lusaka (UNILUS), Lusaka.

.... January 24, 2025

Signature Date

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Declaration by Supervisor

I confirm that the research presented in this study was conducted by the student under my supervision and is submitted with my consent as the University Supervisor.

.... January 23, 2025

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DEDICATION

This dissertation is dedicated to my beloved wife, **Esther Sosala**, whose unwavering support and encouragement have been a cornerstone of my journey. To my dear children, **Francis S. Poto Jr, and Sheinah N. Poto**, your love and joy have inspired me to persevere through every challenge. I also express my sincere gratitude to the **University of Lusaka (UNILUS)** for the opportunity to develop my skills and for their cooperation in ensuring the success of this study. Above all, I dedicate this work to the Almighty God, whose grace, wisdom, and protection have been my strength throughout this endeavor.

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LIST OF ACRONYMS

3D - Three-Dimensional

AFDB – African Development Bank Group

IRCP – Improved Rural Connectivity Project

IT - Information Technology

KPI - Key Performance Indicators

M&E - Monitoring and Evaluation

OPRC - Output and Performance-Based Road Contract

APMT – Project Management Technologies

PPP - Public-Private Partnership

R – Respondent

RBV - Resource-Based View

RDA - Road Development Agency

ROADSIP – Zambia Road Sector Investment Program Project

ROI - Return on Investment

WB – World Bank

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THE ABSTRACT

With an emphasis on the Road Development Agency (RDA), this study investigates how cutting-edge project management technologies affect road development projects in Zambia. The study explores how advanced technologies such as artificial intelligence (AI), building information modeling (BIM), the internet of things (IoT), robotics, drones, and predictive analytics can improve project performance in light of the challenges faced by road projects, including delays, cost overruns, and quality issues. Using a qualitative methodology involving case studies and semi-structured interviews with RDA engineers, the study examines how these technologies can be integrated into road projects to enhance efficiency, safety, cost management, and stakeholder satisfaction. The findings reveal that technologies like BIM, AI, and IoT have the potential to optimize road planning, reduce construction costs, and improve quality by providing real-time data and enabling better decision-making. However, the study also identifies significant challenges, such as high upfront costs, resistance to change, and a shortage of skilled personnel. To address these barriers, the study recommends enhancing workforce training, standardizing digital platforms, and fostering a culture of innovation. The research underscores the importance of strategic technology integration to improve project delivery and support Zambia's sustainable infrastructure development, aligning with the nation's broader socio-economic goals.

Keywords: Road Development Agency, project management technologies, artificial intelligence, building information modeling, internet of things, predictive analytics, sustainable infrastructure, Zambia.

CHAPTER ONE
INTRODUCTION

1.1 Background of the study

The development and maintenance of road infrastructure are fundamental to economic growth and social development, as they enhance trade, improve connectivity, and facilitate mobility (World Bank, 2021). In Zambia, significant investments have been made in road construction projects through government initiatives and collaborations with international development agencies, such as the African Development Bank (AfDB, 2020). Despite these efforts, road projects continue to face persistent challenges, including cost overruns, schedule delays, substandard work, and inefficient resource management (Chileshe & Kangwa, 2019). These inefficiencies not only delay the delivery of critical infrastructure but also increase project costs, ultimately affecting economic productivity and public service delivery (Silwamba, 2023).

One of the major contributors to these inefficiencies is the reliance on traditional project management methods, which often lack real-time data tracking, predictive analytics, and automated reporting mechanisms (Obuya, 2023). Studies indicate that poor stakeholder coordination, inadequate risk management, and inefficient procurement processes further exacerbate these challenges (Onsongo, 2022). Additionally, issues such as delayed contractor payments, weak regulatory enforcement, and resource misallocation have been identified as key barriers to road project success (Silwamba, 2023).

1.1.1 The Role of the Road Development Agency (RDA) in Road Project Performance

The Road Development Agency (RDA) is the statutory body responsible for the construction, maintenance, and management of Zambia's public road network, established under the Public Roads Act No. 12 of 2002. Operating under the Ministry of Infrastructure, Housing, and Urban Development (MIHUD), RDA ensures that road projects align with Zambia's economic development goals (Government of Zambia, 2002). Given the persistent challenges of cost overruns, delays, and substandard infrastructure, the integration of Advanced Project Management Technologies (APMT) within RDA is crucial to enhancing project efficiency, cost control, and overall performance (Chileshe & Kangwa, 2019).

This study focuses on RDA’s role in project planning, execution, and performance monitoring, assessing how digital transformation and APMT adoption can improve road project outcomes. Understanding the institutional responsibilities and challenges facing RDA provides a critical foundation for evaluating technological innovations in project management within Zambia’s road sector.

1.1.2 Rationale for the Study

Given the growing complexity of road projects, there was a critical need to assess how APMT could enhance road project performance in Zambia. Existing research had predominantly focused on quantitative evaluations of project success factors, yet there remained a gap in qualitative insights into the experiences, challenges, and perceptions of key stakeholders regarding the adoption and effectiveness of these technologies (Obuya, 2023). Understanding the practical barriers and enablers of digital transformation in project management was essential for policy formulation, industry best practices, and improved decision-making in Zambia’s road sector (Onsongo, 2022).

This study, therefore, sought to explore the effect of APMT on road project performance at the Road Development Agency (RDA) in Zambia. By employing a qualitative research approach, the study examined the experiences of project managers, engineers, and consultants to determine the extent to which advanced PMT adoption influenced key project performance indicators such as time efficiency, cost control, and stakeholder satisfaction. The findings provided strategic recommendations on overcoming technological adoption challenges, thereby contributing to improving road project efficiency, reducing costs, and ensuring high-quality infrastructure development in Zambia.

1.2 Statement of the Problem

Despite significant investments in Zambia’s road infrastructure, many road construction projects continued to experience poor performance, characterized by delays, cost overruns, and substandard quality (Chileshe & Kangwa, 2019). The inability to deliver projects on time, within budget, and at the required quality standards led to economic inefficiencies, public dissatisfaction, and increased maintenance costs (Silwamba, 2023). One of the most affected projects, the Itezhi Tezhi D769 road, was planned for completion in 24 months but remained incomplete over six years later, with only 70 km out of the planned 109 km finished (Silwamba, 2023).

A major factor contributing to these inefficiencies was the continued reliance on traditional project management methods, which lacked real-time monitoring, predictive analytics, and automated cost tracking (Obuya, 2023). Many road projects still used manual documentation and fragmented communication channels, leading to ineffective scheduling, procurement inefficiencies, and weak stakeholder coordination (Mwansa & Tembo, 2020). As a result, project execution became highly reactive rather than proactive, making it difficult to mitigate risks and ensure timely completion (Onsongo, 2022).

Globally, APMT such as BIM, GIS, electronic procurement systems, and automated scheduling tools had significantly improved project performance, cost efficiency, and risk management (Eadie et al., 2013; Azhar, Khalfan & Maqsood, 2015). However, in Zambia, the adoption of these technologies remained limited, primarily due to high implementation costs, lack of technical expertise, resistance to change, and inadequate policy frameworks (Mulenga & Phiri, 2021).

Existing research on project performance in Zambia's road sector had focused mainly on quantitative assessments, such as cost analysis and delay factors, with little emphasis on qualitative insights into stakeholder experiences, adoption challenges, and implementation barriers of APMT (Obuya, 2023). There was a critical need to explore how APMT could be effectively integrated into Zambia's road sector, particularly within the Road Development Agency (RDA), to improve project planning, monitoring, and execution efficiency.

This study, therefore, sought to bridge this gap by examining the effect of Advanced Project Management Technologies on road project performance at the Road Development Agency in Zambia. By adopting a qualitative research approach, the study provided in-depth insights into the adoption, effectiveness, and challenges of APMT, offering strategic recommendations for improving project efficiency, reducing costs, and ensuring better infrastructure delivery.

1.3 Research Objectives

To assess the effect of APMT on road project performance in Zambia.

1.3.1 Specific Objectives

1. To determine the APMT used in project management at RDA.
2. To evaluate the effect of APMT on the key performance metrics of road projects, including time, cost, quality, and stakeholder satisfaction.
3. To examine the barriers and challenges hindering APMT adoption.
4. To establish strategies for optimising the use of APMT.

1.4 Research Questions

i. What APMT are used in project management within RDA?
ii. How does APMT affect key performance metrics such as time, cost, quality, and stakeholder satisfaction in project management at RDA?
iii. What barriers and challenges hinder the adoption of APMT in project management within RDA??
iv. What strategies can be implemented to optimize the use of APMT in project management at RDA?

1.5 Significance of the Study

The significance of this study lies in its potential to enhance project management practices within the RDA by examining the role of APMT in improving road project performance. Zambia's road construction sector faces persistent challenges such as delays, cost overruns, substandard quality, and inefficient project execution, which hinder infrastructure development and economic growth. This study provides valuable insights into how digital transformation can optimize project management within RDA and, by extension, the entire road sector. By identifying the types of APMT in use, their effect on project performance, and the challenges of adoption, the study contributes to the development of effective strategies for enhancing project efficiency, cost-effectiveness, and quality control.

This research is significant for several key stakeholders, including RDA, policymakers, contractors, researchers, international funding agencies, and the general public:

1.5.1 The Road Development Agency (RDA)

As the primary agency responsible for road infrastructure development in Zambia, RDA is expected to benefit the most from this study. By assessing the types of APMT in use, their effect on project performance, and barriers to adoption, the study will generate data-driven insights that can enhance efficiency in project planning, execution, and monitoring. Furthermore, the study will contribute to improving time, cost, and quality performance through the adoption of technology-driven project management solutions. It will also address challenges in APMT adoption, such as limited technical expertise, high implementation costs, and resistance to change. The findings will enable RDA to develop informed strategies for digital transformation, ensuring that APMT adoption aligns with Zambia's infrastructure development goals. Additionally, the study will support evidence-based decision-making regarding investments in digital tools and capacity-building initiatives aimed at optimizing road project performance.

1.5.2 Government and Policymakers

The study will assist government bodies such as the Ministry of Infrastructure, Housing, and Urban Development in formulating policies and regulatory frameworks to support APMT adoption in public road projects. Strengthening digital integration policies in infrastructure management will be crucial for improving project planning and execution efficiency. Additionally, the study will provide recommendations on encouraging funding mechanisms for APMT investment, ensuring that financial resources are directed toward modernizing project management practices. By establishing national standards for technology adoption in public sector project management, policymakers will be able to enhance transparency, accountability, and project sustainability. This will ensure that project management practices align with global best practices and improve overall road sector performance

1.5.3 Contractors and Consultants in the Road Sector

The study will be valuable to contractors and consultants working with RDA, many of whom may lack full exposure to advanced digital tools for project management. The research will highlight the role of APMT in improving collaboration, decision-making, and project efficiency. By identifying training needs and skills gaps, the study will contribute to the development of capacity-building programs that enhance the adoption and utilization of APMT. Additionally, the study will provide recommendations on best practices for digital project management, ensuring that contractors and consultants align their operations with modernized infrastructure delivery approaches.

1.5.4 Academic and Research Institutions

The study will contribute to the existing body of knowledge on project management in Zambia's road sector, providing a foundation for future research. It will address the research gap on qualitative insights into APMT adoption in public sector project management by providing empirical evidence on the effect of APMT on project performance metrics, including time efficiency, cost control, quality improvement, and stakeholder satisfaction. The study will serve as a reference for future studies on digital transformation in infrastructure project management, informing academic curricula and policy discussions on technology-driven project execution.

1.5.5 International Development Agencies and Investors

The study will provide value to organizations such as the World Bank, African Development Bank (AfDB), and other funding institutions, which require efficient project management systems to ensure the success of road infrastructure investments. The findings will demonstrate how APMT adoption enhances transparency, accountability, and efficiency in road project management. The study will also provide data-driven recommendations on integrating APMT into project funding agreements and technical assistance programs, ensuring that international investors prioritize technology adoption in Zambia's infrastructure projects.

1.5.6 The General Public and Road Users

Efficient road project management directly benefits the general public by ensuring timely infrastructure delivery, reducing costs, and improving road quality. The study is expected to contribute to public welfare by ensuring the timely completion of road projects, reducing delays that inconvenience commuters and businesses. Additionally, it will facilitate resource optimization and cost reduction, leading to more efficient use of public funds. The research will also contribute to improved road quality and durability, enhancing safety and minimizing long-term maintenance expenses. Further, by improving Zambia's transportation infrastructure, the study will support economic growth by fostering trade, investment, and social development.

1.6 Scope and Delimitation of the Study

This study examined the effect of APMT on road project performance in Zambia, focusing on the RDA. It evaluated the influence of APMT on key performance indicators such as time efficiency, cost control, quality assurance, and stakeholder satisfaction, while also identifying challenges to adoption and strategies for optimization.

Geographically, the study was limited to Zambia, specifically RDA's road project management processes, excluding private-sector projects or international agencies. Methodologically, a qualitative approach was used, incorporating interviews, document reviews, and expert insights from RDA stakeholders. The study did not include quantitative statistical analyses, financial estimations, or predictive modeling.

Temporally, the research focused on APMT adoption over the past decade, without assessing future technologies not yet introduced at RDA. The study was further delimited to RDA's overall project management framework rather than individual road projects. While it identified challenges and opportunities in APMT adoption, it did not provide a detailed implementation framework but instead recommended strategies for improving APMT utilization in Zambia's road sector.

1.7 Definition of key concepts

This section defines the key concepts used in the study to ensure clarity and consistency in interpretation. The definitions are drawn from existing literature and contextualized to align with the study's focus on Advanced Project Management Technologies (APMT) and road project performance in Zambia.

Advanced Project Management Technologies (APMT): are defined as digital tools and software solutions designed to enhance project planning, execution, monitoring, and evaluation (Eadie et al., 2013). These technologies include BIM, GIS, electronic procurement systems, automated scheduling software such as Primavera P6 and Microsoft Project, and cloud-based collaboration platforms (Azhar, Khalfan & Maqsood, 2015).

Project performance: refers to the extent to which a project meets its predefined objectives in terms of cost, time, quality, and stakeholder satisfaction (Kerzner, 2017).

Time performance: in project management refers to the ability of a project to be completed within its scheduled timeframe (PMI, 2021).

Cost performance: refers to the extent to which a project remains within its allocated budget (Kerzner, 2017).

Quality performance: relates to the degree to which a project meets established engineering standards, durability expectations, and safety requirements (PMI, 2021).

Stakeholder satisfaction: measures the degree to which project stakeholders including government agencies, contractors, funding institutions, and road users are satisfied with project outcomes (Mulenga & Phiri, 2021).

The Road Development Agency (RDA): is the statutory body responsible for planning, designing, constructing, and maintaining Zambia's public road network (Government of Zambia, 2002). Established under the Public Roads Act No. 12 of 2002, RDA operates under the Ministry of Infrastructure, Housing, and Urban Development and is mandated to ensure that road infrastructure projects align with Zambia's economic and social development goals (Ministry of Infrastructure, Housing, and Urban Development, 2021).

Project management: is the application of knowledge, skills, tools, and techniques to meet project objectives efficiently (PMI, 2021). It encompasses various knowledge areas, including project integration, scope, time, cost, quality, resource, risk, procurement, and stakeholder management (Kerzner, 2017).

The definitions provided in this section established a clear conceptual framework for understanding the key terms used in the study. They ensured consistency in interpretation and aligned with existing literature on Advanced Project Management Technologies (APMT), project performance, and road infrastructure development in Zambia.

1.8 Chapter Summary

This chapter introduces the study on the role of APMT in enhancing road project performance in Zambia, focusing on the RDA. Despite significant investments, road projects continue to face delays, cost overruns, and quality issues due to reliance on traditional project management methods and limited adoption of APMT like BIM and GIS. The study examines the impact of APMT on time, cost, quality, and stakeholder satisfaction, explores adoption barriers, and proposes optimization strategies. Using a qualitative approach, it gathers stakeholder insights to improve project planning, monitoring, and execution. The chapter also outlines the research objectives, questions, significance, and scope while defining key concepts.

CHAPTER TWO:
LITERATURE REVIEW

2.1 Introduction

This chapter provides a comprehensive review of existing literature on the adoption and impact of Advanced Project Management Technologies (APMT) in road construction projects. It begins with a theoretical foundation, exploring key models and frameworks that explain the factors influencing APMT adoption and its role in improving project performance. The chapter then transitions to an empirical review, analyzing real-world applications of APMT in road construction across global, continental, regional, and local contexts. Finally, the chapter identifies research gaps based on the reviewed literature, highlighting areas that require further investigation.

2.2 Theoretical Literature Review

2.2.1 Diffusion of Innovations Theory

The Diffusion of Innovations (DOI) Theory, proposed by Everett Rogers in 1962, explains how new technologies and innovations are adopted over time within organizations and society. It identifies five key attributes that influence the rate of adoption: relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003). These factors determine whether an innovation will be accepted or resisted.

In the context of Advanced Project Management Technologies (APMT) in road project management, DOI is highly relevant. Studies have shown that the adoption of Building Information Modeling (BIM), Geographic Information Systems (GIS), and electronic procurement systems is influenced by their perceived benefits, compatibility with existing processes, and the ease of use (Abuzeinab et al., 2019; Al-Hussein et al., 2014).

For example, in Zambia's road sector, the slow adoption of APMT can be linked to high implementation costs, resistance to change, and lack of technical expertise, all of which align with the barriers outlined in DOI (Mulenga & Phiri, 2021). To facilitate the diffusion process, organizations like the Road Development Agency (RDA) need to implement targeted training and awareness programs to reduce complexity and increase trialability.

2.2.2 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), developed by Davis (1989), is one of the most widely used frameworks for analyzing technology adoption in organizations. It proposes that the two primary factors influencing adoption are:

i. Perceived Usefulness (PU) – The extent to which technology enhances job performance.
ii. Perceived Ease of Use (PEOU) – The degree to which using the technology is free from effort.

In road project management, studies applying TAM have found that project managers and engineers are more likely to adopt digital project management tools if they perceive them as beneficial and easy to use (Adjei & Anin, 2021).

For instance, electronic procurement systems in road construction have been shown to improve transparency, cost efficiency, and decision-making. However, if users perceive them as complex or requiring extensive training, adoption is hindered (Al-Jaghoub et al., 2017).

2.2.3 Resource-Based View (RBV) Theory

The Resource-Based View (RBV), developed by Barney (1991), argues that an organization's unique resources and capabilities determine its competitive advantage. These resources should be valuable, rare, inimitable, and non-substitutable (VRIN criteria) to sustain long-term success.

In the context of APMT adoption, RBV suggests that organizations need to develop technical expertise, invest in software and hardware, and create policies that support digital transformation. Studies have shown that firms with strong IT infrastructure and skilled personnel are more likely to succeed in implementing digital project management tools (Lee & Kim, 2018).

For RDA and other road agencies in Zambia, applying RBV means:

- Investing in APMT-specific training programs for staff.
- Allocating financial resources for advanced digital tools like BIM and Primavera P6.

- Developing an organizational culture that embraces technology-driven project management.

2.2.4 Systems Management Theory

The Systems Management Theory (SMT), introduced by Ludwig von Bertalanffy in the 1950s, views organizations as complex systems composed of interdependent parts that must work together for efficiency. This theory highlights the importance of coordination, communication, and integration in technology adoption.

For road project management, SMT is useful in understanding how multiple stakeholders; government agencies, contractors, engineers, and suppliers must align their operations to effectively implement APMT (Georges & Charles, 2013).

2.2.5 Stakeholder Theory

The Stakeholder Theory, introduced by Freeman (1984), emphasizes that organizations should consider the interests of all stakeholders when making decisions. Stakeholders in road project management include:

- Government agencies (e.g., RDA, Ministry of Infrastructure)
- Contractors and suppliers
- Donor agencies and financial institutions
- Local communities and road users

Applying Stakeholder Theory to APMT adoption means that decision-makers must engage all relevant stakeholders in the implementation process. Research shows that resistance from contractors and regulatory delays are key barriers to technology adoption in infrastructure projects (Woldegiorgis, 2023).

2.2.6 Project Management Maturity Model (PMMM) in Road Construction

The Project Management Maturity Model (PMMM) assesses an organization's project management capabilities through five levels, ranging from ad hoc execution to continuous improvement (Kerzner, 2017; Crawford, 2006). Higher PMMM levels correlate with reduced cost overruns, fewer delays, and improved quality control (Görög, 2016). Developed economies, such as the U.S. and U.K., have successfully integrated digital tracking and AI-driven forecasting into PMMM structures, enhancing efficiency (Mullaly & Thomas, 2009).

However, PMMM adoption in Africa remains low, with road agencies in Zambia, Kenya, and South Africa operating mostly at lower levels due to weak policy enforcement, inadequate training, and resistance to change (Svejvig & Andersen, 2015; Chileshe & Kangwa, 2019). The RDA in Zambia faces similar challenges, including procurement inefficiencies and weak contract oversight (Obuya, 2023). Advancing PMMM requires structured frameworks, digital tracking, workforce training, and policy reforms to enhance road project outcomes (Eadie et al., 2013; Mulenga & Phiri, 2021).

2.3 Empirical Review

The empirical review examined research on project performance and APMT adoption in road construction, focusing on real-world data, trends, and practical impacts. It assessed how APMT influenced time, cost, quality, and stakeholder satisfaction while identifying key factors that affected project performance in Zambia's road sector through global and regional insights.

2.3.1 Integration of Project Management and Technology in Road Construction

Project management in road construction involves the application of structured methodologies, tools, and techniques to ensure projects are completed on time, within budget, and to the required quality standards. According to the PMBOK Guide (2013), key areas of project management include: project integration management, scope management, time management, cost management, quality management, human resources management, communications management, risk management, procurement management, and stakeholder management as fundamental to project success (PMI, 2021). The application of these principles can significantly enhance road project efficiency, yet many projects in Zambia fail to fully implement structured project management approaches (Mulenga & Phiri, 2021).

Globally, the integration of Advanced Project Management Technologies (APMT) has revolutionized the construction industry by streamlining project planning, improving cost estimation, enhancing risk management, and fostering better communication among stakeholders (Eadie et al., 2013; Zhou, Whyte & Sacks, 2012). Tools such as Building Information Modeling (BIM), Geographic Information Systems (GIS), electronic procurement systems, and project scheduling software (e.g., Primavera P6 and Microsoft Project) have been widely adopted in developed economies, leading to improved road project performance, better resource utilization, and enhanced project transparency (Azhar, Khalfan & Maqsood, 2015).

However, in Zambia, the adoption of such technologies remains limited due to factors such as high implementation costs, limited technical expertise, resistance to change, and inadequate policy support (Mwansa & Tembo, 2020). Many road projects still rely on manual documentation, fragmented communication channels, and outdated scheduling techniques, leading to delays, increased costs, and compromised quality standards (Chomba et al., 2022). Furthermore, poor data integration and ineffective stakeholder collaboration often result in mismatched expectations and disputes between contractors, government agencies, and funding institutions (Woldegiorgis, 2023).

2.3.2 Organizational Change and Technology Adoption in Public Sector Institutions

The adoption of APMT in public sector institutions is crucial for improving efficiency, transparency, and project performance. However, challenges such as bureaucratic resistance, regulatory constraints, and limited technical capacity hinder widespread implementation (Mulenga & Phiri, 2021). The Diffusion of Innovation (DOI) Theory explains the stages of technology adoption, while the Technology-Organization-Environment (TOE) model highlights key influencing factors, including regulatory frameworks and institutional readiness (Tornatzky & Fleischer, 1990). Similarly, Lewin's Change Management Model underscores the importance of structured transitions in overcoming resistance to change (Chileshe & Kangwa, 2019).

In Zambia, RDA faces significant barriers to APMT adoption, including rigid policies, hierarchical decision-making, inadequate ICT infrastructure, and a lack of technical skills (Onsongo, 2022). Decision-making delays, financial constraints, and limited digital literacy among engineers and project managers further slow down adoption (Obuya, 2023). Additionally, weak procurement regulations and resistance from compliance officers who favor manual processes restrict the transition to digital tools such as BIM, GIS, and automated scheduling systems (Silwamba, 2023). Financial constraints also pose significant challenges, as the costs associated with software licenses, hardware upgrades, and training are often high for agencies with limited budgets (Mwansa & Tembo, 2020). Infrastructure limitations, such as restricted access to high-speed internet in rural project sites, further hinder real-time project monitoring (Eadie et al., 2013).

To overcome these obstacles, policy reforms must support the integration of digital tools in procurement and project management (Onsongo, 2022). Capacity-building initiatives should enhance workforce skills in APMT, while partnerships with universities and private sector stakeholders can foster technical training (Chileshe & Kangwa, 2019). Pilot testing and phased implementation of APMT can help minimize risks, ensuring smooth adoption (Eadie et al., 2013). Leadership commitment, awareness campaigns, and regulatory support are essential for accelerating digital transformation in Zambia's road sector (Silwamba, 2023). By addressing these challenges, RDA can optimize project performance through improved decision-making, real-time monitoring, and enhanced efficiency.

2.3.3 Advanced Project Management Technologies (APMT) and Their Impact on Road Project Performance

Advanced Project Management Technologies (APMT) refer to digital tools, software, and methodologies designed to improve the efficiency, accuracy, and overall management of construction projects (Eadie et al., 2013; Azhar, Khalfan & Maqsood, 2015). These technologies include Building Information Modeling (BIM), Geographic Information Systems (GIS), electronic procurement systems, project scheduling software (e.g., Primavera P6, Microsoft Project), artificial intelligence-driven project monitoring, and cloud-based collaboration tools (Eadie et al., 2013). These tools enhance project execution by facilitating real-time data collection, predictive analytics, automated reporting, and improved stakeholder coordination (Zhou, Whyte & Sacks, 2012).

2.3.3.1 Role of APMT in Enhancing Project Performance

i. Planning and Design

APMT plays a significant role in project planning and design by enhancing the accuracy and efficiency of project conceptualization and early-stage decision-making. BIM, for instance, enables engineers and project managers to create 3D and 4D models that improve visualization, minimize design errors, and enhance cost estimation (Azhar, Khalfan & Maqsood, 2015). Additionally, GIS supports spatial analysis, enabling site selection, terrain evaluation, and environmental impact assessments (Mwansa & Tembo, 2020). Digital twins and AI-powered predictive modeling also facilitate risk assessments in the pre-construction phase, reducing project uncertainties (Chomba et al., 2022).

ii. Execution and Monitoring

Project execution benefits significantly from APMT due to the integration of automated progress tracking, real-time reporting, and AI-powered project analytics (Eadie et al., 2013). Electronic procurement systems enhance bid evaluation, contract management, and supplier tracking, reducing procurement delays (Onsongo, 2022). Project scheduling software like Primavera P6 and Microsoft Project optimizes time management, ensuring critical path tasks are effectively monitored (Mulenga & Phiri, 2021). AI-powered construction site monitoring tools also use drones and IoT sensors to track project activities, detect deviations, and alert managers in real time (Zou et al., 2018).

iii. Stakeholder Collaboration

APMT fosters seamless communication and collaboration among project stakeholders by enabling cloud-based document sharing, video conferencing, and automated reporting (Chileshe & Kangwa, 2019). Poor communication and misaligned expectations are major contributors to project delays and cost escalations, particularly in multi-agency infrastructure projects (Silwamba, 2023). Digital dashboards and blockchain-based project transparency systems have been successfully implemented in developed economies to improve contractor accountability, procurement integrity, and real-time project audits (Tadesse & Mulugeta, 2017).

2.3.3.2 Effect of APMT on Road Project Performance

This subsection delves into the measurable outcomes of APMT adoption in road construction. It examines the impact of APMT on time, cost, and quality performance metrics, as well as its role in decision-making, monitoring, and stakeholder collaboration.

i. Impact on Time, Cost, and Quality Performance Metrics

Studies indicate that APMT has a direct positive impact on project time management, cost control, and quality assurance. Digital scheduling tools improve project adherence to timelines, while AI-based procurement tracking reduces fraud and budget misallocations (Li & Wu, 2019). Additionally, the use of BIM and GIS for site planning ensures compliance with design specifications, enhancing road durability and safety (Eadie et al., 2013).

ii. Role in Decision-Making, Monitoring, and Stakeholder Collaboration

The implementation of predictive analytics, real-time dashboards, and cloud-based project tracking enhances decision-making processes, reduces risks, and fosters transparent stakeholder engagement (Mulenga & Phiri, 2021). Research shows that real-time digital monitoring can reduce project delays by over 30%, ensuring faster corrective actions when necessary (Silwamba, 2023).

iii. Digital Tools for Risk Management and Project Efficiency

AI-driven risk assessment models, blockchain-based procurement validation, and automated financial auditing tools are becoming essential for risk mitigation and project efficiency (Tadesse & Mulugeta, 2017). Studies show that road projects using these tools experience 25% lower cost overruns and improved compliance with contract milestones (Eadie et al., 2013).

2.3.3.3 Technological Innovations and Global Adoption Trends

Globally, the integration of APMT has led to major advancements in infrastructure project management. Countries such as the United Kingdom, Germany, China, and the United States have established policies mandating the use of BIM, GIS, and electronic procurement systems for road projects, leading to enhanced cost control and risk mitigation (Eadie et al., 2013). The adoption of AI-powered predictive scheduling and automated cost estimation tools has further improved project efficiency in Japan and Singapore (Jiang et al., 2017). However, developing countries, particularly in Africa, still struggle with low adoption rates due to high costs, lack of technical expertise, and limited regulatory frameworks (Mwansa & Tembo, 2020).

2.3.3.4 Case Studies on APMT Implementation in Road Construction

Empirical research on Advanced Project Management Technologies (APMT) implementation in road construction has produced varying results across different countries. The effectiveness of APMT depends on institutional capacity, investment in digital tools, and regulatory frameworks. This section presents case studies at the global, continental, regional, and local levels to highlight how APMT has influenced road project performance across different contexts.

I. Global Case Studies

a. United Kingdom: BIM Integration in Highway Construction

A study on the UK's Highways England Smart Motorway Program demonstrated that Building Information Modeling (BIM) reduced project delays by 50% and improved cost control by 35% (Eadie et al., 2013). By using BIM for 3D modeling, clash detection, and real-time collaboration, the UK's road infrastructure projects benefited from early risk identification, efficient stakeholder coordination, and enhanced design accuracy. However, the study also highlighted challenges such as high initial investment costs and the need for specialized training among project managers.

b. United States: Digital Twin Technology for Highway Maintenance

In the U.S., the Minnesota Department of Transportation (MnDOT) implemented Digital Twin technology, which combines real-time project monitoring with artificial intelligence (AI) for predictive maintenance (Zhou, Whyte & Sacks, 2012). This system improved road asset management, reduced maintenance costs by 30%, and minimized disruption to commuters. The study found that the success of APMT in MnDOT projects was attributed to strong regulatory support, long-term investment in technology, and skilled workforce availability.

c. Australia: E-Procurement and Contract Management in Road Projects

In Australia, the use of e-procurement and automated contract management systems in highway projects led to a 20% improvement in procurement efficiency and a 25% reduction in contractor disputes (Azhar, Khalfan & Maqsood, 2015). The Australian Transport Department implemented digital bidding systems and real-time contract performance monitoring, ensuring that contractors adhered to project timelines and cost estimates. Despite these benefits, the study found that some smaller contractors struggled to adapt due to limited digital literacy.

II. Continental Case Studies (Africa-Wide)

a. Kenya: Digital Project Management Tools for Reducing Delays

In Kenya, the adoption of Primavera P6 and Microsoft Project in major road projects reduced project delays by 35% and cost overruns by 20% (Chomba et al., 2022). Digital scheduling tools enabled better resource allocation, automated progress tracking, and real-time communication among stakeholders. However, implementation challenges included poor digital infrastructure and resistance from engineers accustomed to traditional project management methods.

b. Ethiopia: GIS-Based Project Monitoring for Road Construction

The Ethiopian Roads Authority integrated Geographic Information Systems (GIS) for real-time project tracking and risk assessment, leading to a 28% improvement in project completion rates (Tadesse & Mulugeta, 2017). By using GIS for spatial analysis and infrastructure planning, project managers were able to optimize road alignments, reduce environmental impact, and improve cost forecasting. However, limited skilled personnel and high software acquisition costs restricted full-scale adoption.

c. Nigeria: E-Procurement and Anti-Corruption Measures

In Nigeria, the introduction of e-procurement systems in road construction resulted in a 15% reduction in procurement fraud and a 25% increase in contractor accountability (Olawale & Okpala, 2021). By replacing manual tendering with automated bidding and contract evaluation, the Nigerian government improved transparency and efficiency in awarding contracts. However, challenges such as cybersecurity risks, resistance from traditional contractors, and inadequate IT infrastructure slowed down the system's full implementation.

III. Regional Case Studies (Southern Africa)

a. South Africa: BIM Implementation for Road Infrastructure Projects

South Africa has witnessed an increased adoption of BIM in large-scale road projects, leading to a 40% reduction in design errors and improved coordination among engineers and contractors (Mokgobo & Maritz, 2020). A study on Gauteng's road infrastructure projects found that cloud-based collaboration using BIM enhanced real-time decision-making, reduced rework, and minimized contract disputes. However, BIM adoption in road projects remains lower compared to building construction, largely due to high software costs and lack of standardized guidelines for BIM use in transportation infrastructure.

b. Botswana: Mobile-Based Project Monitoring for Rural Roads

In Botswana, the government implemented mobile-based project tracking systems to improve contractor performance monitoring and data collection on rural road projects (Silwamba, 2023). The technology allowed engineers to submit progress reports, document construction challenges, and upload geotagged images from project sites. While this significantly improved stakeholder communication and reduced project abandonment, issues such as limited internet connectivity in remote areas and inconsistent data updates were noted as challenges.

IV. Local Case Study (Zambia)

a. Zambia: Low APMT Adoption and Its Impact on Project Performance

In Zambia, studies indicate that low adoption of APMT has contributed to slow contractor payments, project delays, and inefficient scheduling (Obuya, 2023). Unlike Kenya and South Africa, where digital project management tools are widely used, Zambia's road sector still relies on manual reporting, paper-based procurement, and traditional scheduling methods (Mwansa & Tembo, 2020). The limited integration of automated scheduling software, GIS-based project monitoring, and e-procurement platforms has led to frequent cost overruns, weak project oversight, and disputes between contractors and government agencies. Additionally, poor policy enforcement and inadequate investment in capacity-building programs continue to hinder the transition to modern project management technologies.

2.3.4 Project Performance in Road Construction

Project performance in road construction refers to the ability of a project to meet predefined objectives concerning cost, time, quality, and stakeholder satisfaction (Kerzner, 2017). In the context of Zambia's road sector, project performance is a critical factor that determines the efficiency and effectiveness of infrastructure delivery, impacting national economic growth and social development (World Bank, 2021). However, achieving optimal project performance remains a challenge due to delays, cost overruns, poor quality workmanship, and ineffective resource management (Silwamba, 2023).

2.3.4.1 Key Performance Indicators (KPIs) in Road Projects

Key Performance Indicators (KPIs) are essential for evaluating the effectiveness and efficiency of road construction projects. These indicators help measure progress, assess performance, and identify areas that require improvement. Various studies highlight that KPIs in road construction projects generally revolve around four key aspects: time, cost, quality, and stakeholder satisfaction (Sharma & Kumar, 2015; Zou et al., 2018; Onsongo, 2022). Effective KPI monitoring enables road agencies to identify risks, enhance decision-making, and ensure that projects align with predefined objectives (Mulenga & Phiri, 2021).

iv. Time Performance

Time performance refers to the ability of a project to be completed within the planned schedule (Sharma & Kumar, 2015). Delays in road construction projects have significant consequences, including increased costs, contractual disputes, and negative socio-economic impacts (Li & Wu, 2019). Effective scheduling techniques, real-time progress tracking, and proactive risk management strategies are crucial to mitigating delays. The use of Advanced Project Management Technologies (APMT), such as Building Information Modeling (BIM) and Global Positioning Systems (GPS), has proven to enhance time management by optimizing project scheduling and execution (Onsongo, 2022).

v. Cost Performance

Cost performance evaluates the extent to which a project adheres to its financial budget (Zou et al., 2018). Cost overruns are a common challenge in road construction, often resulting from poor cost estimation, contract variations, inflation, and inefficient procurement processes (Chileshe & Kangwa, 2019). Proper cost control mechanisms, including real-time cost tracking and digital procurement systems, can help mitigate financial risks. Additionally, strategies such as value engineering and risk-based budgeting are effective in improving cost performance (Silwamba, 2023).

vi. Quality Performance

Quality performance in road construction is assessed based on compliance with design specifications, structural integrity, and durability (Onsongo, 2022). Poor quality outcomes often result from substandard materials, inadequate supervision, and weak regulatory enforcement (Saito, Shimaoka & Takeda, 2013). Stringent quality management systems, including material testing, site inspections, and digital quality control tools, are essential in ensuring compliance with industry standards. The implementation of ISO 9001-certified quality management systems and the adoption of BIM for design validation significantly improve quality assurance in road projects (Mulenga & Phiri, 2021).

vii. Stakeholder Satisfaction

Stakeholder satisfaction is a critical measure of project success, as it determines how well a project meets the expectations of contractors, government agencies, and road users (Liu & Teng, 2018). Stakeholder satisfaction is influenced by factors such as effective communication, transparency, and community involvement. The Construction Industry Research and Information Association (CIRIA) (2014) highlights that ensuring minimal disruption to local communities, engaging stakeholders early, and providing timely project updates are essential strategies for maintaining stakeholder trust. Digital stakeholder management platforms, such as cloud-based reporting tools, can facilitate better engagement and responsiveness (Silwamba, 2023).

2.3.4.2 Factors Influencing Project Performance

The performance of road construction projects is influenced by a variety of internal and external factors that impact efficiency, cost, and quality outcomes. Understanding these factors is critical for improving project execution and minimizing risks (Eadie et al., 2013).

i. Project Planning and Management

Proper project planning and management play a crucial role in ensuring project success (Kerzner, 2017). Poor planning leads to inefficiencies, budget overruns, and delays. Studies have shown that integrating digital project management tools, such as Primavera P6 and BIM, enhances planning accuracy and improves resource allocation (Mulenga & Phiri, 2021). A structured approach to project scheduling and risk management is necessary to maintain high performance levels (Onsongo, 2022).

ii. Regulatory and Policy Frameworks

Government policies and regulatory requirements significantly impact road project performance (Silwamba, 2023). Inconsistent policies, bureaucratic delays, and weak enforcement of construction standards contribute to inefficiencies in project execution (Chileshe & Kangwa, 2019). Strengthening regulatory frameworks and ensuring compliance with procurement laws can enhance project efficiency and transparency (Liu & Teng, 2018).

iii. Technical Expertise and Workforce Skills

The availability of skilled personnel is a key determinant of project performance (Tornatzky & Fleischer, 1990). A lack of technical expertise in project management and construction methodologies leads to errors, rework, and poor-quality outcomes. Training programs focused on APMT adoption and advanced construction techniques can improve workforce competency and project delivery (Onsongo, 2022).

iv. **Financial and Resource Constraints**

Budget limitations and inadequate resource allocation negatively affect project performance (Zou et al., 2018). In many developing countries, including Zambia, funding gaps result in project delays and compromised construction quality (Chileshe & Kangwa, 2019). Efficient financial management, strategic procurement, and leveraging public-private partnerships (PPPs) can help bridge financial shortfalls and improve project outcomes (Silwamba, 2023).

v. **Environmental and Climatic Conditions**

External factors, such as weather conditions and environmental constraints, can also impact road construction projects (Li & Wu, 2019). Heavy rainfall, soil instability, and extreme temperatures affect material performance and project scheduling. Integrating Geographic Information Systems (GIS) into project planning can help mitigate environmental risks and improve project resilience (Eadie et al., 2013).

2.3.5 Challenges and Barriers to APMT Adoption

The adoption of APMT in road construction projects presents several challenges that hinder its widespread implementation. While APMT offers significant benefits, including enhanced project efficiency, cost control, and risk management, several barriers prevent full-scale adoption, particularly in developing economies. These challenges range from resistance to change, skill gaps, and regulatory limitations to more technical concerns like cybersecurity risks and integration complexities (Mulenga & Phiri, 2021). Understanding these barriers is critical to formulating effective strategies for overcoming them and ensuring that APMT adoption leads to sustainable improvements in project performance.

2.3.5.1 Universal Challenges

i. **Resistance to Change and Workforce Adaptation**

One of the most significant barriers to APMT adoption is resistance to change among employees and stakeholders. Construction professionals accustomed to traditional project management methods often hesitate to adopt new digital solutions due to concerns over job security, unfamiliarity with technology, and skepticism about its effectiveness (Eadie et al., 2013). According to Lewin's Change Management Model, employees experience three phases of change: unfreezing, changing, and refreezing, and organizations must actively manage these transitions to reduce resistance (Lewin, 1951). Studies show that poor leadership commitment and lack of incentives further exacerbate resistance, making it difficult to transition from manual to automated systems (Onsongo, 2022).

ii. Training and Capacity Development Gaps

A lack of technical expertise and inadequate training programs pose a major obstacle to APMT adoption. In many developing countries, including Zambia, engineers, project managers, and procurement officers lack the necessary skills to operate digital project management tools effectively (Chileshe & Kangwa, 2019). Studies have found that while training programs exist, they are often inconsistent, underfunded, or not aligned with industry needs (Silwamba, 2023). Furthermore, universities and technical institutions in Africa have been slow to integrate APMT-related coursework into engineering and project management curricula, resulting in a workforce ill-equipped to handle modern project management technologies (Mwansa & Tembo, 2020).

iii. Policy, Regulatory, and Organizational Constraints

Weak regulatory frameworks and inconsistent government policies have also hindered APMT adoption in road infrastructure projects. In some cases, procurement regulations lack provisions for digital project tracking, e-procurement, and real-time performance monitoring (Mulenga & Phiri, 2021). Bureaucratic inefficiencies and slow decision-making processes further delay the implementation of new technologies in road agencies like Zambia's Road Development Agency (RDA) (Obuya, 2023). Additionally, public-sector projects often experience budget limitations, which restrict investments in APMT infrastructure, making it difficult for organizations to sustain long-term digital transformation (Eadie et al., 2013).

iv. Cybersecurity Risks in APMT Implementation

The digitalization of project management processes exposes organizations to cybersecurity threats, including data breaches, hacking attempts, and malware attacks. APMT systems, particularly those involving cloud-based collaboration, remote data access, and online procurement, are vulnerable to cyber threats if robust cybersecurity frameworks are not in place (Zhou, Whyte & Sacks, 2012). Studies indicate that many organizations lack cybersecurity awareness and fail to invest in security measures such as multi-factor authentication, encryption, and data backup protocols (Jiang et al., 2017).

As a result, concerns over data privacy, intellectual property theft, and system vulnerabilities discourage many agencies from adopting APMT solutions (Silwamba, 2023).

2.3.6 Strategies for Overcoming Barriers

2.3.6.1 Change Management Models

Effective change management strategies are essential for overcoming resistance to APMT adoption. Lewin's three-step change model (unfreeze, change, refreeze) provides a structured approach to guiding employees through digital transformation (Lewin, 1951). Another widely used framework is Kotter's Eight-Step Change Model, which emphasizes leadership involvement, stakeholder engagement, and continuous reinforcement to sustain long-term adoption (Kotter, 1996). Successful case studies in the construction sector suggest that providing incentives, fostering a culture of innovation, and promoting knowledge-sharing initiatives can help accelerate workforce adaptation to APMT (Eadie et al., 2013).

2.3.6.2 Policy Reforms and Capacity-Building Initiatives

Government and industry leaders must introduce policy reforms that support APMT integration in public infrastructure projects. Strengthening procurement regulations to mandate e-procurement, real-time project tracking, and digital reporting can drive widespread adoption (Mulenga & Phiri, 2021). Capacity-building initiatives should focus on expanding digital literacy programs, incorporating APMT coursework in engineering and management degrees, and providing continuous professional training (Mwansa & Tembo, 2020). Countries like South Africa and Kenya have successfully implemented national digital infrastructure policies, leading to improved APMT uptake in road construction projects (Tadesse & Mulugeta, 2017).

2.3.6.3 Pilot Testing and Gradual Implementation

Gradual adoption of APMT through pilot testing can help mitigate risks and build stakeholder confidence. Research suggests that implementing small-scale, controlled APMT trials allows organizations to evaluate the effectiveness, usability, and return on investment of new technologies before full-scale implementation (Zhou, Whyte & Sacks, 2012). Countries like China and Germany have successfully phased in BIM and GIS technologies through pilot projects, allowing agencies to refine policies and training programs based on early feedback (Jiang et al., 2017). In Zambia, a phased approach to APMT adoption, starting with priority road projects under RDA, can help identify best practices for wider implementation (Obuya, 2023).

2.4 The Role of RDA in Road Project Performance in Zambia

The RDA plays a central role in Zambia's road infrastructure development by overseeing policy implementation, infrastructure execution, contractor oversight, monitoring and evaluation, and stakeholder engagement (AfDB, 2020). Empirical research highlights the challenges and opportunities in RDA's efforts to improve project performance through modern project management approaches.

2.4.1 Policy Implementation and Strategic Planning

RDA formulates and enforces policies that guide road project planning, execution, and maintenance in line with the National Transport Policy and Road Sector Investment Programme (ROADSIP) (Ministry of Infrastructure, Housing, and Urban Development, 2021). However, funding constraints and bureaucratic inefficiencies have hindered timely policy implementation (Silwamba, 2023).

2.4.2 Infrastructure Development and Project Execution

Despite RDA's efforts to expand Zambia's road network, empirical studies indicate frequent inefficiencies in project execution, resulting in delays and cost escalations (Chomba et al., 2022). The adoption of APMT, including BIM, GIS, and automated scheduling tools, has been recommended to enhance cost estimation, progress monitoring, and decision-making (Eadie et al., 2013).

2.4.3 Contractor and Consultant Oversight

RDA regulates contractors and consultants by prequalifying bidders, awarding contracts, and enforcing performance standards (Ministry of Infrastructure, Housing, and Urban Development, 2021). Studies show that poor contractor accountability, delayed payments, and weak contract enforcement negatively impact road project performance (Silwamba, 2023). Strengthening oversight through digital project management tools can enhance contractor performance tracking and compliance (Azhar, Khalfan & Maqsood, 2015).

2.4.4 Monitoring and Evaluation (M&E) of Road Projects

Effective monitoring and evaluation (M&E) are critical for tracking project performance, cost efficiency, and compliance (World Bank, 2021). However, research highlights that manual reporting and fragmented data collection hinder real-time progress tracking (Mwansa & Tembo, 2020). The integration of Remote Sensing, Digital Twin Models, and Cloud-Based Project Management Systems can improve risk management and decision-making (Zhou, Whyte & Sacks, 2012).

2.4.5 Stakeholder Engagement and Community Involvement

RDA is responsible for engaging government agencies, private sector partners, and local communities to ensure road projects meet stakeholder needs. Limited communication and transparency have led to community resistance and project delays (Chomba et al., 2022). Research suggests that digital communication platforms and transparent project disclosure mechanisms can strengthen stakeholder trust and collaboration (Obuya, 2023).

2.4.6 Challenges Affecting RDA's Project Performance

Despite RDA's role, several empirical studies have identified persistent challenges, including:

- **Reliance on Traditional Project Management Methods:** Manual documentation and outdated scheduling techniques limit real-time monitoring and proactive decision-making (Mulenga & Phiri, 2021).
- **Slow Adoption of APMT**: Limited implementation of BIM, GIS, and e-procurement systems affects project tracking, cost control, and transparency (Eadie et al., 2013).
- **Inefficient Procurement and Payment Delays**: Delayed contractor payments and ineffective contract management slow down projects and create financial disputes (Chomba et al., 2022).
- **Weak Regulatory and Monitoring Frameworks**: Poor enforcement of construction standards and monitoring mechanisms result in low-quality infrastructure and project risks (Silwamba, 2023).

Addressing these challenges through the integration of APMT presents an opportunity to enhance project performance, improve infrastructure delivery, and increase efficiency in Zambia's road sector.

2.5 Summary of literature review and research gaps

This section presents the reviewed studies and the research gaps identified within them.

Global Case Studies on APMT Implementation				
Author & Year	**Country of Study**	**Focus of the Study**	**Key Findings**	**Research Gap**
Eadie et al. (2013)	United Kingdom	BIM integration in highway construction	BIM reduced project delays by 50% and improved cost control by 35%. Enhanced risk identification and stakeholder coordination.	High initial investment costs, need for specialized training among project managers, and resistance to full-scale adoption.
Zhou, Whyte & Sacks (2012)	United States	Digital Twin technology for highway maintenance	Digital Twin technology improved asset management, reduced maintenance costs by 30%, and minimized commuter disruptions.	Requires strong regulatory support, long-term investment, and skilled workforce availability for large-scale implementation.
Azhar, Khalfan & Maqsood (2015)	Australia	E-procurement and contract management	E-procurement improved procurement efficiency by 20% and reduced contractor disputes by 25%.	Small contractors struggled to adapt due to limited digital literacy and technical expertise.

Jiang et al. (2017)	China	AI-powered predictive scheduling in infrastructure projects	AI-powered predictive scheduling reduced project risks by 30% and improved real-time cost estimation accuracy.	High implementation costs, limited AI adoption in developing countries due to regulatory gaps.
Continental Case Studies (Africa-Wide)				
Author & Year	**Country of Study**	**Focus of the Study**	**Key Findings**	**Research Gap**
Chomba et al. (2022)	Kenya	Use of digital project management tools	Digital scheduling tools reduced project delays by 35% and cost overruns by 20%. Improved resource allocation and progress tracking.	Poor digital infrastructure and resistance from engineers accustomed to traditional methods.
Tadesse & Mulugeta (2017)	Ethiopia	GIS-based project monitoring for road construction	GIS-based project monitoring improved completion rates by 28%, optimized road alignments, and enhanced cost forecasting.	Limited skilled personnel and high software acquisition costs restricted full-scale adoption.
Olawale & Okpala (2021)	Nigeria	E-procurement in road construction	E-procurement reduced procurement fraud by 15% and increased contractor accountability by 25%.	Cybersecurity risks, resistance from traditional contractors, and inadequate IT infrastructure hinder adoption.

Mwansa & Tembo (2020)	Africa-wide	Adoption trends of BIM and GIS in road projects	Adoption of BIM and GIS in road projects remains low compared to building construction.	Lack of standardized guidelines for BIM use in road infrastructure projects.
Regional Case Studies (Southern Africa)				
Author & Year	**Country of Study**	**Focus of the Study**	**Key Findings**	**Research Gap**
Mokgobo & Maritz (2020)	South Africa	BIM implementation in road infrastructure projects	BIM adoption in road projects reduced design errors by 40% and improved engineer coordination.	BIM adoption remains lower in road construction compared to building projects due to high costs and lack of standardized guidelines.
Silwamba (2023)	Botswana	Mobile-based project monitoring for rural roads	Mobile-based project tracking improved contractor performance monitoring and data collection on rural road projects.	Limited internet connectivity in remote areas and inconsistent data updates affected system reliability.
Local Case Study (Zambia)				
Author & Year	**Country of Study**	**Focus of the Study**	**Key Findings**	**Research Gap**
Obuya (2023)	Zambia	Impact of low APMT adoption on	Low adoption of APMT has led to slow contractor payments,	Lack of policy enforcement, limited investment in

		project performance	project delays, and inefficient scheduling.	training programs, and reliance on manual reporting.
Mwansa & Tembo (2020)	Zambia	Comparison of Zambia's project management practices with Kenya and South Africa	Zambia's road sector still relies on manual procurement and scheduling, unlike Kenya and South Africa.	Need for structured digital transformation policies and stronger institutional support for APMT adoption.
Onsongo (2022)	Zambia	Regulatory challenges in APMT adoption by RDA	RDA faces regulatory challenges and limited ICT infrastructure, hindering the adoption of APMT.	Weak government incentives for digital transformation and lack of funding for procurement modernization.
Chileshe & Kangwa (2019)	Zambia	Workforce resistance to APMT adoption	Resistance to change among engineers, procurement officers, and contractors affects APMT uptake.	Lack of structured capacity-building programs and awareness initiatives.

2.3.5 Conceptual Framework

This study's conceptual framework illustrates the relationship between Advanced Project Management Technologies (APMT) and road project performance at the Road Development Agency (RDA) in Zambia. The framework identifies key variables and their interactions, providing a structured approach to understanding how APMT adoption influences project outcomes. Blow is a diagrammatic representation showing the study's connecting concepts.

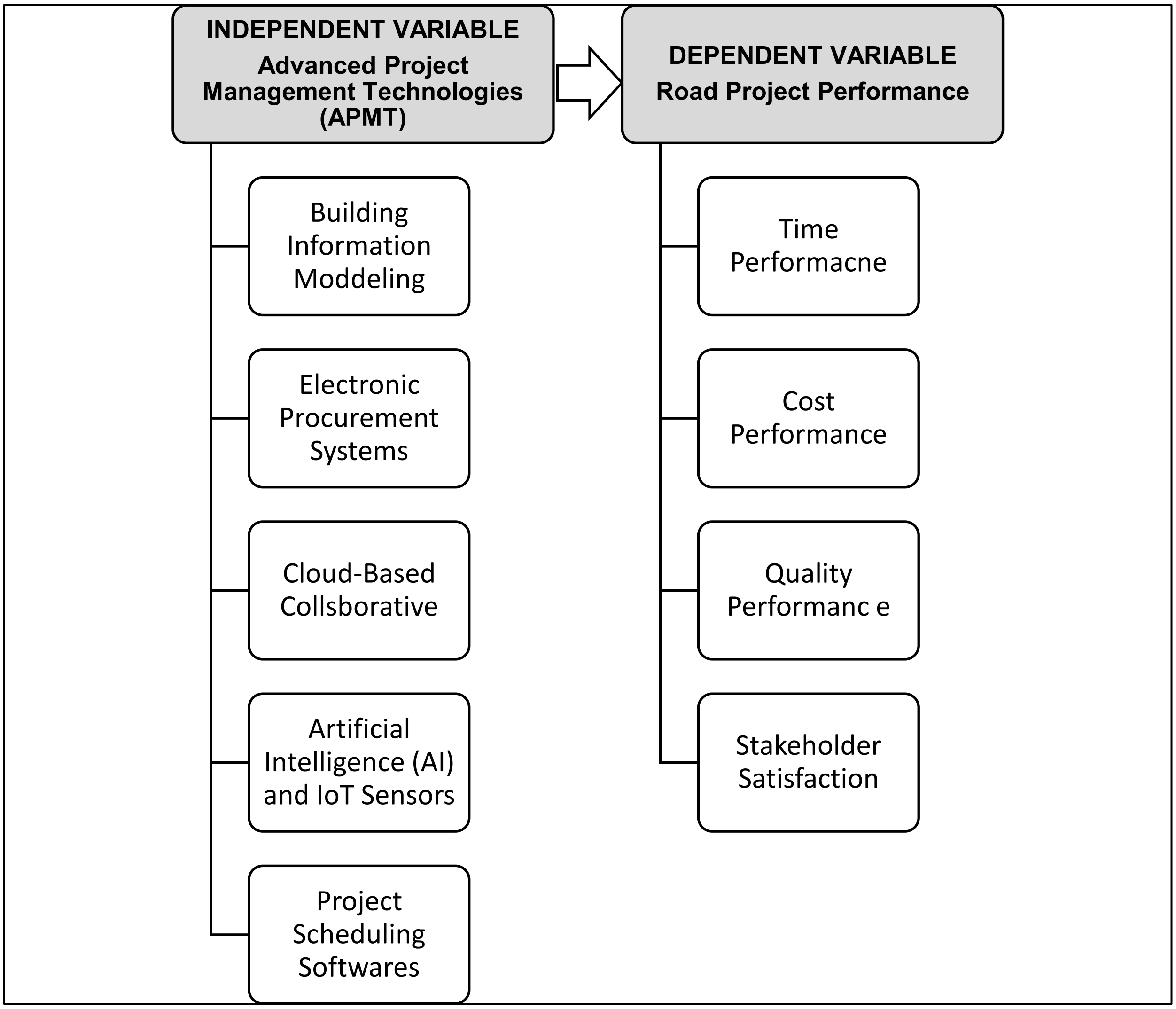

Figure 2- 1: Conceptual Framework

2.4 Chapter Summary

This chapter provided a comprehensive review of literature on the adoption and effect of Advanced APMT in road construction. The theoretical review explored key frameworks, including the Diffusion of Innovation (DOI) Theory, the Technology-Organization-Environment (TOE) Model, and Lewin's Change Management Model, which help explain the factors influencing technology adoption and the organizational dynamics that affect APMT implementation.

The empirical literature review analyzed real-world studies on APMT adoption at global, continental, regional, and local levels, highlighting how digital tools such as BIM, GIS, electronic procurement systems, and AI-driven project monitoring have influenced project planning, execution, monitoring, and stakeholder collaboration. Case studies from countries such as the UK, the US, Kenya, South Africa, and Zambia demonstrated both the benefits and challenges associated with technology integration. Findings indicated that while APMT enhances project efficiency, cost control, and transparency, challenges such as resistance to change, financial constraints, regulatory barriers, and technical capacity gaps continue to hinder adoption, especially in developing economies like Zambia.

The chapter also examined key performance indicators (KPIs) relevant to road project performance, focusing on time, cost, quality, and stakeholder satisfaction, and how APMT influences these metrics. It further discussed barriers to APMT adoption, including bureaucratic resistance, cybersecurity risks, and inadequate digital infrastructure, along with strategies for overcoming these obstacles, such as policy reforms, capacity-building programs, and phased technology implementation.

Finally, the chapter identified research gaps, emphasizing the need for more localized studies on APMT adoption in Zambia’s road sector, stronger regulatory frameworks, and enhanced workforce training programs. These insights formed the foundation for the subsequent chapters, which delved into the research methodology and empirical investigation.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlines the research methodology, including the design, philosophical orientation, target population, sampling, data collection, ethical considerations, and analysis techniques. It details the validation measures and limitations, ensuring a structured approach to examining the impact of APMT on road project performance at RDA in Zambia.

3.2 Philosophical Orientation

This research was guided by the post-positivist paradigm, specifically the interpretivist philosophy. The interpretivist approach holds that reality is socially constructed, subjective, and best understood through human experiences and interactions (Creswell & Poth, 2018). This paradigm was chosen because it allowed for an in-depth exploration of the lived experiences of project managers, engineers, and policymakers regarding the use of APMT in Zambia's road sector. Interpretivism asserts that knowledge is not absolute but constructed through human perceptions and interactions with the environment (Guba & Lincoln, 1994).

The adoption of interpretivism in this study was based on the need to understand participants' perceptions, experiences, and contextual factors influencing APMT adoption. Since road construction projects involve multiple stakeholders with diverse experiences, a qualitative approach was most suitable for capturing these diverse viewpoints in their natural settings (Denzin & Lincoln, 2011).

The historical development of interpretivism dates back to anti-positivist thinkers such as Kant, Hegel, and later Max Weber, who emphasized understanding social actions within their specific contexts (Myers, 2008). In contrast to positivism, which seeks generalizable and objective truths, interpretivism allows for context-dependent interpretations that are crucial in exploring human-centered phenomena such as technology adoption in project management (Saunders, Lewis, & Thornhill, 2019).

3.2.1 Ontological Assumptions

Ontology refers to the nature of reality and existence, guiding how the research perceives what is real and knowable (Crotty, 1998). In this study, reality was viewed as multiple, subjective, and constructed through human experiences, aligning with the interpretivist paradigm (Guba & Lincoln, 1994). The study was based on the following ontological assumptions:

i. **Reality is constructed in the human mind:** The study assumed that participants' understanding of APMT adoption and its effects on project performance was based on their personal experiences and perceptions rather than an objective external reality (Hathcoat et al., 2019).
ii. **Reality is shaped by human experiences:** The study recognized that engineers, project managers, and policymakers shape their understanding of APMT through direct interaction with these technologies in road projects (Creswell & Poth, 2018).
iii. **Reality is interpreted based on prior experience (a posteriori knowledge)**: Participants' insights were influenced by their past encounters with project management technologies and their effectiveness in improving road construction projects (Saunders et al., 2019).
iv. **Reality is socially constructed rather than independent:** The study acknowledged that knowledge about APMT was developed through interactions between the researcher and respondents, emphasizing collaborative meaning-making (Guba & Lincoln, 1994).

3.2.2 Epistemological Assumptions

Epistemology refers to the nature of knowledge and how it is acquired (Cohen, Manion, & Morrison, 2018). This study adopted an interpretivist epistemology, recognizing that knowledge is subjective, co-constructed, and context-dependent. The epistemological stance was based on the following assumptions:

i. **Knowledge is subjective:** Since perceptions and experiences of APMT adoption vary among stakeholders, the study relied on participants' interpretations to construct meaning (Denzin & Lincoln, 2011).

ii. **Knowledge is acquired through interaction:** Data was collected through interviews and observations, allowing knowledge to emerge from researcher-participant engagement (Creswell & Creswell, 2017).

iii. **Knowledge is shaped by dialogue and discourse:** The study depended on open-ended discussions with participants to understand barriers, enablers, and effectiveness of APMT adoption (Guba & Lincoln, 1994).

3.2.3 Axiological Assumptions

Axiology concerns the role of values in research and how they influence the study process (Heron & Reason, 1997). Unlike positivist research, which aims for value-neutrality, qualitative research acknowledges the impact of researcher biases and subjectivity. The axiological stance of this study was based on the following principles:

i. **Researcher involvement influences the findings:** Since qualitative studies rely on direct interaction with participants, the researcher's background, experiences, and worldview shaped the interpretation of APMT adoption at RDA (Creswell & Poth, 2018).

ii. **Participants' values shape their responses:** The study recognized that engineers, project managers, and policymakers brought their own professional biases and expectations regarding APMT implementation, influencing their perceptions (Guba & Lincoln, 1994).

iii. **Reflexivity is essential in qualitative research:** The researcher-maintained reflexivity by acknowledging personal biases and ensuring that interpretations remained true to the participants' lived experiences (Finlay, 2002).

3.2.4 Rhetorical Assumptions

Rhetorical assumptions relate to the language and style used in research reporting. Unlike quantitative studies, which rely on statistical generalization, qualitative research employs descriptive, interpretive, and narrative forms of presentation (Creswell & Poth, 2018). The rhetorical stance of this study was guided by the following:

i. **Use of participant quotations and narratives:** To illustrate findings, the study incorporated direct excerpts from interviews, ensuring that the voices of project managers and engineers were authentically represented (Riessman, 2008).

ii. **Contextualized interpretation of findings:** The study provided detailed descriptions of the factors influencing APMT adoption, linking them to broader themes in project management and technological innovation (Denzin & Lincoln, 2011).

iii. **Thematic organization of results**: Data was presented in structured thematic sections, aligning with the interpretivist tradition of qualitative research (Braun & Clarke, 2006).

3.3 Research Approach

Since the study requires an in-depth, descriptive interpretation of experiences specific to those working for the RDA, a qualitative research approach was employed. This methodical and subjective method aimed at studying and understanding life experiences, delivering significant insights into complex phenomena (Creswell & Poth, 2018). The qualitative approach was selected because it enables researchers to capture detailed perspectives, contextual interpretations, and nuanced understandings that would not be achievable through quantitative methods (Denzin & Lincoln, 2011).

The technique was chosen because it enabled an exploration of the depth, richness, and complexity inherent in human experiences, which is particularly useful in understanding the nuanced effects of advanced project management systems on road project performance. Unlike quantitative methods, which strive for generalizability, qualitative research emphasizes individuals' unique perspectives and the specific situations in which they function (Creswell and Poth, 2018). By focusing on subjective realities, the study hoped to identify not just the obvious advantages and challenges of these technologies, but also the underlying reasons that influence their implementation and outcomes.

3.3.1 Research Design

According to Yin (2018), qualitative research employs various designs, each tailored to specific study objectives and contexts. Among the commonly used qualitative research approaches are ethnography, phenomenology, grounded theory, narrative research, and case studies. Phenomenology, which was adopted for this study, focuses on understanding individuals' lived experiences and how they perceive and interpret specific phenomena (Creswell & Poth, 2018). It is a widely used approach in social sciences and management research, particularly when exploring human-centered processes such as technology adoption in organizations (Van Manen, 2016).

A phenomenological research design was appropriate for this study as it aimed to capture the lived experiences of project engineers and consultants utilizing Advanced Project Management Technologies (APMT) at the Road Development Agency (RDA). This approach enabled the study to explore how APMT influences professional practices, decision-making processes, and project performance in Zambia's road sector. Through interviews, focus group discussions, and document analysis, participants' perceptions were examined in-depth, allowing for the extraction of meaningful insights regarding both the advantages and challenges associated with APMT adoption (Smith & Osborn, 2015).

Unlike case studies, which analyze a single event or entity in detail, phenomenology emphasizes subjective human experiences to uncover the deeper meanings behind how individuals interact with, perceive, and adapt to new technologies (Moustakas, 1994). Given the contextual and experiential nature of APMT adoption, this design provided the necessary framework for analyzing how project engineers and consultants perceive and engage with technology in road project management.

3.3.2 Target Population

The target population refers to the group of individuals relevant to the research question, from which study participants are drawn (Polit & Beck, 2017). In qualitative research, defining the target population is crucial, as it ensures that the data collected is rich, relevant, and representative of the study phenomenon (Morse, 2016). Since qualitative research does not seek statistical generalization, purposive sampling was applied to select participants with direct experience in APMT adoption in road projects (Creswell & Creswell, 2017).

For this study, the target population consisted of project engineers at the RDA and external consultants involved in road construction projects. The RDA has a total of 122 engineers, who, along with consultants, play a central role in project planning, execution, and monitoring. These professionals were selected based on their direct responsibilities, ensuring that their first-hand experiences with APMT provided valuable insights into the challenges, benefits, and potential improvements in the implementation of digital tools in project management.

RDA is structured into five core departments: Planning and Design, Construction and Rehabilitation, Maintenance, Corporate Services, and Finance. These departments contain specialized units, including Planning, Design and Research, Public-Private Partnerships (PPP), Bridge, IT, Construction, Rehabilitation, Maintenance, Axle Load, Procurement, and Finance. By sampling across these divisions, the study incorporated perspectives from professionals responsible for policy formulation, project execution, financial management, and technical oversight. This ensured a holistic assessment of APMT's effects on road project performance by capturing diverse operational and strategic viewpoints.

3.3.3 Sampling Design and Sample Size

3.3.3.1 Sampling Design

Sampling design is a critical component of qualitative research, as it determines how participants are selected to ensure the study achieves its objectives (Polit & Beck, 2017). This study employed a non-probability sampling design, specifically heterogeneous purposive sampling, to capture a broad range of experiences and perspectives related to APMT adoption at the RDA. Since non-probability sampling involves the intentional selection of participants based on their expertise rather than random selection, it was appropriate for this study, which aimed to gather in-depth insights from professionals directly involved in APMT implementation (Etikan, Musa, & Alkassim, 2016).

Heterogeneous purposive sampling was chosen because it ensures diverse perspectives are represented, allowing for a comprehensive understanding of the research problem (Palinkas et al., 2015). This approach was particularly relevant in assessing APMT adoption, as it captured multiple viewpoints from professionals with different functional roles in project management. Given that RDA has a total of 122 engineers responsible for project planning, execution, and monitoring, the study focused on selecting those with direct involvement in APMT implementation. Additionally, external consultants engaged in road construction projects were included to provide further insights into APMT adoption outside RDA but within the same sector.

Participants were selected based on their direct experience with APMT, their representation across various professional roles, and their availability and willingness to participate in qualitative interviews (Saunders, Lewis, & Thornhill, 2019). This purposive selection ensured that the study was grounded in practical industry knowledge and real-world project challenges, allowing for a detailed assessment of the applicability of APMT and the factors influencing its adoption in Zambia's road sector (Morse, 2016).

3.3.3.2 Sample Size

Determining an appropriate sample size in qualitative research depends on the research design, objectives, and data saturation point. Unlike quantitative research, qualitative studies do not require large samples but instead prioritize depth over breadth, ensuring that the selected participants offer rich, detailed insights into the phenomenon under investigation (Creswell & Creswell, 2017).

Phenomenological research, such as this study, typically involves small sample sizes, ranging from 3 to 10 participants (Moustakas, 1994). However, to achieve broader representation across RDA units and external stakeholders, 25 participants were selected from a total population of 122 RDA engineers. This approach ensured that multiple viewpoints were captured, offering a well-rounded understanding of APMT adoption in Zambia's road sector.

3. 4 Methods and Techniques of Data Collection

Data collection is the systematic process of acquiring information to address research objectives (Kumar, 2019). In qualitative research, data collection procedures are designed to capture participants' complex, multidimensional experiences and perspectives (Creswell & Poth, 2018). These methods are often unstructured or semi-structured, allowing the researcher to explore participants' responses in depth and extract meaningful insights (Denzin & Lincoln, 2011). This study employed qualitative data collection techniques to ensure a comprehensive understanding of the impact of Advanced Project Management Technologies (APMT) on road construction projects.

This study used two types of data gathering tools: primary and secondary data collection methods. Both forms were chosen for ensuring a thorough approach to data collection, including participant input with supporting background information (Merriam and Tisdell, 2016).

3.4.1 Types of Data Collection

Data collection in qualitative research consists of primary and secondary data sources, both of which contribute to a comprehensive understanding of the research problem. Primary data collection involves gathering new, firsthand information directly from participants using methods such as interviews, focus groups, and observations (Creswell, 2014). This type of data is highly relevant to the study objectives as it reflects the current status of the subject matter. In contrast, secondary data collection entails analyzing existing information that was originally gathered for different purposes. Secondary sources provide valuable context and background information, supporting and enhancing the interpretation of primary data (Silverman, 2016). For this study, document analysis was used as a secondary data collection method, offering additional insights into the research question.

3.4.1.1 Primary Data Collection

This study primarily relied on semi-structured interviews, a widely used qualitative research method that allows for both structure and flexibility (Kvale & Brinkmann, 2009). This approach ensured that participants' perspectives, experiences, and perceptions were captured through open-ended questions, while also allowing the researcher to explore emerging themes through probing and follow-up questions (Creswell, 2014). Semi-structured interviews strike a balance between consistency and adaptability, ensuring that core themes are addressed while allowing for deeper exploration of individual insights.

To facilitate an engaging and interactive discussion, the interviews were designed to be fluid and participant-driven, encouraging respondents to freely express their experiences and opinions regarding the implementation of APMT in RDA road projects. This method allowed the study to capture nuanced perspectives on APMT adoption, challenges, and its impact on project performance. The depth and breadth of responses were analyzed to identify patterns, emerging themes, and insights that contribute to the research objectives (Creswell & Poth, 2018).

3.4.1.2 Secondary Data Collection

To complement the primary data, secondary data collection was conducted to provide additional context and verification of findings. Secondary data consists of existing reports, documents, and prior research that contribute to a broader understanding of the research topic (Silverman, 2016). This study employed document analysis, a systematic review of written materials related to APMT adoption and project performance in the road sector (Bowen, 2009).

The secondary data sources included reports, project management plans, technical specifications, and academic research on project management systems. By analyzing these documents, the study was able to cross-validate primary data findings, strengthen conclusions, and provide a more comprehensive perspective on the challenges and benefits of APMT adoption (Creswell & Poth, 2018). Triangulating primary and secondary data ensured that the research findings were robust, credible, and contextually grounded in both empirical insights and documented evidence.

By integrating semi-structured interviews with document analysis, this study provided a holistic perspective on how APMT affects road construction projects in Zambia, ensuring that the findings were rich, reliable, and actionable.

3.5 Data Analysis

The qualitative data acquired in the study was analyzed using theme analysis. Thematic analysis is a popular qualitative analytic technique for detecting, interpreting, and reporting patterns in data. It enables flexible and detailed data exploration, ensuring that rich insights are derived while keeping a clear link to the research objectives (Braun and Clarke, 2006). This method entails a systematic procedure of familiarization with the data, coding, theme identification, reviewing, defining, and naming themes, and lastly generating the report.

3.6 Ethical Considerations

Ensuring ethical integrity in research involving human participants is essential to maintaining credibility, transparency, and respect for participants' rights (Resnik, 2020). Ethical concerns arise in studies where researcher-participant interactions may introduce potential biases or conflicts of interest (Smith, 2018). However, in this study, all ethical guidelines were strictly followed, and no unethical practices were involved in data collection. Although the researcher is employed by the RDA, it is important to emphasize that this position did not influence the outcome of the study, ensuring that findings remained objective and independent (Saunders, Lewis, & Thornhill, 2019).

Prior to participation, informed consent was obtained from all respondents, demonstrated by signed consent forms (Creswell & Creswell, 2017). This process ensured that participants were fully aware of the research objectives, their role in the study, and their right to withdraw at any stage without providing justification (Bhandari, 2021). Anonymity and confidentiality were also upheld, ensuring that respondents' identities and responses were protected and not disclosed in any published materials (Flick, 2018). Additionally, autonomy and voluntary participation were prioritized, allowing respondents to share their experiences without coercion or undue influence (Denzin & Lincoln, 2011).

By adhering to these ethical principles, the study ensured that data collection was conducted with integrity, participant rights were safeguarded, and findings remained unbiased and credible (Bryman, 2016).

3.7 Analytical Framework

“Analysis of data was a process of inspecting, cleaning, transforming, and modelling data with the goal of highlighting useful information, suggesting conclusions, and supporting decision making" (Blackwell, 1991). In this research, constant comparative analysis was used. This involved the acute analysis of data collected, where the researcher recorded data from one text and compared it to other pieces of data that were either comparable or different. During the comparison, the researcher looked at what made the data different or similar based on the responses given. This method was ideal for qualitative research because it allowed the researcher to critically examine and draw new meanings and ideas from the data obtained (Glaser and Strauss, 1967).

3.8 Data Validation Method

In qualitative research, ensuring the validity of data was crucial to establishing the credibility and trustworthiness of the findings. For this study on the impact of advanced PMTs on road construction projects, the following data validation methods were employed.

3.8.1 Triangulation

Triangulation involves using multiple data sources, methods, or investigators to cross-check and validate the findings. This study used methodological triangulation by combining semi-structured interviews and document analysis. By comparing data from these different sources, the researchers could identify consistencies and discrepancies, enhancing the overall validity of the research (Creswell and Poth, 2018).

3.8.2 Member Checking

Member checking, also known as respondent validation, involved sharing the findings or interpretations with the participants to verify their accuracy and resonance with their experiences. Using Google Sheets, a structured questionnaire was used to validate the findings. Participants selected provided responses from a supplementary questionnaire to validate responses provided in the semi-structured interviews. This process helped to validate the data and provided an opportunity for participants to correct any inaccuracies (Birt et al., 2016).

3.9 Chapter Summary

This chapter outlined the research methodology, detailing the philosophical orientation, research design, target population, sampling methods, data collection techniques, ethical considerations, and data analysis. The study adopted an interpretivist paradigm and phenomenological design to explore the lived experiences of project engineers and consultants regarding APMT adoption.

A qualitative approach was used, with 25 participants purposively selected from 122 RDA engineers. Semi-structured interviews and document analysis ensured comprehensive data collection, while thematic analysis identified key patterns. Ethical considerations such as informed consent, confidentiality, and voluntary participation were upheld, ensuring credibility. Triangulation and member checking validated findings, reinforcing the study’s objectivity despite the researcher's affiliation with RDA.

Overall, this chapter provided a rigorous methodological framework, ensuring the research’s credibility and relevance in assessing APMT adoption and its impact on road project performance in Zambia.

CHAPTER FOUR

ANALYSIS AND PRESENTATION OF RESULTS

4.1 Introduction

This chapter presents the findings of the study on the effect of APMT on road project performance at the RDA in Zambia. The chapter explores the specific APMT adopted by RDA, their impact on key project performance metrics; timeliness, cost control, quality assurance, and stakeholder satisfaction, and the challenges hindering their full adoption. The analysis also includes direct insights from respondents, providing an in-depth understanding of their experiences and perceptions regarding APMT implementation. The chapter concludes with a summary of key findings, setting the stage for discussions in the subsequent chapter.

4.2 Data Analysis

The data were subjected to a thorough thematic analysis, which included coding, categorizing, and analyzing interviewee responses to discover recurring themes. The data was analyzed using a structured approach, with each interview response thoroughly analyzed and categorized based on the significant themes that emerged. These themes were closely linked to the research questions, ensuring that the data analysis yielded useful insights into how PMTs impacted project performance. The theme analysis included the following steps:

i. Coding: Responses were assessed and assigned preliminary classifications based on technology, challenges, impacts, and recommendations.
ii. Classification: The codes were divided into broad areas, such as impacts on project performance including cost, time, and quality; challenges encountered during technological integration, and ideas for enhancing the adoption of these technologies.
iii. Theme Development: The categorized codes were refined and arranged into separate themes, assisting in the formation of a cohesive narrative of the findings.
iv. Theme Interpretation: Interpretation was another step in the theme analysis process when the patterns found in the data were compared to the objectives and

questions of the study. This interpretation made it possible to comprehend the impact of advanced PMTs on RDA road project performance measures in detail.

Through this iterative process of coding, categorization, and theme development, the researcher was able to create a coherent narrative that linked the respondents' experiences and opinions to the research questions. These themes addressed not only the technologies' immediate impact on project outcomes but also the underlying barriers and opportunities that RDA faces when adopting these advanced technologies into their project management approaches.

4.2 Data Presentation

4.2.1 APMT used in project management at RDA

The RDA in Zambia has adopted various APMT to enhance the efficiency, monitoring, and execution of road construction and maintenance projects. These technologies play a

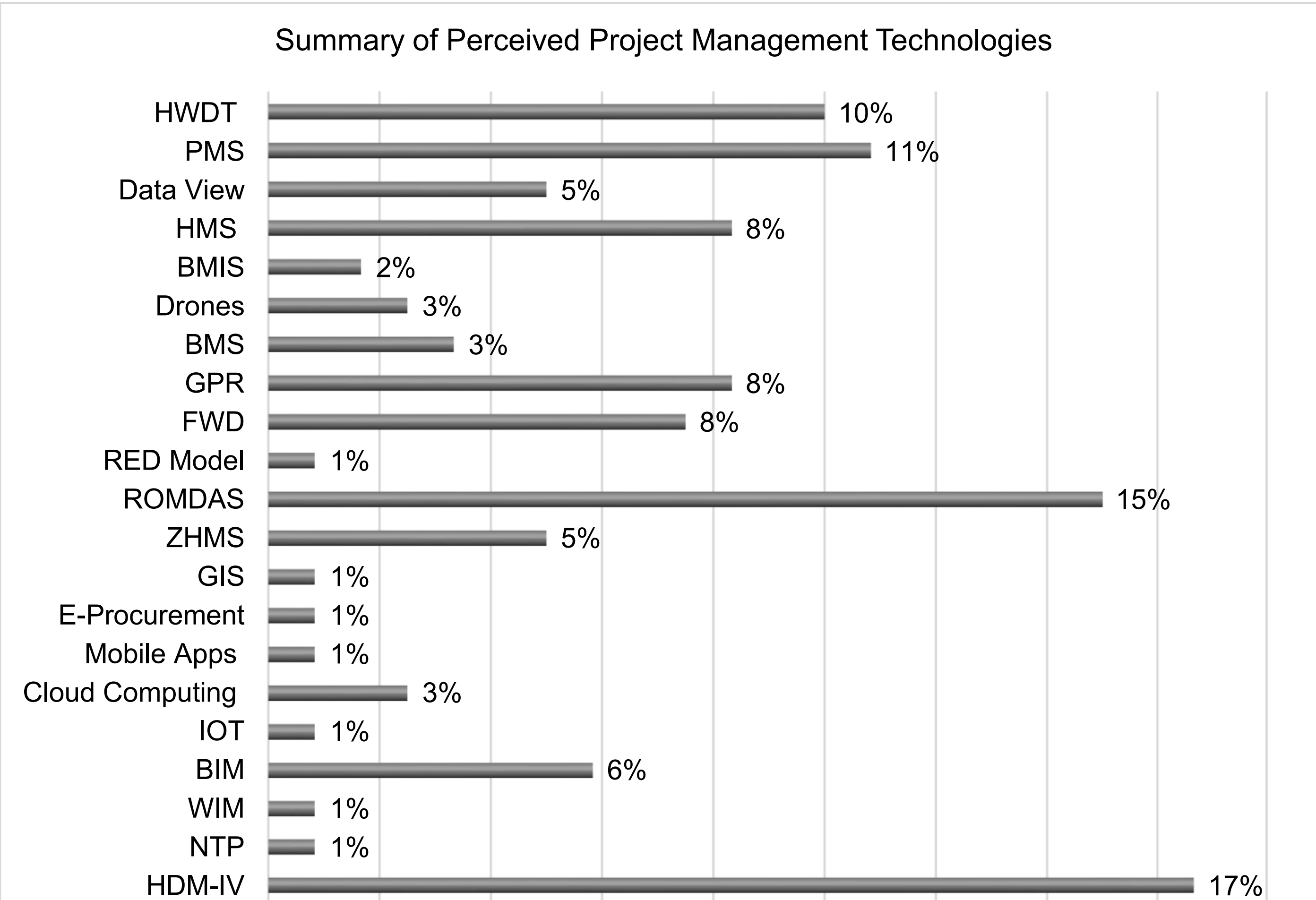

Figure 4. 1: Summary of Perceived Advanced PMTs in the RDA

crucial role in improving project planning, cost control, quality assurance, and stakeholder coordination. The key APMT identified in this study, along with their perceived significance and prevalence, are presented in the chart below:

(a) **HDM-IV** emerges as the most perceived technology in project management with **17%** of the respondents recognizing its importance. This suggests that HDM-IV is widely considered a critical tool in modern project management practices.

(b) **ROMDAS** follows closely with **15%**, indicating it's also highly valued among project management technologies. Its significant recognition could imply its effectiveness or widespread adoption in project management scenarios.

(c) **Project Management Software (PMS)** is perceived by **11%** of respondents, showing it's a staple in the field, though not as dominant as HDM-IV or ROMODAS. This might reflect its traditional role and reliability in managing projects.

(d) **HWDT** with **10%** indicates a notable presence, perhaps due to its specific application or niche in project management where it excels.

(e) **Technologies like GPR, FWD, and HMS** are all recognized by **8%** of respondents, suggesting these technologies are considered equally important in certain contexts or industries within project management.

(f) **Building Information Modeling (BMS)** at **6%** shows it's gaining traction, likely due to its importance in construction and infrastructure projects. However, its lower percentage might indicate it's not as universally applied across all project management domains.

(g) **Technologies like Data View, ZHMS, Cloud Computing, Drones, and BMS** are perceived by **3-5%** of respondents, indicating they are recognized but perhaps not as essential or widely implemented as the top technologies. This could be due to their specialized applications or newer adoption rates.

(h) **Technologies like RED Model, BMIS, GIS, E-Procurement, Mobile Apps, IoT, WIM, and NTP** are at the lower end with **1-2%** recognition. This might suggest these are either emerging technologies, less relevant to general project management, or perhaps more niche in their application.

4.2.1.1.1 Respondents' Insights on Advanced Technologies

The table below captures firsthand perspectives provided by participants of our study where 'R' stands for 'Respondent', followed by a unique number assigned to each participant to preserve anonymity while facilitating the tracking of individual feedback. This offered a window into their experiences and perceptions of these technologies in real-world applications.

Table 4. 1: Respondents' Insights on advanced Project Management Technologies

Technology	Respondent Direct Quote
Highway Development and Management Model (HDM-IV)	R12 - "HDM-IV has streamlined our economic and technical analysis of road projects, aiding in the timely preparation of annual work plans and optimizing resource allocation."
Road Measurement and Data Acquisition System (ROMDAS)	R5 - "ROMDAS, though rarely used in quality assurance, is highly valuable during the construction phase to ensure compliance with the International Roughness Index (IRI) requirements prior to issuing Interim Payment Certificates (IPCs). This ensures the longevity of the built roads and eliminates subjectivity in the results of finished sections."
	R5 – "Technologies like ROMDAS allows us to monitor road conditions, enabling us to proactively address maintenance needs resulting in reduced long-term maintenance costs."
Project Management Systems (PMS)	R18 - "This system enables efficient tracking of project progress, resource allocation, and cost management, ensuring that projects are delivered on time and within budget."
	R3 - "By providing real-time data and analytics, PMS support decision-making, enhance coordination among stakeholders, and enhance risk mitigation."

Technology	Respondent Direct Quote
Heavy Weight Deflectometer Testing (HWDT)	R9 - "By simulating the impact of heavy loads, HWDT provides accurate data on pavement strength and structural integrity. This helps us to identify and prioritize sections for holding maintenance, ensuring that roads can withstand the ongoing demands of industrial and commercial traffic, and prevent premature failure."
Falling Weight Deflectometer (FWD)	R14 - "FWD tests have given us a detailed understanding of the pavement conditions, allowing us to calculate the residual life of the road pavement and design the appropriate maintenance intervention accordingly."
Ground Penetrating Radar (GPR)	R7 - "We have been able to prevent delays and additional expenses by using GPR to detect possible subsurface problems early."
Highway Management Systems (HMS)	R21 - "Data outputs from these technologies aid the agency in informed decision making, resulting in efficient management of the road network and improved overall maintenance strategies."
Zambia Meteorological Hazard System (ZMHS)	R2 - "In order to ensure that no road is left unattended, ZMHS has been crucial in planning our road maintenance schedules, particularly during the rainy season."
Building Information Modelling (BIM)	R16 - "If we were to fully integrate BIM, it has huge potential to ensure seamless coordination between design and construction teams, reducing rework and improving project outcomes."
	R1 - "Despite high investment cost, BIM would give us a 3D visualization of all project phases, facilitating better coordination, clash detection, and resource management, resulting in efficiency and rework reduction."

Technology	Respondent Direct Quote
	R11 - "With digital representation, BIM can potentially enhance collaboration among stakeholders, improve construction efficiency, and ensure that project deliverables are delivered on time and within budget."
Data View	R13 - "In Zambia, where road conditions vary significantly and project requirements are diverse, Data View would enable us to assess infrastructure data in a clear, accessible format."
Cloud Computing	R19 - "Cloud solutions have made our data more accessible, facilitating smooth team collaboration."
Drones	R6 - "Drones have given us a fresh perspective on our projects and drastically cut down on the time needed to perform site inspections. We use it to examine long-span bridge segments that are inaccessible to us physically."
World Bank – Roads Economic Decision (RED) Model	R4 - "The RED Model enables us to perform sensitivity and risk analysis which is beneficial for evaluating road projects, particularly in legacy and comparative assessments alongside HDM-IV."
Bridge Management Systems (BMS)	R15 - "This system focuses on maintaining and managing bridge infrastructure, critical for projects like the Kazungula, Katima Mulilo and Mongu – Kalabo bridges, ensuring effective scheduled maintenance and rehabilitation."
Bridge Management Information System (BMIS)	R10 - "This system is used for resource optimization and allocation, extending the lifespan of small bridges. It’s managed by provincial engineers to ensure the safety and functionality of key transport links across Zambia."
WIM and IoT	R8 - "We expect these technologies like NTP and WIM, to become increasingly important in future projects as we continue to explore their potential."

4.2.2 The Impact of PMTs on Road Project Performance Metrics

By grouping the impacts into major themes, the thematic analysis shows how increased project performance is a result of efficiency in timeliness, cost control, quality, stakeholder satisfaction, and project outcomes. This method aids in understanding each impact area's significance in relation to project management and performance. The impact categories and their corresponding key impacts together with a percentage distribution, are illustrated in the presentation below;

4.2.2.1 Perceived Impacts on Timelines

Theme 1: **Efficiency in Project Processes**

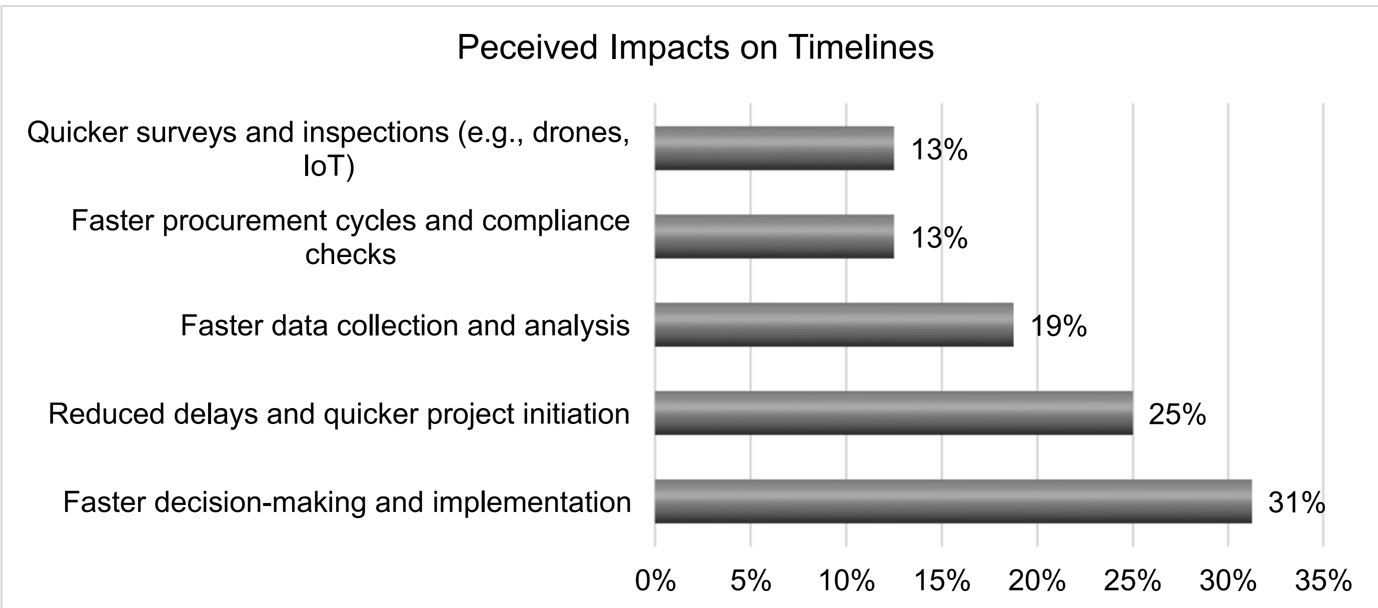

Figure 4. 2: Perceived Impacts of on Timelines

In the context of road project performance, the thematic analysis highlights that efficiency in timeliness is a critical factor. The chart above underlines this by showing:

i. **Quicker Surveys and Inspections (13%)**: This suggests that PMTs are streamlining the initial data gathering phase, which is crucial for road projects where timely assessments can prevent delays in construction.

ii. **Faster Procurement Cycles and Compliance Checks (13%):** Similar to the above, technology aids in expediting the procurement of materials and ensuring compliance, which is vital for maintaining the momentum of road construction projects.

iii. **Faster Data Collection and Analysis (19%):** Here, technology significantly enhances the speed at which data is collected and analyzed, allowing for quicker adjustments and decisions, essential in dynamic road project environments.

iv. **Reduced Delays and Quicker Project Initiation (25%):** This is a key finding, indicating that technologies are pivotal in reducing the time from planning to action, a significant performance metric for road projects where delays can be costly.

v. **Faster Decision-making and Implementation (31%):** The highest impact, suggesting that technology facilitates rapid decision-making, which directly translates to faster implementation phases, crucial for meeting timelines in road construction.

4.2.2.1.1 Respondents' Insights on Timelines

Below are insights from respondents on how PMTs are currently impacting project timelines, with some noting the potential for even greater efficiency as these technologies become fully integrated.

Table 4. 2: Respondents' Insights on Timelines

Theme	Respondent	Respondent Direct Insight
Perceived Impact on Timelines	R17	"The integration of technologies has already made our surveys and inspections quicker, but with full integration, we expect even greater time savings at project start-up."
	R8	"Emerging technologies have begun to streamline procurement, but we anticipate a more significant impact on compliance and speed once they're fully implemented."
	R25	"Data collection and analysis are have improve, but the potential for real-time decision-making could revolutionize project timelines if these technologies mature."
	R12	"We are seeing reduced delays, but with full-scale integration of these new technologies, project initiation could become almost instantaneous."

Theme	Respondent	Respondent Direct Insight
	R3	"Decision-making has sped up, yet we believe that with complete technology adoption, the implementation phase could be dramatically faster."

4.2.2.2 Perceived Impacts on Costs

***Theme 2:* Cost Optimization**

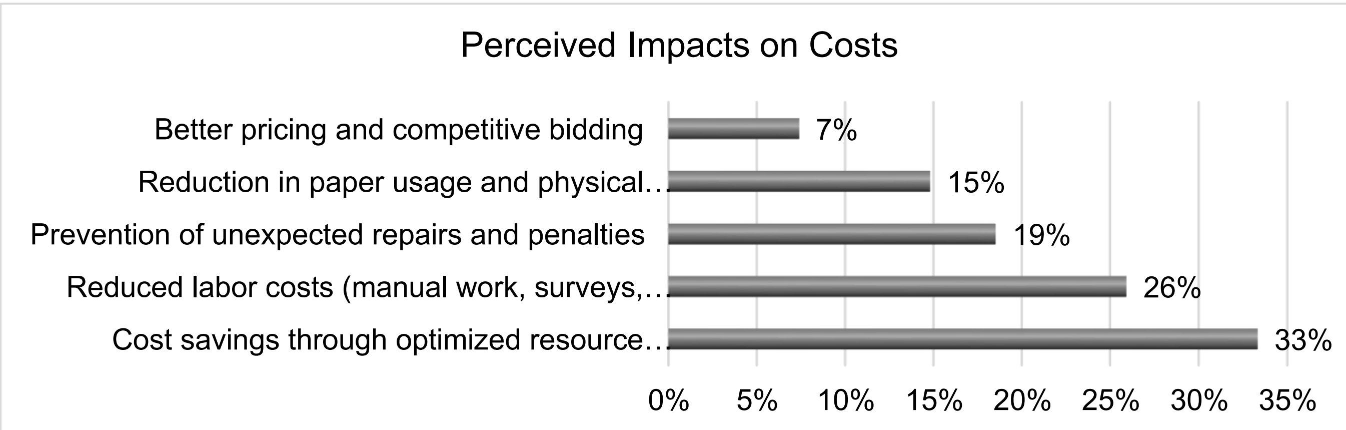

Figure 4. 3: Perceived Impacts on Costs

Cost control is another major theme, and the chart illustrates how technology influences this aspect:

(a) **Better Pricing and Competitive Bidding (7%):** Though the impact is lower, it shows that technology might be introducing more transparency or efficiency in bidding processes, potentially saving costs in road projects.

(b) **Reduction in Paper Usage and Physical Storage (15%):** This points to digital transformation in project management, reducing overhead costs associated with physical documentation, which in road projects can be substantial due to the volume of paperwork.

(c) **Prevention of Unexpected Repairs and Penalties (19%):** A significant impact, technology here likely aids in predictive maintenance or quality assurance, avoiding costly repairs or fines, which are common in road infrastructure projects.

(d) **Reduced Labor Costs (Manual Work, Surveys, etc.) (26%):** This high impact suggests technology like drones or automated systems are reducing the need for manual labor, which is beneficial for large-scale road projects where labor costs can escalate.

(e) **Cost Savings through Optimized Resource Allocation (33%):** The highest impact, indicating technology's role in ensuring resources are allocated efficiently, a critical metric for cost control in road projects where resource mismanagement can lead to significant overruns.

4.2.2.2.1 Respondents' Insights on Cost

The following table presents direct insights from respondents regarding the impact of technology on project costs, with some highlighting the anticipated full economic benefits as these technologies evolve.

Table 4. 3: Respondents' Insights on Cost

Theme	Respondent	Direct Insight
Perceived Impact on Costs	R14	"The use of e-Procurement has shown some improvement in competitive bidding through as subjectivity is slowly being eliminated, but we are optimistic about substantial cost reductions once these tools are fully utilized."
	R21	"Paper reduction is significant like use of PMS, but the full potential for cost savings through digitalization is yet to be realized as these technologies evolve."
	R7	"Early detection of risks has saved us money, but with further integration, we could prevent most unexpected costs, enhancing our cost efficiency."
	R19	"Automation like RODMAS in road condition data collection has cut labor costs, but we see an even greater reduction potential as these emerging technologies become standard practice."
	R5	"For example, use of HDM-IV makes resource allocation more efficient, but we are on the cusp of achieving optimal cost savings as these technologies become mandatory to be used for decision making."

4.2.2.3 Perceived Impacts on Quality

***Theme 3*: Enhancement of Standards and Performance**

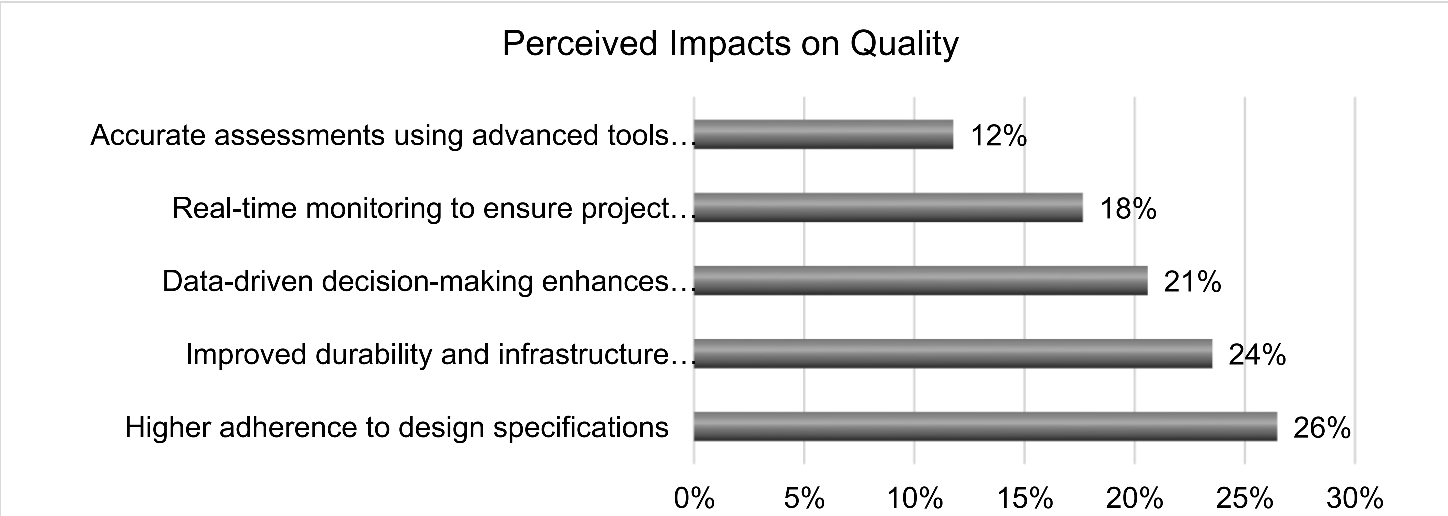

Figure 4. 4: Perceived Impacts on Quality

Quality in road projects ensures longevity and safety, and the chart reflects:

i. **Accurate Assessments Using Advanced Tools (12%):** Technology provides precise tools for assessment, ensuring the quality of road construction from the outset.

ii. **Real-time Monitoring to Ensure Project Standards are Met (18%):** This indicates that technology allows for ongoing quality control, critical for adhering to safety and durability standards in road projects.

iii. **Data-Driven Design Making Enhances Accuracy in Decision and Construction (21%):** The use of data in design ensures that road projects are built with precision, reducing errors that could compromise quality.

iv. **Improved Durability and Infrastructure Performance (24%):** A significant impact, showcasing technology's role in enhancing the lifespan and performance of road infrastructure.

v. **Higher Adherence to Design Specifications (26%):** The highest impact, technology ensures that what is designed is what gets built, maintaining high-quality standards throughout the road project lifecycle.

4.2.2.3.1 Respondents' Insights on Quality

Below, respondents share how technology is improving project quality, with certain insights pointing towards the potential for achieving near-perfect quality with the full integration of emerging technologies.

Table 4. 4: Respondents' Insights on Quality

Theme	Respondent	Direct Insight
Perceived Impact on Quality	R4	"Advanced tools like FWD, HWDT and GPR are improving our assessments, but with full integration, the quality of our initial project phases could be enhanced."
	R18	"The use of BIM and Data view in real-time monitoring could ensure zero deviation from quality standards through the digital visualization of the project life cycle. However, this is only achievable if we invest in this this cutting technology."
	R22	"Data-driven design reduces errors, like using ROMDAS and FWD in certification of completed road projects before project closure. These technologies have full potential for near-perfect quality only when these technologies become part of our solicitation documents for quality assurance."
	R6	"Scheduled maintenance has slightly enhanced the durability of our roads; however, the inconsistency due to subjective decision-making means that some roads due for intervention are left unattended, leading to further deterioration. If we maintain consistency in our maintenance schedules, we could

Theme	Respondent	Direct Insight
		significantly extend the lifespan of our infrastructure."
	R15	"Adherence to design specifications is better, but with complete technological integration, we could achieve almost perfect execution."

4.2.2.4 Perceived Impacts on Stakeholder Satisfaction

Theme 4: **Building Trust and Transparency**

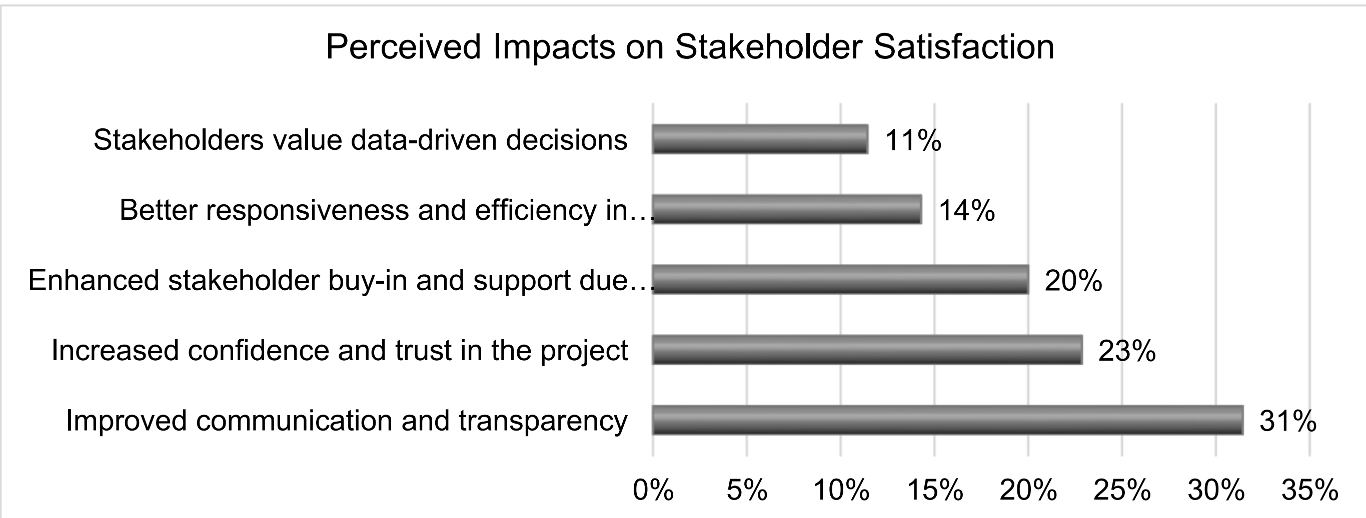

Figure 4. 5: Perceived Impacts on Stakeholder Satisfaction

Stakeholder satisfaction is crucial for project success, and the chart shows:

(a) **Stakeholders Value Data-Driven Decisions (11%):** This moderate impact reflects that stakeholders in road projects appreciate the transparency and reliability that data-driven decisions bring, fostering trust.

(b) **Better Responsiveness and Efficiency in Addressing Inquiries and Concerns (14%):** Technology enhances communication, making stakeholders feel more involved and heard, which is important in large community-impacting projects like roads.

(c) **Enhanced Stakeholder Buy-in and Support Due to Visible Improvements (20%):** Visible progress or improvements facilitated by technology increase stakeholder support, vital for road projects which often require public consent or cooperation.

(d) **Increased Confidence and Trust in the Project (29%):** A strong impact, indicating that technology's role in maintaining project integrity and transparency builds stakeholder confidence, crucial for long-term project support.

(d) **Improved Communication and Transparency (31%):** The highest impact, suggesting that technology significantly improves project visibility and stakeholder engagement, which is essential for road projects where public perception can affect project progress.

4.2.2.4.1 Respondents’ Insights on Stakeholder Satisfaction

The table below includes insights from respondents on how technology has enhanced stakeholder satisfaction, with some respondents envisioning even greater engagement through full technology integration.

Table 4. 5: Respondents’ Insights on Stakeholder Satisfaction

Theme	Respondent	Direct Insight
Perceived Impact on Stakeholder Satisfaction	R2	"Stakeholders value data-driven decisions, and with full technology integration, their involvement could be even more profound, increasing satisfaction."
	R11	"Our responsiveness has improved, but with these emerging technologies fully integrated, stakeholder communication could reach new levels of efficiency."
	R23	"Visible improvements have already boosted stakeholder support, yet we anticipate a significant increase in engagement once these technologies are fully integrated into our processes. A prime example is the funding provided by the World Bank (WB) and the African Development Bank (AFDB) for initiatives like ROADSIP, OPRC, and IRCP, which underscores the potential for enhanced stakeholder involvement through technological advancements."
	R16	"Trust is growing due to transparency, but with the full potential of these technologies, confidence in our projects could be absolute."

4.2.3 Challenges and Barriers with APMTs Adoption

A qualitative analysis of the challenges and barriers associated with the adoption of various PMTs within the RDA in Zambia. The insights provided are based on stakeholder interviews and expert consultations, aiming to provide a comprehensive understanding of the landscape. This chart below illustrates the perceived challenges and barriers in incorporating advanced PMTs into road project management in Zambia. The challenges are ranked by their prevalence percentage among respondents.

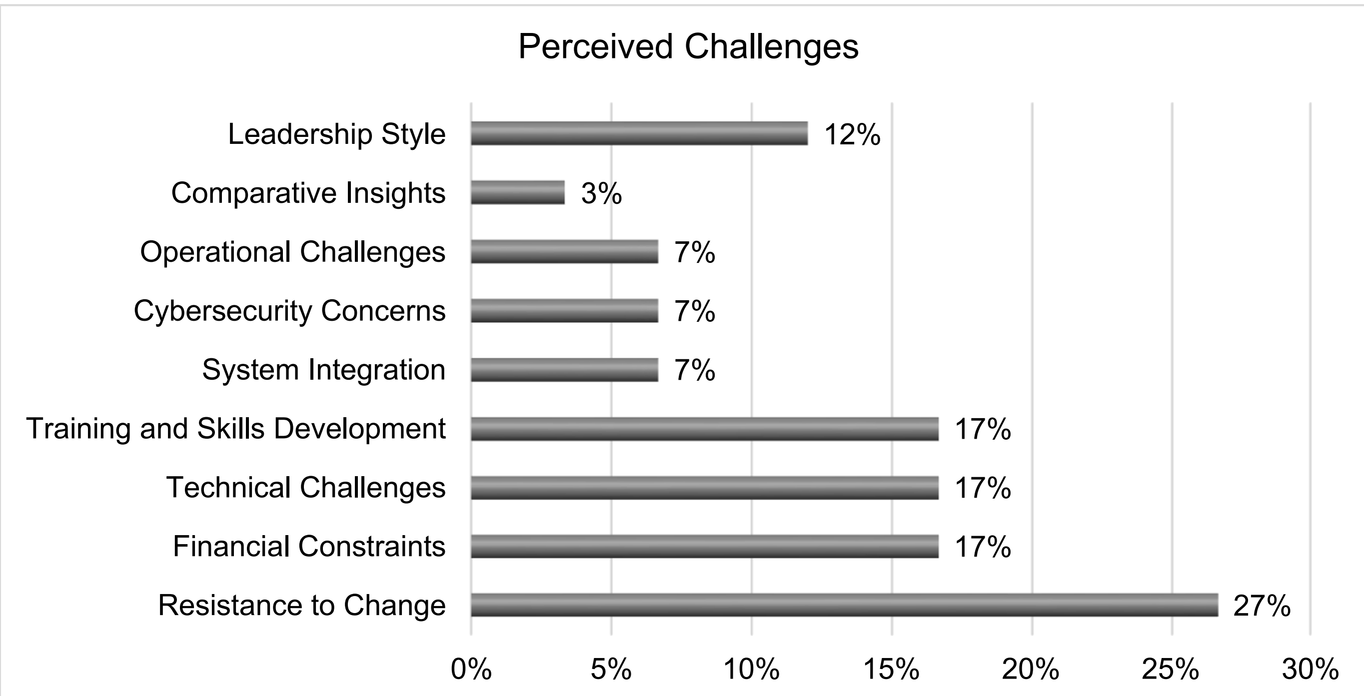

Figure 4. 6: Perceived Challenges

(a) **Theme 1: Leadership Style (12%):** Leadership style is identified as a significant challenge, with 12% of respondents highlighting it. This suggests that the effectiveness of technology adoption is heavily influenced by the approach and adaptability of leadership within RDA.

(b) **Theme 2: Comparative Insights (3%):** Only 3% see comparative insights as a challenge, indicating that benchmarking against other road agencies' is minor concern, possibly due to limited exposure.

(c) **Theme 3: Operational Challenges (7%):** Operational challenges, at 7%, point to difficulties in integrating new technologies into existing workflows, which might relate to process changes or operational disruptions.

(d) **Theme 4: Cybersecurity Concerns (7%):** With 7%, cybersecurity is a moderate challenge, reflecting concerns over the security of digital systems being used in project management.

(e) **Theme 5: System Integration (7%):** Also, at 7%, system integration indicates issues with making different technologies work together seamlessly, a common obstacle in tech adoption.

(f) **Theme 6: Training and Skills Development (17%):** A notable challenge, with 17% of responses, indicating that there's a significant gap in the staff ability to effectively use advanced technologies, underscoring the need for continuous training.

(g) **Theme 7: Technical Challenges (17%):** At 17%, technical challenges cover issues like system failures, compatibility problems, or technical know-how, which are critical for operational efficiency.

(h) **Theme 8: Financial Constraints (17%):** Financial constraints also scored 17%, suggesting that budget limitations are a major barrier to adopting and maintaining advanced systems.

(i) **Theme 9: Resistance to Change (27%):** The highest at 27%, resistance to change is the most prevalent challenge, indicating a cultural or psychological barrier within the organization or among stakeholders against adopting new methods.

4.2.3.1.1 Respondents' Insights on Challenges

The following table presents direct insights from respondents on the challenges faced when implementing advanced project management technologies in road projects.

Table 4. 6: Respondents' Insights on Challenges

Category	Respondent	Respondent Direct Insight
Challenges	R14	"One major challenge is the resistance to change among some staff; they're not fully embracing the new systems."
	R7	"The integration of technology sometimes leads to data overload, making it hard to sift through what's relevant."

Category	Respondent	Respondent Direct Insight
	R22	"There's a skills gap; not everyone is trained to use these advanced tools effectively, which hampers progress."
	R19	"Ensuring consistent maintenance schedules with technology is tough when decisions are still influenced by subjectivity."
	R3	"Sometimes, the technology doesn't fully integrate with existing systems, causing inefficiencies in project management."

4.3 Chapter Summary

This chapter presented the findings on the effect of APMT on road project performance at RDA, focusing on the APMT in use, their adoption, effect on key performance metrics, and challenges hindering their implementation.

The study found that RDA utilizes various APMT tools, including e-procurement systems, project scheduling software (e.g. Microsoft Project), cloud-based collaboration platforms, and Geographic Information Systems (GIS) to support project planning, execution, and monitoring. However, the adoption of advanced tools like BIM and AI-driven project analytics remains low, primarily due to financial constraints, limited technical expertise, and resistance to change.

While APMT has the potential to enhance project scheduling, cost tracking, quality assurance, and stakeholder coordination, its full-scale implementation is yet to be realized. The integration of real-time data analysis, automated reporting, and collaborative digital platforms is slowly emerging, with ongoing challenges such as high implementation costs, insufficient training, interoperability issues, and weak policy frameworks hindering widespread adoption.

The findings provide insights into the current state of APMT at RDA, its influence on road project performance, and the key barriers affecting its implementation. The next chapter discusses these findings in greater detail.

CHAPTER FIVE
DISCUSSION OF RESULTS

5.1 Introduction

This chapter discusses the study findings on the effect of APMT on road project performance at the RDA in Zambia, structured around the study's objectives. It examines the APMT used, their impact on timeliness, cost control, quality, and stakeholder satisfaction, and the challenges hindering adoption. The findings are compared with existing literature to identify alignments and divergences. Additionally, the chapter explores the practical implications of APMT adoption, highlighting opportunities to improve efficiency and address barriers, providing insights on enhancing digital project management integration for better infrastructure development outcomes.

5.2 Objective 1: To determine the APMT used in project management at RDA.

The findings indicate that the RDA has adopted APMT to enhance efficiency in road project planning, execution, and monitoring. The most widely used technologies include Highway Development and Management Model (HDM-IV), Road Measurement Data Acquisition System (ROMDAS), Heavy Weight Deflectometer Testing (HWDT), Falling Weight Deflectometer (FWD), Geographic Information Systems (GIS), Bridge Management Systems (BMS), and Project Management Software (PMS). These tools primarily support road condition assessment, cost estimation, and data-driven decision-making. However, emerging technologies such as Building Information Modeling (BIM), cloud computing, and drones remain underutilized, with their adoption limited to pilot projects or selected interventions. The findings suggest that while RDA has recognized the potential of these technologies, their full-scale integration remains a challenge due to financial constraints, technical capacity gaps, and policy limitations.

5.2.1 Comparison with Global and Regional Practices

At the global level, countries such as the United Kingdom and the United States have successfully integrated BIM and AI-driven project monitoring, leading to significant efficiency gains. Eadie et al. (2013) report that BIM adoption in the UK reduced project delays by 50% and improved cost control by 35% due to real-time collaboration and risk identification. Similarly, Zhou, Whyte & Sacks (2012) found that Digital Twin technology in the US highway sector improved asset management and cut maintenance costs by 30%. These findings highlight the transformative potential of advanced digital tools, which are yet to be fully realized in Zambia's road sector.

At the continental level, countries such as Kenya and Ethiopia have leveraged digital project management tools with notable success. Kenya's adoption of Primavera P6 and Microsoft Project reduced project delays by 35% and cost overruns by 20% by optimizing scheduling and resource allocation (Chomba et al., 2022). Ethiopia's use of GIS-based project monitoring improved completion rates by 28%, facilitating better alignment of infrastructure planning (Tadesse & Mulugeta, 2017). By comparison, RDA's GIS usage is largely limited to spatial analysis rather than real-time project tracking, suggesting an opportunity for further development. In Nigeria, the introduction of e-procurement systems improved transparency, reducing procurement fraud by 15% and increasing contractor accountability by 25% (Olawale & Okpala, 2021). While Zambia has adopted e-Procurement, its effectiveness remains limited due to system instability, frequent failures, and technical challenges. These inefficiencies hinder full-scale implementation, preventing the system from achieving the expected gains in efficiency and transparency.

At the regional level, South Africa has made significant strides in BIM adoption for road infrastructure projects, reducing design errors by 40% and improving coordination among engineers (Mokgobo & Maritz, 2020). In Botswana, mobile-based project tracking systems have enhanced contractor performance monitoring, particularly in rural road projects (Silwamba, 2023). In contrast, Zambia has yet to adopt mobile monitoring tools for tracking road projects in real time, indicating a gap in leveraging digital solutions for field-based assessments.

5.2.2 The Local Context: Why Zambia Lags Behind

Despite the proven benefits of APMT, Zambia's road sector still relies on semi-automated and manual project management approaches, significantly affecting efficiency. The study finds that while RDA has integrated HDM-IV and ROMDAS for project analysis, predictive analytics, cloud-based collaboration, and AI-driven monitoring remain largely absent. Obuya (2023) attributes this low adoption to slow policy enforcement, limited investment in training, and reliance on outdated reporting systems. Similarly, Mwansa & Tembo (2020) highlight that, unlike Kenya and South Africa, which have made structured progress toward digital transformation, Zambia’s road sector lacks clear policies mandating the use of APMT in project execution. Further, Onsongo (2022) identifies regulatory barriers and inadequate ICT infrastructure as critical factors preventing full-scale APMT adoption, limiting RDA’s ability to transition to modern project management solutions.

5.2.3 Key Insights on the State of APMT at RDA

- Widespread reliance on HDM-IV and ROMDAS for road assessments, with GIS and PMS playing supporting roles.
- Emerging technologies such as BIM, cloud computing, and IoT remain in their infancy, with limited application beyond pilot projects.
- Unlike global and regional counterparts, RDA has not yet embraced real-time project tracking, AI-based risk management, or fully digital procurement systems.
- Policy and financial constraints continue to delay APMT integration, making Zambia's road project management processes less efficient than those in other African nations.

5.3 Objective 2: To evaluate the effect of APMT on Key Performance Metrics of Road Projects

The findings reveal that APMT have had a significant but gradually emerging impact on key performance metrics in road projects managed by the RDA. The four major performance dimensions assessed include time, cost, quality, and stakeholder satisfaction. While some technologies, such as HDM-IV, ROMDAS, and PMS, have improved planning and monitoring processes, the full benefits of AI-driven analytics, BIM, and cloud collaboration are yet to be realized due to limited adoption.

5.3.1 Effect of APMT on Time Performance

Efficient project scheduling and execution are crucial for ensuring timely completion of road projects. The study found that APMT has contributed to reduced project delays by improving data collection, analysis, and decision-making. Tools like ROMDAS and GIS have enhanced survey efficiency, allowing for quicker road condition assessments and project planning. Similarly, project scheduling software such as Microsoft Project and

Primavera P6, though not fully utilized at RDA, has been shown to optimize resource allocation and track project milestones.

Internationally, the UK's use of BIM has led to a 50% reduction in project delays, demonstrating the potential of digital modeling in streamlining construction workflows (Eadie et al., 2013). Similarly, in the United States, Digital Twin technology has minimized maintenance delays and disruptions, leading to better long-term road asset management (Zhou, Whyte & Sacks, 2012). In contrast, Zambia's road sector is still in the early stages of integrating real-time project tracking technologies, with delays often attributed to manual reporting, inefficiencies in procurement, and slow approval processes.

At the regional level, Kenya's adoption of Primavera P6 has resulted in a 35% reduction in project delays, while Ethiopia's GIS-based project monitoring has improved completion rates by 28% (Chomba et al., 2022; Tadesse & Mulugeta, 2017). Despite these successes, RDA's GIS adoption remains limited to spatial mapping rather than real-time construction monitoring, affecting the speed of project execution. Drones and AI-driven construction monitoring tools, which have been successfully implemented in other countries for faster inspections and progress tracking, are rarely used in Zambia's road sector.

5.3.2 Effect of APMT on Cost Performance

The study findings indicate that APMT has played a role in reducing project costs, although its full-scale cost-saving potential is yet to be realized. Technologies like HDM-IV and ROMDAS have optimized maintenance planning, reducing unnecessary expenditures. Additionally, e-Procurement has improved cost transparency, though its effectiveness remains constrained by system instability and frequent failures.

Globally, AI-based procurement and contract management systems have significantly lowered project costs. In Australia, automated bidding and real-time contract tracking reduced procurement inefficiencies by 20% and contractor disputes by 25% (Azhar, Khalfan & Maqsood, 2015). Similarly, in China, AI-driven predictive scheduling reduced project risks by 30%, leading to better cost control (Jiang et al., 2017). Comparatively, RDA still relies on manual and semi-automated processes, making cost estimation and budget tracking less efficient.

At the continental level, Nigeria’s e-Procurement system helped reduce procurement fraud by 15% and improve contractor accountability by 25% (Olawale & Okpala, 2021). While Zambia has adopted e-Procurement, it remains unstable, limiting its ability to fully optimize cost control. Automation in resource allocation, material tracking, and contractor management, key cost-saving measures in other countries is not yet fully leveraged by RDA, resulting in budget overruns and inefficient financial management.

5.3.3 Effect of APMT on Quality Performance

APMT has contributed to improved quality assurance and compliance with road design standards. Technologies such as Falling Weight Deflectometer (FWD), Heavy Weight Deflectometer (HWDT), and Ground Penetrating Radar (GPR) have provided accurate pavement assessments, ensuring durability and long-term performance of road infrastructure.

In developed countries, BIM and Digital Twin models have been instrumental in ensuring high construction quality. For example, in the UK, BIM integration led to a 40% reduction in design errors and improved collaboration among engineers (Eadie et al., 2013). Likewise, South Africa’s use of BIM in road infrastructure projects has improved engineer coordination and reduced construction defects (Mokgobo & Maritz, 2020). However, in Zambia, BIM is yet to be fully integrated into RDA’s road projects, limiting its ability to enhance quality assurance through digital design validation and clash detection.

Moreover, real-time quality monitoring tools, such as AI-driven defect detection and IoT-based pavement sensors, are not yet widely used at RDA. These technologies have been successfully applied in Japan and Singapore to maintain high construction standards and reduce maintenance costs (Jiang et al., 2017). Given Zambia’s persistent issues with substandard road infrastructure and premature pavement failures, greater investment in automated quality monitoring and compliance tracking is required to enhance long-term road performance.

5.3.4 Effect of APMT on Stakeholder Satisfaction

The study findings highlight that APMT has had a moderate impact on stakeholder satisfaction, primarily through improved data-driven decision-making and transparency. Tools like PMS and GIS have enhanced project planning and reporting, allowing stakeholders to access more accurate project data. Additionally, e-Procurement has improved procurement transparency, reducing opportunities for corruption.

However, compared to best practices globally, RDA's stakeholder engagement processes remain largely traditional, with limited use of digital dashboards, real-time progress updates, and automated reporting tools. In the United States, the use of cloud-based project collaboration platforms has improved stakeholder engagement and trust, ensuring smoother project implementation (Zhou, Whyte & Sacks, 2012). Similarly, in Botswana, mobile-based project tracking tools have enhanced communication between project managers and contractors, leading to more effective issue resolution (Silwamba, 2023).

In Zambia, stakeholder dissatisfaction is often linked to project delays, cost overruns, and lack of timely communication. The limited use of digital public engagement platforms, automated grievance redress mechanisms, and AI-driven sentiment analysis tools means that stakeholder concerns are not always promptly addressed. Enhancing transparency and responsiveness through APMT could strengthen public confidence in road projects and reduce disputes among contractors, government agencies, and funding institutions.

5.4 Objective 3: To examine the barriers and challenges hindering APMT adoption

The adoption of APMT at RDA faces several challenges that hinder its full-scale implementation and effectiveness. The findings indicate that these barriers are primarily organizational, technical, financial, and regulatory. While APMT has been successfully integrated into road project management in many developed economies, Zambia's road sector continues to struggle with structural and institutional constraints.

5.4.1 Resistance to Change and Workforce Adaptation

One of the most significant challenges identified is resistance to change among engineers, project managers, and procurement officers at RDA. Many professionals accustomed to traditional project management methods view APMT as complex and disruptive, leading to slow adoption rates. This challenge is not unique to Zambia, as studies show that resistance to digital transformation is a common barrier in public infrastructure agencies worldwide (Eadie et al., 2013). Lewin's Change Management

Model highlights that successful technology adoption requires structured efforts in unfreezing old habits, implementing change, and reinforcing new behaviors (Lewin, 1951). The findings align with research by Chileshe & Kangwa (2019), which noted that a lack of structured capacity-building programs in Zambia has contributed to skepticism and reluctance among RDA personnel.

5.4.2 Technical and Infrastructure Limitations

The findings also indicate that Zambia's ICT infrastructure remains inadequate for widespread APMT implementation. Unlike in developed economies where cloud computing, AI-driven analytics, and real-time project tracking are seamlessly integrated into project management, RDA faces frequent system failures, data loss risks, and limited software interoperability. The unstable functionality of e-Procurement, for example, has discouraged full reliance on the system despite its initial adoption. Similar challenges have been observed in other African countries, where fragmented ICT ecosystems hinder project efficiency (Mwansa & Tembo, 2020). Additionally, technologies such as BIM and GIS remain underutilized due to a shortage of trained personnel, further limiting the potential benefits of digital project management tools.

5.4.3 Financial Constraints and High Implementation Costs

The cost of acquiring, maintaining, and upgrading APMT tools is another major challenge at RDA. Budget limitations restrict the ability to invest in high-end digital tools such as AI-driven project scheduling, blockchain-based procurement, and IoT-enabled monitoring. This issue is also prevalent in Nigeria and Ethiopia, where financial constraints have slowed down e-Procurement adoption and GIS integration (Olawale & Okpala, 2021; Tadesse & Mulugeta, 2017). The high initial investment required for APMT solutions is often a barrier, particularly in developing economies where road agencies must balance competing infrastructure priorities.

5.4.4 Regulatory and Policy Gaps

The regulatory environment in Zambia does not fully support the mandatory adoption of APMT in road projects, which contributes to inconsistent implementation across different projects. Unlike South Africa, where BIM adoption is mandated for public infrastructure projects (Mokgobo & Maritz, 2020), Zambia lacks clear legal frameworks requiring the use of digital project management tools. Research by Onsongo (2022) confirms that weak government incentives and a lack of funding for procurement modernization further delay full-scale adoption at RDA. Strengthening procurement laws, updating project tracking regulations, and enforcing compliance with APMT standards could play a key role in overcoming these regulatory obstacles.

5.4.5 Cybersecurity Risks and Data Security Concerns

The increased reliance on digital platforms exposes RDA to cybersecurity threats, including hacking, unauthorized access to procurement data, and system breaches. Studies indicate that cybersecurity awareness in Zambia's road sector is relatively low, making it a potential area of vulnerability (Zhou, Whyte & Sacks, 2012). Countries such as China and Germany have successfully integrated multi-factor authentication, encrypted data transmission, and blockchain-based security frameworks to protect sensitive project data (Jiang et al., 2017). Without similar security measures in place, APMT implementation in Zambia remains prone to risks, discouraging full adoption.

5.5 Objective 4: To establish strategies for optimizing the use of APMT.

To enhance the adoption and effectiveness of APMT at RDA, the findings highlight several strategies that could overcome existing challenges and maximize technological benefits. Drawing insights from global and regional case studies, the following strategies have been identified as critical for optimizing APMT use.

5.5.1 Strengthening Leadership Commitment and Change Management

Successful digital transformation requires strong leadership commitment and structured change management approaches. The findings emphasize that leadership engagement at RDA needs to be proactive in championing APMT adoption, incentivizing workforce adaptation, and addressing resistance to change. Research by Lewin (1951) and Kotter (1996) suggests that effective change models must include clear communication, stakeholder involvement, and continuous reinforcement. Countries like the UK and the US have successfully embedded leadership-driven digital transformation strategies in their road agencies, ensuring long-term commitment to APMT (Eadie et al., 2013).

5.5.2 Expanding Capacity Building and Workforce Training

One of the most critical strategies is enhancing digital literacy and technical skills among RDA personnel. The findings indicate that the limited expertise in BIM, GIS, and AI-based project monitoring tools is a major constraint. Comparative studies from South Africa and Kenya show that integrating APMT training into engineering and project management curricula has significantly improved workforce competency (Chomba et al., 2022). Additionally, Zambia can benefit from public-private partnerships with technology firms and academic institutions to provide specialized training programs tailored for road construction professionals (Mwansa & Tembo, 2020).

5.5.3 Improving ICT Infrastructure and System Stability

Addressing infrastructure deficiencies and system reliability issues is key to optimizing APMT use. The study suggests that enhancing server capacity, improving internet connectivity at remote project sites, and ensuring stable operation of e-Procurement and project tracking software will boost technology adoption at RDA. Similar infrastructure investments in Botswana's mobile-based project tracking and China's AI-powered monitoring systems have resulted in significant project performance improvements (Silwamba, 2023; Jiang et al., 2017).

5.5.4 Enforcing Regulatory Reforms and APMT Standardization

Establishing clear policies mandating the use of APMT in Zambia's road sector would ensure consistency in digital project management implementation. Case studies from South Africa and Nigeria show that introducing legally binding APMT adoption policies strengthens compliance, transparency, and accountability in infrastructure projects (Mokgobo & Maritz, 2020; Olawale & Okpala, 2021). The findings indicate that reviewing procurement laws, updating contract requirements to include digital project tracking, and ensuring penalties for non-compliance can drive APMT integration across all road projects.

5.5.5 Phased Implementation and Pilot Testing

The study highlights that gradual, phased adoption of APMT could help mitigate risks and build confidence among stakeholders. Several global case studies emphasize that implementing pilot projects for new technologies allows road agencies to test system functionality, identify challenges, and refine strategies before full-scale rollout (Zhou, Whyte & Sacks, 2012). Countries such as Japan and Germany have successfully implemented APMT in select projects first, ensuring a smooth transition toward broader adoption (Jiang et al., 2017). Zambia could similarly start with high-priority projects under RDA, using pilot results to guide wider adoption.

5.5.6 Enhancing Cybersecurity Measures and Data Protection

Strengthening cybersecurity frameworks is essential to safeguard sensitive procurement and project management data. The findings suggest that introducing blockchain-based security, multi-layer authentication, and encrypted cloud storage solutions can mitigate cyber risks associated with APMT adoption (Eadie et al., 2013). China and the US have demonstrated that investing in cybersecurity training, developing robust security policies, and conducting regular system audits significantly reduces digital vulnerabilities in road project management (Zhou, Whyte & Sacks, 2012).

5.6 Chapter Summary

This chapter discussed the study's findings on APMT adoption, impact, challenges, and optimization at RDA. While tools like HDM-IV, ROMDAS, and GIS are in use, advanced technologies such as BIM, AI, and cloud computing remain underutilized. APMT has improved project timeliness, cost efficiency, quality, and stakeholder satisfaction, but full benefits are yet to be realized due to inconsistent application. Key barriers include resistance to change, financial constraints, ICT limitations, and regulatory gaps. To optimize APMT adoption, strategies such as leadership commitment, workforce training, regulatory reforms, and improved ICT infrastructure are needed. The next chapter presents conclusions and recommendations for enhancing APMT use in Zambia's road sector.

CHAPTER SIX
CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter presents the study's conclusions on the effect of APMT on road project performance at the RDA in Zambia. It summarizes key findings in relation to the study objectives and provides recommendations for improving APMT adoption. The chapter also discusses study limitations, contributions to knowledge, and areas for further research. The findings highlight progress made and existing gaps in APMT implementation, offering insights for policymakers, industry practitioners, and researchers to enhance road infrastructure project management in Zambia.

6.2 Conclusion

This study examined the effect of APMT on road project performance at the Road RDA in Zambia. The research was guided by four key objectives: identifying the APMT used in project management at RDA, evaluating their impact on key performance metrics, assessing the barriers to their adoption, and establishing strategies for optimizing their use. The findings revealed that while RDA has integrated some APMT tools, such as HDM-IV, ROMDAS, HWDT, and GIS, the adoption of more advanced digital solutions like BIM, cloud-based project collaboration, and artificial intelligence-driven project monitoring remains limited.

The study further established that APMT positively impacts road project performance by improving time efficiency, cost control, quality assurance, and stakeholder coordination. Technologies such as ROMDAS and HDM-IV enhance road condition assessments and maintenance planning, while GIS and project management software improve decision-making and project monitoring. However, despite these advantages, the full potential of APMT is yet to be realized due to factors such as financial constraints, technical skill gaps, resistance to change, and regulatory barriers.

Challenges hindering APMT adoption at RDA include leadership reluctance to embrace digital transformation, inadequate ICT infrastructure, cybersecurity concerns, and limited training opportunities. Compared to international best practices, Zambia lags in adopting integrated digital tools that facilitate real-time monitoring, predictive analytics, and automated project tracking. While countries like the United Kingdom, the United States, and South Africa have successfully leveraged APMT to reduce project delays, cost overruns, and inefficiencies, Zambia continues to rely on semi-automated and manual processes that limit efficiency gains.

To optimize APMT utilization, the study recommends a phased integration approach, capacity-building initiatives, improved regulatory frameworks, and strategic investments in digital infrastructure. Strengthening institutional policies to mandate the use of APMT in procurement, contract management, and project oversight will enhance transparency and efficiency. Additionally, fostering public-private partnerships to fund digital transformation projects and enhancing workforce training programs will be crucial in overcoming adoption barriers.

In conclusion, APMT presents a significant opportunity to improve road project performance in Zambia, but its full impact will only be realized through sustained investment, leadership commitment, and systematic capacity development. Addressing the identified challenges and leveraging lessons from global best practices will enable RDA and other stakeholders to maximize the benefits of digital transformation in road infrastructure management.

6.3 Recommendations

To enhance the adoption and effectiveness of APMT in road project management at RDA, the following recommendations are proposed:

6.3.1 Policy and Regulatory Enhancements

i. The government should update procurement regulations to mandate digital tools such as e-procurement and BIM in project execution.
ii. Clear ICT policies should be developed to provide guidelines for technology integration, data security, and system standardization.

6.3.2 Financial and Infrastructure Investment

i. Increased funding should be allocated to APMT adoption, with a focus on acquiring modern project management software and enhancing ICT infrastructure.
ii. Public-Private Partnerships (PPPs) should be leveraged to support investment in digital solutions and capacity-building initiatives.

6.3.3 Workforce Training and Capacity Building

i. Continuous professional development programs should be introduced to enhance engineers' and project managers' skills in digital project management tools.
ii. Universities and technical institutions should incorporate APMT training in engineering and project management curricula.

6.3.4 Change Management and Stakeholder Engagement

i. RDA should implement structured change management frameworks, such as Lewin's Change Model, to facilitate smooth technology transition and reduce resistance.
ii. Awareness campaigns should be conducted to educate stakeholders on the benefits of APMT, fostering buy-in from policymakers, contractors, and road users.

6.4 Limitations of the Study

Despite its contributions, this study faced several limitations:

- **Scope Restriction**: The study focused exclusively on RDA, limiting the generalizability of findings to other key players like local authorities in Zambia.
- **Sample Size Constraints**: A limited number of participants were engaged, meaning some perspectives, particularly from external stakeholders such as contractors and funding agencies, may not be fully captured.
- **Reliance on Qualitative Data**: The study used qualitative data, which, while rich in insights, lacks the statistical robustness that could be provided by a mixed-methods approach.
- **Technology Implementation Dynamics**: Given the evolving nature of digital transformation, the study presents findings based on current adoption trends, which may change with further advancements.

6.5 Contribution to the Body of Knowledge

This study contributes to the existing literature on project management and road construction in the following ways:

- **Empirical Insights into APMT Adoption**: By analyzing APMT use at RDA, this research adds context-specific evidence on digital transformation in Zambia's road sector.
- **Barriers and Challenges Framework**: The study categorizes and examines key barriers to APMT adoption, offering a structured understanding of the constraints faced in public-sector road projects.
- **Comparative Analysis**: By drawing comparisons with global, continental, and regional case studies, this study highlights gaps in Zambia's project management approaches and offers best practices for improvement.
- **Policy and Strategic Recommendations**: The study provides actionable recommendations to policymakers, industry practitioners, and scholars seeking to enhance APMT adoption in road infrastructure development.

6.6 Recommendations for Further Research

To build on this study's findings, the following areas are suggested for further research:

- **Quantitative Impact Analysis**: A study incorporating statistical methods to assess the financial and operational benefits of APMT adoption.
- **Comparative Studies**: Cross-country comparisons of APMT adoption in road projects to identify best practices applicable to Zambia.
- **Integration of AI and Big Data**: Research into the potential of AI-driven predictive analytics and big data applications in road project management.
- **Stakeholder Perceptions**: An in-depth study exploring contractor and funding agency perspectives on APMT implementation.
- **Effectiveness of Change Management Strategies**: Investigation into how different change management models influence technology adoption in public-sector road agencies.

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APPENDICES

Appendix A. Semi-Structured Interview Guide

EFFECT OF ADVANCED PROJECT MANAGEMENT TECHNOLOGY ON ROAD PROJECT PERFORMANCE: A QUALITATIVE STUDY OF ROAD DEVELOPMENT AGENCY IN ZAMBIA

Thank you for participating in this interview, which aims to explore the impact of advanced PMTs on the performance of road projects managed by the Road Development Agency (RDA) in Zambia. Recent advancements such as Digital Twin Technology (real-time digital replicas for better monitoring and optimization), Internet of Things (IoT) (smart sensors for real-time site data), Big Data and Analytics (data-driven decision-making and risk prediction), Drones and UAVs (aerial surveys and progress tracking), Automation and Robotics (automated machinery for efficient construction tasks), Augmented Reality (AR) and Virtual Reality (VR) (immersive design visualization and on-site guidance), and Cloud-Based Collaborative Platforms (real-time collaboration tools like Microsoft Teams and Procore) are transforming project management. These technologies aim to improve efficiency, reduce costs, enhance quality, and boost stakeholder satisfaction. This interview seeks to explore your experiences with these technologies, their impact on project outcomes, the challenges you face, and your recommendations for optimizing their use. Your insights are invaluable and will contribute to enhancing road project performance in Zambia.

Position:...

Organization: ....

Date:...

Location:...

Section 1: Latest Technologies

1. What are the advanced Project Management Technology used in RDA?
2. Which of these technologies are you familiar with or have knowledge of?

Section 2: Impact on Performance

1. How have these technologies affected project timelines, costs, and quality?
2. What changes have you noticed in stakeholder satisfaction due to these technologies?

   In what ways have these technologies impacted the overall outcomes of road projects managed by the RDA?

Section 3: Challenges and Opportunities

1. What challenges and barriers has the RDA encountered in adopting and integrating these technologies?
2. What opportunities do these technologies present for improving road project management at the RDA?

Section 4: Recommendations

1. What recommendations would you offer for better integration of these technologies within the RDA?
2. What strategies can be implemented to optimize the use of APMT in project management at RDA?

Appendix B. Questionnaire

EFFECT OF ADVANCED PROJECT MANAGEMENT TECHNOLOGIES ON ROAD PROJECT PERFORMANCE: A QUALITATIVE STUDY OF ROAD DEVELOPMENT AGENCY IN ZAMBIA

Instructions for Respondents

Thank you for participating in this survey on the impact of advanced Project Management Technologies on road project performance at the Road Development Agency (RDA) in Zambia. Your feedback is crucial in understanding how these technologies affect project outcomes and how their use can be optimized. Circle or mark the letter that best represents your opinion.

Section 1: Latest Technologies

1. **Which of the following technologies have been used in RDA road projects?**
   A. Highway Development and Management Model (HDM-IV)
   B. Road Measurement and Data Acquisition System (ROMDAS)
   C. Project Management Systems (PMS)
   D. Heavy Weight Deflectometer Testing (HWDT)
   E. Falling Weight Deflectometer (FWD)
   F. Ground Penetrating Radar (GPR)
   G. Highway Management Systems (HMS)
   H. Zambia Meteorological Hazard System (ZMHS)
   I. Building Information Modelling (BIM)
   J. Data View
   K. Cloud Computing
   L. Drones
   M. World Bank – Roads Economic Decision (RED) Model
   N. Bridge Management Systems (BMS)
   O. Bridge Management Systems (BMIS)
   P. National Tolling Program
   Q. Weigh In Motion Technology
   R. Internet of Things (IoT)

S. Mobile Apps
T. E-Procurement
U. Geographical Information System
V. World Bank – Roads Economic Decision (RED) Model

2. **Which of the following Technologies are you familiar are you with?**
   A. Highway Development and Management Model (HDM-IV)
   B. Road Measurement and Data Acquisition System (ROMDAS)
   C. Project Management Systems (PMS)
   D. Heavy Weight Deflectometer Testing (HWDT)
   E. Falling Weight Deflectometer (FWD)
   F. Ground Penetrating Radar (GPR)
   G. Highway Management Systems (HMS)
   H. Zambia Meteorological Hazard System (ZMHS)
   I. Building Information Modelling (BIM)
   J. Data View
   K. Cloud Computing
   L. Drones
   M. World Bank – Roads Economic Decision (RED) Model
   N. Bridge Management Systems (BMS)
   O. Bridge Management Systems (BMIS)
   P. National Tolling Program
   Q. Weigh In Motion Technology
   R. Internet of Things
   S. Mobile Apps
   T. E-Procurement
   U. Geographical Information System
   V. World Bank – Roads Economic Decision (RED) Model

Section 2: Impact on Performance

1. **To what extent have these technologies impacted project timelines?**
   A. Greatly improved
   B. Somewhat improved

C. No change
D. Somewhat worsened
E. Greatly worsened

2. **To what extent have these technologies impacted project costs?**
   A. Greatly reduced
   B. Somewhat reduced
   C. No change
   D. Somewhat increased
   E. Greatly increased
3. **To what extent have these technologies impacted project quality?**
   A. Greatly improved
   B. Somewhat improved
   C. No change
   D. Somewhat worsened
   E. Greatly worsened
4. **Have these technologies affected stakeholder satisfaction?**
   A. Yes, positively
   B. Yes, negatively
   C. No change
   D. Unsure

Section 3: Challenges and Opportunities

1. **What challenges has the RDA faced in adopting these technologies?**
   A. Lack of Strong Leadership Support
   B. System Integration
   C. Comparative insights
   D. Cybersecurity Concerns
   E. Financial Constraints
   F. Operational Challenges
   G. Resistance to Change
   H. Training and Skills Development
   I. Technical Challenges

2. **What opportunities do these technologies present?**
    A. Data-Driven Decision Making and Predictive Analytics
    B. Enhanced Monitoring and Real-Time Management
    C. Cost Efficiency and Resource Optimization
    D. Improved Project Quality and Timelines
    E. Scalability and Collaboration
    F. Sustainability and Safety Enhancements
    G. Capacity Building and Automation
    H. Continuous Monitoring and Maintenance Optimization
    I. Preventive Maintenance and Cost-Effectiveness
3. **What strategies could be implemented to optimize the use of these technologies?**
    A. Training and Capacity Building
    B. Embrace Technology Integration
    C. Policy Development and Regulation
    D. Investing in Moden Infrastructure and Equipment
    E. Cooperation and Knowledge Exchange
    F. Systematic Monitoring and Evaluation

Section 4: Challenges and Opportunities

4. **Do you have any additional recommendations for better integrating these technologies?**
    A. No
    B. Yes: ____
    ____
    ____
    ____
    ____

Appendix C. Plagiarism Check Similarity Report

SIMILARITY REPORT

PLAGIARISM CHECK.ORG

0% SIMILARITY OVERALL

64.53% POTENTIALLY AI

SCANNED ON: 23 JAN 2025, 7:55 AM

AI Detector Results

Highlighted sentences with the lowest perplexity, most likely generated by AI.

LIKELY AI 43.13%

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School of Postgraduate Studies IMPACT OF ADVANCED PROJECT MANAGEMENT TECHNOLOGIES ON ROAD PROJECT PERFORMANCE: A QUALITATIVE STUDY OF THE ROAD SECTOR IN ZAMBIA A Proposal Submitted to the School of Postgraduate Studies, University of Lusaka in Partial Fulfillment of the ward of the Master of Science in Project Management.
BY POTO FRANCIS MSCPM22112966 ©2024. DECLARATION I, Poto Francis , declare that this dissertation titled Impact of Advanced Projec t Management Technologies on Road Project Performance: A Qualitative Study of the Road Sector in Zambia is my own original work and has not been submitted for any degree or examination in an y other institution . It is being submitted in partial fulfilment of the degree of Masters of Project Management to the University of Lusaka (UNILUS), Lusaka. Signed: Date: January 20, 2025 Supervised by: Dr. Sydney Ngoma Signature: Date: 23.01 2025 Page | i DEDICATION This dissertation is dedicated to my beloved wife, Esther Sosala, whose unwavering support and encouragement have been a cornerstone of my journey . To my dear children, Sheinah Poto and Francis S. Poto Jr.,