HOPE SUMMIT 2026

HOME OF PROJECT EXCELLENCE

PEOPLE | PURPOSE | PERFORMANCE

ACADEMIC PROGRAMME PROCEEDINGS

18-19 NOVEMBER 2026

HOPE SUMMIT 2026

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HOPE SUMMIT 2026 - HOME OF PROJECT EXCELLENCE

18–19 NOVEMBER 2026
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FOREWORD

The HOPE Summit 2026 Academic Programme provides a platform for the dissemination of original research and emerging developments in the fields of project leadership, project management, business, and organisational performance. The conference aims to foster meaningful engagement between academia and industry through the exchange of knowledge, research findings, and practical insights.

The 2026 Call for Papers invited the submission of conceptual, empirical, methodological, and practice-based research contributions. Submissions were received from authors representing multiple institutions across South Africa and internationally, reflecting the growing interest in advancing research and practice within the project leadership and management disciplines.

Following a rigorous academic review process, 16 papers were accepted for presentation at the HOPE Summit 2026. These papers address a diverse range of contemporary topics including project governance, artificial intelligence in project management, innovation, organisational performance, and public-sector project delivery.

Of the accepted papers, 11 are published in these proceedings. The remaining five highest-ranked papers were selected for a dedicated journal publication pathway and are under consideration for publication in a special issue of the South African Journal of Industrial Engineering (SAJIE). These papers will be presented at the conference but are not reproduced in these proceedings to avoid duplicate publication.

The Organising Committee and Scientific Council extend their sincere appreciation to all authors, reviewers, and committee members whose contributions made this publication possible. Their commitment to academic excellence, scholarship, and research integrity has ensured the quality and relevance of the work presented in this volume.

We trust that these proceedings will contribute to the ongoing advancement of project leadership, project management, and related disciplines, while supporting meaningful dialogue between researchers, practitioners, and industry leaders.

Prof Taryn Bond-Barnard
Chair: HOPE Summit Scientific Council

PEER REVIEW PROCESS

REVIEW POLICY

All papers published in the HOPE Summit 2026 Academic Programme Proceedings were subjected to a formal double-blind peer-review process administered by the Scientific Council.

Only full paper submissions were considered for inclusion in the proceedings. Abstract-only submissions were not eligible for publication.

SUBMISSION AND SCREENING

Authors submitted full papers in response to the HOPE Summit 2026 Call for Papers.

Prior to peer review, submissions were screened by the Scientific Council to ensure compliance with conference scope, formatting requirements, and minimum academic standards. Papers deemed outside the scope of the conference or not meeting submission requirements were excluded from further consideration.

DOUBLE-BLIND PEER REVIEW

Each eligible submission was assigned to a minimum of two independent reviewers possessing expertise relevant to the paper's subject area.

The peer-review process was conducted on a double-blind basis:

- Authors were not informed of reviewer identities.
- Reviewers were not informed of author identities.
- Reviews were conducted independently and confidentially.

EVALUATION CRITERIA

Reviewers assessed submissions according to the following criteria:

- Relevance to the conference themes.
- Originality and contribution to knowledge.
- Theoretical and conceptual rigour.
- Research methodology and research design.
- Quality of analysis and interpretation.
- Practical and managerial relevance.
- Clarity, structure, and presentation quality.

Reviewers provided both quantitative scores and qualitative feedback.

ACCEPTANCE DECISIONS

Acceptance recommendations were based on reviewer evaluations and scores. Where required, authors were requested to consider reviewer feedback and revise their papers prior to final acceptance.
The Scientific Council reviewed all recommendations before confirming acceptance decisions.

REVIEW OUTCOMES

A total of 16 papers were accepted for presentation at HOPE Summit 2026.
Of these:

- 11 papers are published in these proceedings.
- 5 highly rated papers were selected for a journal publication pathway and are under consideration for publication in a special issue of the South African Journal of Industrial Engineering (SAJIE). These papers will be presented

at the conference but have been excluded from these proceedings to avoid duplicate publication.

ACADEMIC INTEGRITY
The HOPE Summit is committed to maintaining high standards of academic integrity and scholarly quality. All published papers represent original work submitted by the authors and accepted following peer review conducted in accordance with recognised academic conference practices.

PROCEEDINGS INFORMATION
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Professor Taryn Bond-Barnard

ACKNOWLEDGEMENTS

Establishing the inaugural HOPE Summit Academic Programme has been a collaborative effort, made possible through the knowledge, expertise, and commitment of many individuals.

We extend our sincere appreciation to the members of the HOPE Summit Scientific Council for their dedication to developing the Academic Programme and establishing its academic foundations.

Our particular thanks go to Prof Taryn Bond-Barnard, Academic Programme Chair, for her leadership and coordination throughout the development of the programme. We also acknowledge the contributions of Prof Wynand van Dyk, Prof Carl Marnewick, Prof Martina Huemann, Prof Giel Bekker, and Prof Morteza Bagherpour for their academic guidance, strategic input, and commitment to maintaining the quality and integrity of the programme.

We further acknowledge Stellenbosch University, the University of Johannesburg, and the University of Pretoria, whose representation on the Scientific Council and academic collaboration have played an important role in establishing this inaugural initiative.

Our sincere gratitude also goes to the independent reviewers who generously contributed their time, expertise, and professional judgement to the double-blind peer-review process. Their thoughtful evaluations, constructive feedback, and commitment to scholarly excellence were instrumental in ensuring the quality, rigour, and credibility of the Academic Programme. We would particularly like to thank: Prof Alice Chan, Ms Rofhiwa Mmakuthe, Prof Hannelie Nel, Prof Rudolph Oosthuizen, Mr Ben Peters, Ms Ruchika Sinha, Prof George Thopil, Prof Reinhard Wagner

Together with the members of the Scientific Council, these reviewers made a valuable contribution to the assessment and development of the papers included in the programme.

We would also like to thank all authors who submitted their research to the inaugural Academic Programme. Your willingness to share knowledge, explore new ideas, and contribute to scholarly debate is greatly appreciated. We particularly congratulate the authors of the fifteen accepted papers and thank them for sharing their research and perspectives with the HOPE Summit community.

As we come together for HOPE Summit 2026, we hope that the research, ideas, and perspectives presented through this inaugural Academic Programme will stimulate meaningful discussion, strengthen collaboration between academia and industry, and contribute to advancing project leadership, project management, and organisational performance. We look forward to the exchange of knowledge during the Summit and to the broader impact these contributions may have on research, education, and professional practice beyond the conference.



Professor Taryn Bond-Barnard
Academic Programme Chair
Department of Industrial Engineering
Stellenbosch University



Samuli Karjalainen
Event Director
Hope Summit 2026

SCIENTIFIC COUNCIL, EDITORIAL COMMITTEE

SCIENTIFIC COUNCIL

The academic review, selection, and editorial processes for the HOPE Summit 2026 Academic Programme were overseen by the Scientific Council.

The Scientific Council is responsible for: providing academic oversight of the conference programme, appointing reviewers with relevant subject-matter expertise, monitoring the peer-review process, ensuring compliance with accepted academic and ethical standards, confirming final acceptance decisions and overseeing the publication of conference proceedings.

The Scientific Council represents expertise across project leadership, project management, industrial engineering, organisational management, and related disciplines. The committee reflects institutional diversity and includes members from multiple higher education institutions.

The HOPE Summit Scientific Council confirms that all accepted papers were evaluated according to established academic standards and that final acceptance decisions were based on reviewer recommendations and academic merit.

PEER REVIEWERS

We gratefully acknowledge the following academic reviewers for their expertise, time and valuable contributions to the double-blind peer-review process. Together with the Scientific Council members who also served as reviewers, their efforts helped uphold the academic quality and standards of the inaugural HOPE Summit Academic Programme.

Scientific Council

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TOP FIVE PAPERS – SELECTED FOR SAJIE SPECIAL ISSUE

RECOGNISING ACADEMIC EXCELLENCE AT HOPE SUMMIT 2026

As part of the Hope Summit 2026 Academic Programme, submitted papers underwent a rigorous double-blind peer-review process, with each paper evaluated by at least two independent reviewers.

Based on the review outcomes, five highly rated papers were selected for consideration for publication in a special issue of the **South African Journal of Industrial Engineering (SAJIE)**.

These papers represent valuable research contributions to project management, industrial engineering and related disciplines, addressing contemporary challenges and opportunities for organisations and society.

The selected papers will be presented during **Hope Summit 2026, 18–19 November, at DHL Stadium, Cape Town**. Unlike papers published in the Hope Summit Academic Programme Proceedings, these five contributions are excluded from this publication to allow for their subsequent consideration by SAJIE. Publication in the special issue remains subject to the journal's additional editorial, review and publication requirements.



SELECTED PAPERS

Paper Title: **Beyond the Hype: Challenges, Mitigation Strategies and Value Realisation in AI-Enabled Project Management**
Authors: Nosipho Manzini and Carl Marnewick
Affiliations: Department of Applied Information Systems, University of Johannesburg, South Africa

Paper Title: **The Impact of Project Sponsors' Rotation on Project Outcomes**
Authors: Dingaan Motaung, Carl Marnewick and Annlizé L. Marnewick
Affiliations: Postgraduate School of Engineering Management and Department of Applied Information Systems, University of Johannesburg, South Africa

Paper Title: **Disruptive Innovation Strategies in Mineral Sands Processing: Leveraging Agile Project Management Methodologies for Project Acceleration through Minimum Viable Products**
Author: Andre Huysamen
Affiliation Department of Industrial Engineering, Stellenbosch University, South Africa

Paper Title: **Analysing Factors Contributing to Government Construction Project Abandonment in Namibia: A Systems Approach Using Interpretive Structural Modelling (ISM) with MICMAC Analysis**
Authors: Lovely Frampton Damaseb and Taryn Bond-Barnard
Affiliations: Department of Industrial Engineering, Stellenbosch University, South Africa

Paper Title: **Artificial Intelligence in IT Project Delivery: A Scoping Review of Adoption, Outcomes, and Organisational Readiness**
Authors: Vusi Sithole, Suzaan Pretorius and Elma van der Lingen
Affiliations: Department of Engineering & Technology Management, University of Pretoria, South Africa

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Hope Summit congratulates the authors of these five selected papers and acknowledges their contributions to advancing research, professional knowledge and evidence-based practices in project-oriented organisations.

WITH APPRECIATION TO OUR PARTNERS

SUPPORTING PROJECT EXCELLENCE THROUGH COLLABORATION

Academic Collaboration

Stellenbosch University
iYunivesithi
Universiteit

University of Johannesburg

Universiteit van Pretoria
University of Pretoria
Yunibesithi ya Pretoria

Hope Summit Partners

We sincerely thank our partner organisations for their commitment and support in making Hope Summit 2026 possible. Their contributions help us bring together people, organisations and knowledge from across industries to strengthen project excellence, leadership and organisational capability.

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MEGAPROJECTS' IMPACT ON ORGANISATIONS: A COST OVERRUN PERSPECTIVE

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ABSTRACT

Megaprojects are vital for infrastructure development and economic growth but are frequently plagued by cost overruns. Various factors causing cost overruns are known through previous research, but little research has been done specifically on the impact of cost overruns on the company implementing a megaproject. This is particularly where the implementing company is not involved in a public-private partnership and must carry sole responsibility for and impact of cost overruns. A descriptive case study was used to investigate the phenomenon at hand. This allowed for an in-depth understanding of the factors contributing to cost overruns as well as the impact of these overruns on the company. Ten interviews were conducted with senior employees who were involved in the megaproject implementation. The analysis revealed that the case study faced similar external factors that contributed to cost overruns as identified in the literature review, along with distinct internal challenges specific to the private energy producer. The participants noted that the decisions made by the leadership had significant political repercussions, which negatively impacted the organisation's revenue status.

Keywords: Behavioural economics, Cost overruns, Megaprojects

* Corresponding Author

1 INTRODUCTION

Megaprojects are large-scale, complex endeavours typically costing USD 1 billion or more which can be comprised of various stakeholders (public and private) and may take several years to design and execute [1]. These types of projects involve a substantial investment of time and resources [2]. Difficulties in megaprojects express themselves as a collection of errors and challenges that are thought to pose a threat to the objectives of a megaproject and its stakeholders [3]. The most frequent challenges megaprojects encounter are overruns in cost and schedule [4].

Overruns are calculated as the difference between the baseline and the actual cost and delivery time [5]. Cost overruns have numerous causes which can be internal and external to a project [6]. Nine out of ten megaprojects encounter cost overruns; real-world overruns of up to 50% are usual and over 50% are not unusual [7]. The cost and schedule overruns in a megaproject can affect the success of a company, which can ultimately threaten its survival or lead to collapse [2]. This is due to inaccurate information about costs, timelines, benefits and risks frequently provided throughout project development and decision-making. As a result, cost overruns, delays and benefit deficiencies threaten the project's viability during execution and operation [7]. Due to limited descriptions available on the cost overrun impacts of megaprojects on an organisation, the following research questions were posed:

1. What are the factors that contribute to cost overruns on a megaproject?
2. How does a megaproject's cost overruns impact the overall company?

2 LITERATURE REVIEW

Megaproject cost overruns have significant implications for organisations, affecting financial stability, stakeholder trust and project sustainability. While megaprojects can yield positive outcomes such as economic growth, social benefits and sustainable development [8], they are also complex, involving multiple stakeholders and high levels of risk and uncertainty [9]. In the case of power generation megaprojects, cost overruns can lead to operational inefficiencies, as seen in South Africa's Kusile and Medupi projects. Delays in these projects contributed to national electricity shortages, financial strain and a loss of public trust, forcing the utility company to seek government support through tariff increases [10]. These challenges illustrate how cost overruns can damage an organisation's reputation and make future investments less likely [11].

Beyond financial losses, cost overruns disrupt internal operations, diminish project quality and erode stakeholder confidence. Organisations may cut corners to stay within budget, which compromises long-term viability [12]. High-profile examples, such as the Channel Tunnels 80% cost increase, show how overruns can provoke public backlash and reputational damage [13].

2.1 Factors contributing to cost overruns

The size and complexity of megaprojects make the economic losses associated with cost overruns enormous. However, multiple factors have been identified which contribute to cost overruns in megaprojects. The impact and the rate of recurrence are dependent on the type of project and location [14]. A study by Cantarelli et al. [15] highlights four main factors: (1) economic – this is often due to intentional cost underestimation that is deemed economically

sound, (2) political – this may be due to strategic misrepresentation, (3) psychological – this includes notions of optimism bias and planning errors, and (4) technical – this includes forecasting errors due to insufficient data or expertise.

The Olaniran et al. [16] study focused on cost overruns of hydrocarbon/oil and gas megaprojects and developed a conceptual framework for analysing the cost overruns. They collected data from 69 hydrocarbon/oil and gas megaprojects from six continents. Four themes were derived from these 69 megaprojects to categorise the nature of cost overruns: (1) project characteristics, (2) people, (3) technology and (4) structure and culture. These themes were affected by external factors such as political, economic, legal and environmental issues and the involvement of stakeholders [16].

Across seven studies spanning South Africa, China, India, the United States and other global samples, cost overruns in megaprojects reflect contrasting governance and context. South African energy projects (Kusile, Medupi) suffered severe overruns driven by weak site and managerial controls, unstable structures, inexperience and corruption/state capture [4]. In China, three flagship transport and energy projects achieved comparatively low overruns through strong leadership, political backing, external supervision and cohesive corporate cultures [17]. India's review of 30 projects found extreme overruns in roads (~250%), with land acquisition delays, poor estimating, scope changes and contractor issues prominent [14]. Global tunnel projects highlighted political, legal/regulatory and economic drivers, including contracting mechanisms and topography [18]. Additional evidence from energy and hydrocarbons linked overruns to deliberate underestimation, forecasting errors, inadequate organisational design, governance and stakeholder dynamics, while U.S. rail projects underscored political/psychological factors (strategic misrepresentation, inflation), long timelines and scope growth [19].

The analysis of the seven cases indicates that cost overruns arise from a broad, interdependent set of drivers spanning technical, economic, political, legal, psychological, and environmental domains. Technical factors are most frequently implicated (21 instances), followed by economic and political (17 each), legal (14), psychological (13), and environmental (4). Cross-cutting determinants—project organisational structure and leadership, contracting mechanisms, operations and maintenance factors, main project variables, strategies and vision, and inherent project properties—affect nearly all domains simultaneously, underscoring governance and capability as foundational risks. Recurrent proximate causes include scope changes (and on-site variations), lengthy implementation, weak contractor performance and site management, delays in land acquisition and equipment supply, forecasting and estimation errors (including incomplete or inaccurate estimates), material planning shortcomings, financing and ownership structures, corporate reputation and culture, bias and risk perceptions, external supervision, legal–political constraints (e.g., law-and-order issues, corruption), slow client decision-making, and price shocks (inflation and general escalation). Collectively, these patterns point to systemic rather than purely technical origins of cost escalation.

The reviewed studies provide a comprehensive analysis of cost overruns in megaprojects, offering valuable insights into the influence of various external factors. Key findings from the analysis indicate that technical factors have the most significant impact on cost overruns, followed by economic and political factors, reflecting their substantial influence on project

costs. Legal and psychological factors also have considerable impact, with environmental factors having the least impact.

To mitigate these effects, organisations must prioritise realistic planning and risk management, addressing the root causes of overruns to ensure better management of large-scale projects [20].

3 METHOD

A qualitative research methodology was employed, specifically a case study approach, to investigate the causes of megaproject cost overruns. The primary aim was to explore the impact of these cost overruns on the overall organisation. This approach provided deeper insight into the complexities of managing megaprojects and how organisations address cost overruns in practice.

A descriptive case study approach enabled a systematic examination to understand the causes of megaproject cost overruns [21]. The private energy producer is a South African-based company. The undisclosed megaproject identified for the research study is one of the largest foreign investments for expanding the private energy producer's presence in the US market. The case study was selected because it was a multi-billion-dollar megaproject. It is considered a megaproject due to its massive scale and complexity. The project was originally scheduled for completion in four years, but it ultimately took around seven years to finish, with the cost to completion estimated at $12.8 billion. This marked a significant increase from the original estimate of $8.9 billion at the time of the final investment decision (FID). Data was collected from ten participants in strategic leadership roles who were involved in the megaproject. Personal identifiers have not been used to safeguard the study participants' privacy. Table 1 outlines the participants profile, including the length of service in the organisation and the duration in the megaproject case study. Purposive sampling was used to select participants with substantial experience in the planning, execution, and management of megaprojects, ensuring that the data collected provided informed insights into the causes and organisational impacts of cost overruns.

Table 1: Participant profile

Study Participant	Length of Service	Duration in the megaproject case study
Participant 1	29 years	3 years
Participant 2	25 years	3 years
Participant 3	35 years	Less than 1 year
Participant 4	18 years	2 years
Participant 5	22 years	3 years
Participant 6	31 years	2.5 years
Participant 7	18 years	2 years
Participant 8	30 years	2 years

Study Participant	Length of Service	Duration in the megaproject case study
Participant 9	29 years	2 years
Participant 10	31 years	Less than 1 year

The interviews were analysed using the Gioia methodology [22]. Initially, interview transcripts were coded into first-order concepts using participants' own terms and expressions. These concepts were then compared and grouped into second-order themes that reflected broader theoretical patterns relevant to the study. Finally, related themes were consolidated into overarching dimensions that formed the basis of the findings. To enhance the credibility of the analysis, the coding structure was reviewed iteratively, with themes continually compared against the original interview data to ensure consistency and accurate representation of participants' perspectives. This resulted in a graphic presentation (Figure 1).

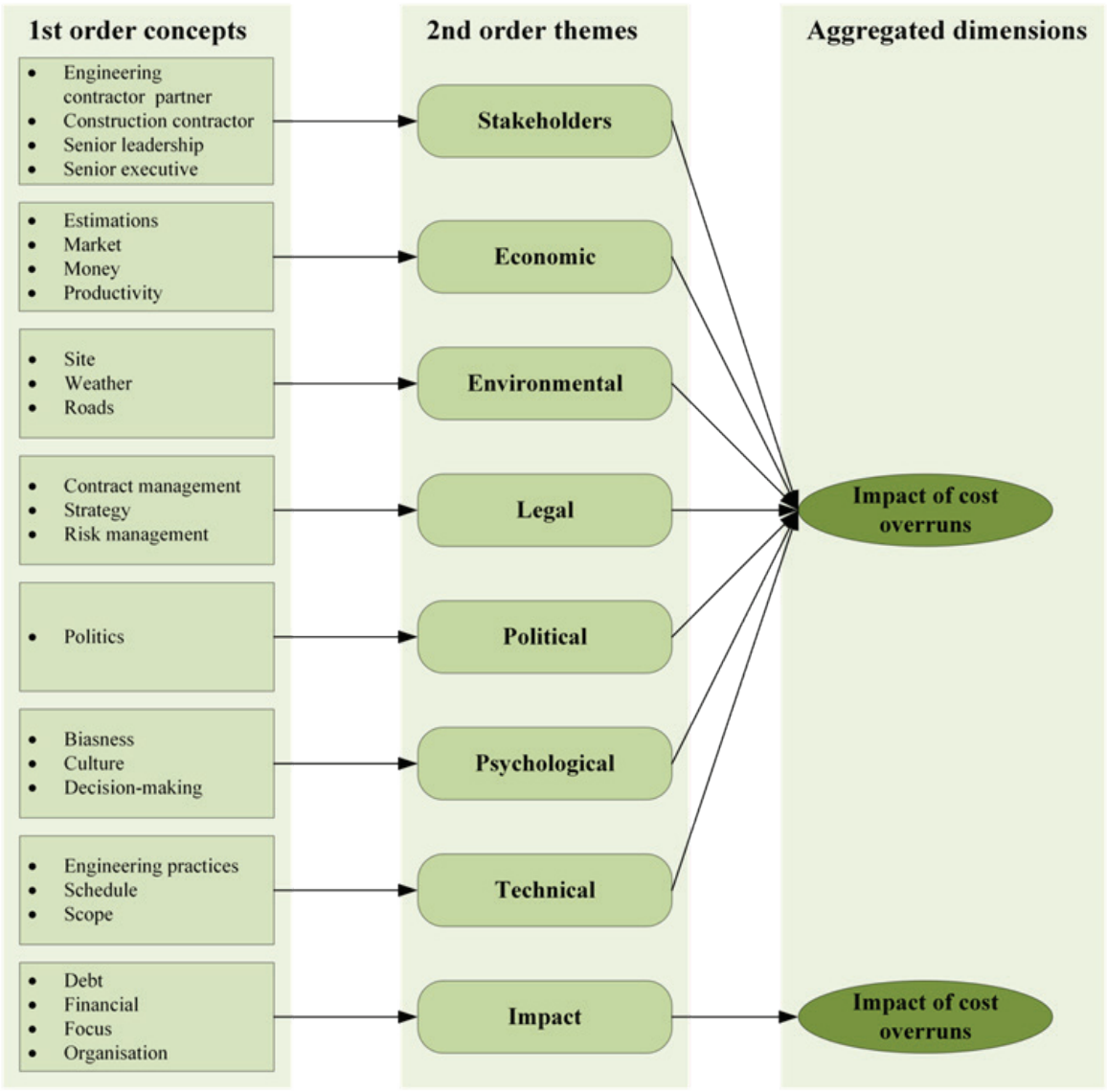


Figure 1: Data structure derived from interviews

4 FINDINGS

4.1 Stakeholders

Cost overruns were closely linked to governance and accountability across four actors—the construction contractor, senior leadership (including the board), the engineering-contractor (EC) partner, and a senior executive. Participants described a project culture that discouraged transparency with contractors, enabling uncritical acceptance of claims: "*You had a culture that was not conducive to openness and transparency and building up relationships with contractors*" (P6); "*we trusted our contractors when they said that productivity is 1.12… never in the world was a plant built at 1.12*" (P1). Leadership decision rights were exercised without consistently weighing risk: "*They can still make a call. But they should make a call taking account of all these factors*" (P9), with later board actions aimed at avoiding a repeat of "*such a precarious situation*" (P7). EC accountability was diluted by privileged access upward "*they knew they had a direct line to the GEC and they felt protected" (P8) "and by executive influence over EC selection. It made the management of the EC almost impossible*" (P8). Excluding internal engineering and project teams from early phases further reduced challenge and technical diligence. Overall, organisational structure, decision rights, and leadership quality—rather than technical factors alone—shaped cost outcomes.

4.2 Economic

Cost escalation was driven by weaknesses in financial structuring, estimating discipline, productivity assumptions, and market positioning. On financing, the reimbursable form lacked expenditure control "*was chosen as a reimbursable project but no controls to make sure that the money flow was appropriate*" (P6) and debt exposure created schedule-driven pressure that curtailed re-baselining and interface management: "*because we are borrowing money we're rushed for speed… we're not doing interface management*" (P1). Estimating processes did not keep pace with risk transfer and relied on over-stretched assumptions: the estimate "*was not updated from a risk transfer of productivity to the company*" (P3) and "*is not stringent enough so they push boundaries of the estimate and its assumption set*" (P6), producing systematic underestimation. Strategic choices traded capability for speed and price, depressing labour productivity and technical competence "*you will get the lowest productivity in the world, the lowest technical skills*" (P1). Market strategy prioritised first-mover advantage "*hit the market first, retain market share*" (P8) without sufficient competitive and demand analysis, creating costly misalignment. These dynamics were compounded by deviations from internal governance (e.g., acceptance of non-competitive rates), reinforcing how governance, estimation accuracy, and leadership choices drove overruns.

4.3 Environmental

Environmental conditions—site, weather, and access roads—materially disrupted construction and escalated costs via lost productivity, rework, and schedule slippage. Site-specific hazards ranged from extreme events to geotechnical constraints: "*it was a hurricane that flooded the site*" (P8), and "*the site posed significant civil challenges… marshy terrain*" that increased complexity and time (P9). Prolonged rainfall reduced mobility and throughput "*they had a lot of rain and accessibility was a big issue*" (P3) yet anticipated seasonal risks were not adequately reflected in planning or estimating. Access design amplified exposure: drainage and haul-road standards were insufficient "*the roads should get rid of water as quickly as*

possible… [we] didn't allow for any of that" (P4); during wet conditions "*you couldn't even drive around… it was just muddy and extremely difficult to do work there*" (P5). While environmental drivers are typically location-specific, in this case they became systemic because weather-related risks were insufficiently identified, quantified, and mitigated during front-end planning and cost estimation.

4.4 Legal

Cost escalation was amplified by legal/contractual choices that weakened risk allocation, accountability, and incentives. In risk management, the fully reimbursable form shifted exposure onto the owner without adequate controls "*Cost control was basically non-existent, across the board*" (P4) and a remote team operated "*not [with] a risk-based approach*" while introducing "*a lot of secrecy*" (P7). Strategy drift intensified the problem: a cost-driven project was run to an aggressive schedule, with leadership prioritising pace over re-baselining and risk treatment, reflecting organisational and succession pressures rather than cost efficiency. Contract management removed normal levers for performance: "*All the contracts, none of them had delayed damages associated with any of the performances*" (P4), eliminating deterrents to delay. Enforcement was further undermined by hierarchy and access "*the EPCm contractor… has a direct line to the senior executive… if you… apply contractual remedies they just pick up the phone and you're almost dead in the water*" (P8). Together, the contracting strategy, strategic prioritisation of schedule, and diminished enforceability eroded governance, reduced accountability, and propagated inefficiencies that manifested as cost overruns.

4.5 Political

Participants pointed out several issues, including political interference within the organisation, impacting the appointment of an engineering contractor, the governance process for approving the cost estimate and the exclusion of internal projects and engineering teams from the early stages of the project. Participant 8 said, "*I understand it was a board decision, but I do think there where interventions of the senior executive at the time which forced a certain commercial approach*". While the participant acknowledged that the decision was ultimately made by the board, this implies that the senior executive's influence played a significant role in shaping the decision-making process and possibly overriding other considerations. Participant 10 added that "*internal company politics played a big role*" suggesting that decisions were driven by politics instead of objective analysis.

Additionally, Participant 1 reiterated, "*So again, pressures, political pressure, commitments, promises, changed a cost-driven project into a schedule-driven project*". The emphasis changed to meet specific deadlines, compromising cost-effectiveness in the process. This implies a conflict between financial considerations and the need to adhere to a schedule, highlighting how internal politics altered project dynamics. The case study revealed that political dynamics and pressures led to decision-making driven by political objectives rather than financial and technical feasibility, contributing to cost overruns and shifting the project's focus and outcomes.

4.6 Psychological

Cost escalation was reinforced by behavioural dynamics—how decisions were made, how leaders led, what the organisation valued, and the biases that shaped judgment. On decision-making, participants stressed the mismatch between investment scale and organisational capacity—"*the scale of the investment… was huge compared to the private energy producer's… market cap… a high-risk decision*" (P9) and flagged governance slippage when "*that got cut by 20%… by [three senior executives]*" (P10), a top-down estimate reduction with adverse execution consequences. Leadership climate muted challenge and learning "*that bureaucratic, don't ask questions, do what you're told kind of leadership*" (P7) and underscored the need for seasoned project leaders "*you need experienced leadership, people who understand how to do projects*" (P6). Culture further impeded transparency and alignment: "*not conducive to openness and transparency and building up relationships with contractors*" (P6), compounded by cross-cultural disconnects "*We didn't understand the American culture… the business construct… and we were removed from the project*" (P7). Finally, optimism bias normalised underestimation and reactive management "*don't talk to me with the problems, we'll sort that out as they come along*" (P2); "*decision-makers… will rather believe a lower number than… a realistic number*" (P9). Together, these psychological factors bypassed robust appraisal and governance, strained contractor relationships, and propagated underestimation—ultimately translating into cost overruns.

4.7 Technical

Cost escalation stemmed from an unstable scope baseline, under-developed engineering at FID, and schedule-driven execution. Scope control weakened post-FID when team continuity broke down "*it's fine to change the scope up until FID… [but] after FID… the engineering team was not the same team… that sat with the original design*" (P7) and key work was underestimated "*the to-go scope was under-estimated*" (P8). Technically, the project proceeded without sufficient maturity for its risk profile: "*the project was underdeveloped for an FID on such a large-scale, high-risk project, and it was known*" (P9); engineering at gate four by the EC partner was underdeveloped, creating rework and integration risk. Execution priorities further eroded cost discipline: "*we actually put more value on the schedule… as soon as we make FID then it must be done yesterday… every project is schedule-driven until they realise how much it is going to cost*" (P2), reinforced by a perceived "*window of opportunity*" (P9). In effect, incomplete engineering and an unsettled scope at FID, combined with accelerated schedules, produced optimistic estimates, interface failures, and prolonged durations—underscoring the need for through-gate planning, stable teams, and firm scope governance before sanction.

4.8 Megaproject cost overruns impact on overall company

Cost overruns cascaded through the balance sheet, operating performance, portfolio focus, and organisational design. First, leverage increased sharply: the firm is "*still… carrying the load of debt… it drained all our money*" (P3); debt that was expected to be serviceable now "*we can't*" repay (P7). Second, financial performance deteriorated as returns lagged rising financing needs "*we had to borrow more… we're not getting the returns… severely hamstringing our balance sheet*" (P2) to the point that "*if you didn't do that plant, we would*

be profitable today… now, we can't even be profitable at $30 per barrel" (P4). Third, concentration risk crowded out the rest of the business: a "*huge portion" of resources was tied up, so "other operations that needed maintenance… probably didn't get it*," and because "*this is not just a once-off… debt… has to be continuously serviced, that problem carries on for a long time afterwards*" (P9). Finally, structure and capacity were reshaped to cope "*we split [the project division] into multiple departments… [believing it] was incapable of doing projects*" (P1) while the enterprise had to "*start doing more with less resources*" (P5). Together, these impacts entrenched a prolonged financial and organisational drag well beyond the project timeline.

Participants noted that cost overruns in the megaproject had serious consequences, including drops in the share price, revenue challenges and political fallout, all harming the organisation's financial health. The literature highlights that megaprojects are inherently complex, involve numerous stakeholders and carry high risks and uncertainties [9]. Key issues include frequent cost overruns, delayed timelines and governance lapses, which the case study confirmed. Notably, the exclusion of the owner's teams and lack of quality control led to financial losses. This financial strain has impacted the company's reputation and willingness to invest in future megaprojects [12]. The case study vividly demonstrated the challenges. The megaproject featured extensive involvement by the board, senior executives and executives. A troubling discovery in the case study was the exclusion of the owner's project and engineering teams from the project's inception. Another significant finding was the leadership's failure to adhere to internal quality assurance processes when approving cost estimates, leading to adverse financial consequences for the organisation.

The literature review also indicates that megaprojects often face delays and scope changes, resulting in cost overruns and economic losses. Such financial impacts can damage an organisation's reputation and affect future megaproject investments [12]. As a result, organisations may become hesitant to invest in future large-scale projects due to financial strain and reputational damage [11]. These case study further reveals that the private energy producer still at the time of writing continued to experience the financial repercussions of the cost overruns from the undisclosed megaproject.

5 DISCUSSION

The primary contribution of this study is to move the conversation from the well-charted terrain of overrun causes [1, 7, 15, 16] onto the less-examined terrain of overrun consequences for the sponsoring organisation. In the case examined, a 43.82% overrun propagated into four interlocking organisational impacts i.e. debt, financial position, strategic focus, and organisational structure. Each of these impacts are traceable to specific human-made decisions rather than to exogenous shocks (Figure 2). The remainder of this section addresses the two research questions in turn, before returning to these four organisational impacts.

The first research question focused on factors that contributed to this cost overrun. Forty-six factors were identified based on a meta-analysis of 7 studies that investigated 225 megaprojects. These 46 factors were classified into 6 primary external forces as per [16]: (1) economic mainly due to cost underestimate, (2) environmental due to topographical influence and climate conditions, (3) political mainly due to strategic misrepresentation, (4) psychological due to optimism bias, (5) technical mainly due to forecasting errors and

additional scope, and lastly (6) legal due to regulatory requirements and the type of contracting philosophy.

From the analysis of the interviews, various factors were identified that contributed to the 43.82% cost overrun, with stakeholders, economic and psychological themes contributing the most. Contrary to the literature review, the environment played an important role in the cost overrun. This is evident from the interviewees who revealed that it seemed as if the project team was unaware of the impact of the weather on the overall performance of the project. Table 2 highlights the difference between the cost overrun categories identified in the literature and in the case study. A major difference is that in the case study, politics did not play such a major role in the cost overrun as suggested in the literature. Another major difference is the impact of the environmental factors in the case study. Environmental factors played a major role in the cost overrun of this megaproject.

Table 2: Factor comparison

Theme	Literature	Case Study	Difference
Political	19.8%	5.3%	⌄
Legal	16.3%	15.8%	›
Environmental	4.7%	15.8%	⌃
Stakeholders	24.4%	21.1%	›
Economic	19.8%	21.1%	›
Psychological	15.1%	21.1%	⌃

Various theoretical lenses can be applied to this case study to make sense of the cost overruns. Principal-agent theory examines relationships where one party (the principal) delegates work to another party (the agent), who performs that work on the principal's behalf [23]. This theory addresses challenges that arise due to misaligned incentives and information asymmetry where agents have more information about their actions than principals do. Key issues relevant to the case study, highlighted by principal-agent theory, are as follows:

- **Contractual relations:** In this instance, the EC partner inflated the costs or underperformed because they knew the project owners would bear the financial risks. The interviewees highlighted that the EC partner was untouchable due to their relationship with the senior executive.
- **Information asymmetry:** The agent had more information than the principals and exploited this to their advantage [24]. This was highlighted where the contractors knew the impact of the weather on the project schedule and still maintained that they would have a higher-than-normal productivity rate. This was not possible and resulted in delays that contributed to the cost overruns.
- **Moral hazard:** This implies that the agent takes risks or acts in a way that benefits them but increases costs or risks for the principal, knowing that the principal bears the consequences [24]. The principal absorbed all the costs from the various contractors as the contractors did not make provision for delayed damages.

To address these issues, principals often design incentive structures and monitoring mechanisms that aim to align the agent's actions with the principal's goals. In this case study the agents did not have any incentive to deliver on time as no penalties were enforced as per the contracts. Monitoring mechanisms from a governance perspective were also not conducive as the senior executive undermined project governance, reduced agent accountability and contributed to cost overruns and inefficiencies. Countermeasures to counter the agents' behaviour were not in place.

Cost overruns can also be contextualised within the broader environment through institutional theory [25].

- **External pressures:** Throughout the project, the company faced changing environmental and safety regulations from both federal and state authorities in the United States of America, these adjustments required the company to make modifications to project specifications, which added complexity and increased costs. For instance, regulatory adjustments demanded enhanced compliance with air quality and emission standards which led to revisions in design, procurement and construction stages, driving costs higher than initially projected.
- **Internal governance structures:** Inefficient decision-making processes and inadequate oversight mechanisms such as governance structures contribute to project inefficiencies [26]. The case study highlighted that internal governance was not followed during the review of estimates, and non-competitive rates were accepted.
- **Coercive pressures:** Coercive isomorphism occurs when organisations are forced to conform to institutional norms and expectations through regulations, laws, or other forms of external pressure [27]. The company was coerced into the megaproject. When the company embarked on the project, they envisaged that they would be the first in the market and establish long-term dominance. Due to the delays and the cost overruns, this did not happen and potential customers found other suppliers.

The identified psychological theme warrants the investigation of cost overruns from a behavioural economics perspective. This perspective focuses specifically on the following:

- **Optimism bias:** Flyvbjerg [28] defines optimism bias as "the tendency to be overly optimistic about the outcome of planned actions, including overestimation of the frequency and size of positive events and underestimation of the frequency and size of negative ones". The project planners and stakeholders were overly confident about project timelines and costs. This led to underestimation of risks and the required resources. The interviewees highlighted this optimistic bias that led to the notion that issues would resolve themselves and to lower cost estimates. These led to financial issues (debt and market loss).
- **Strategic misrepresentation:** Some stakeholder (actors) knowingly underestimated costs as well as overstated their productivity. These misrepresentations were revealed later within the project lifecycle. Since there were no contractual obligations, the private energy producing company had to absorb all the costs and associated risks.

When using the six primary external forces to understand the cost overrun factors for the undisclosed megaproject in a private energy producer, the following findings were observed:

- **Stakeholder:** Poor accountability, leadership changes, exclusion of key internal project and engineering teams and incomplete engineering contributed to cost overruns and project failures.
- **Economic:** Lack of internal governance, inaccurate estimating and acceptance of non-competitive rates contributed to cost overruns and compromised the project's financial stability and efficiency.
- **Environmental:** Inadequate planning for weather-related risks and site conditions led to work stoppages, delays and increased costs, highlighting the need for better risk management and environmental considerations in project planning.
- **Legal:** The choice of contracting strategy and the direct relationship between the EPCm contractor and the senior executive undermined project governance, reducing accountability and contributing to cost overruns and inefficiencies.
- **Political:** Political dynamics and pressures within the private energy producer resulted in decision-making that prioritised political objectives over financial and technical feasibility, contributing to cost overruns and altering the project's focus and outcomes.
- **Psychological:** Leadership's bias and decisions, along with an inflexible organisational culture, created significant risks and challenges, including inadequate investment evaluations and strained contractor relationships, highlighting the need for more transparent, culturally aware and collaborative practices to improve project outcomes.
- **Technical:** The incomplete engineering and scope at the time of FID, combined with political and schedule-driven pressures, led to significant project risks, highlighting the need for more thorough planning, stable teams and better alignment between engineering and scope management to avoid cost and schedule overruns.

The second research question focused on the impact of the cost overruns on the company itself. A mapping was done between the various identified factors and the impact on company's debt and finances, the shift in focus as well as the organisational structures. This mapping is highlighted in Figure 2.

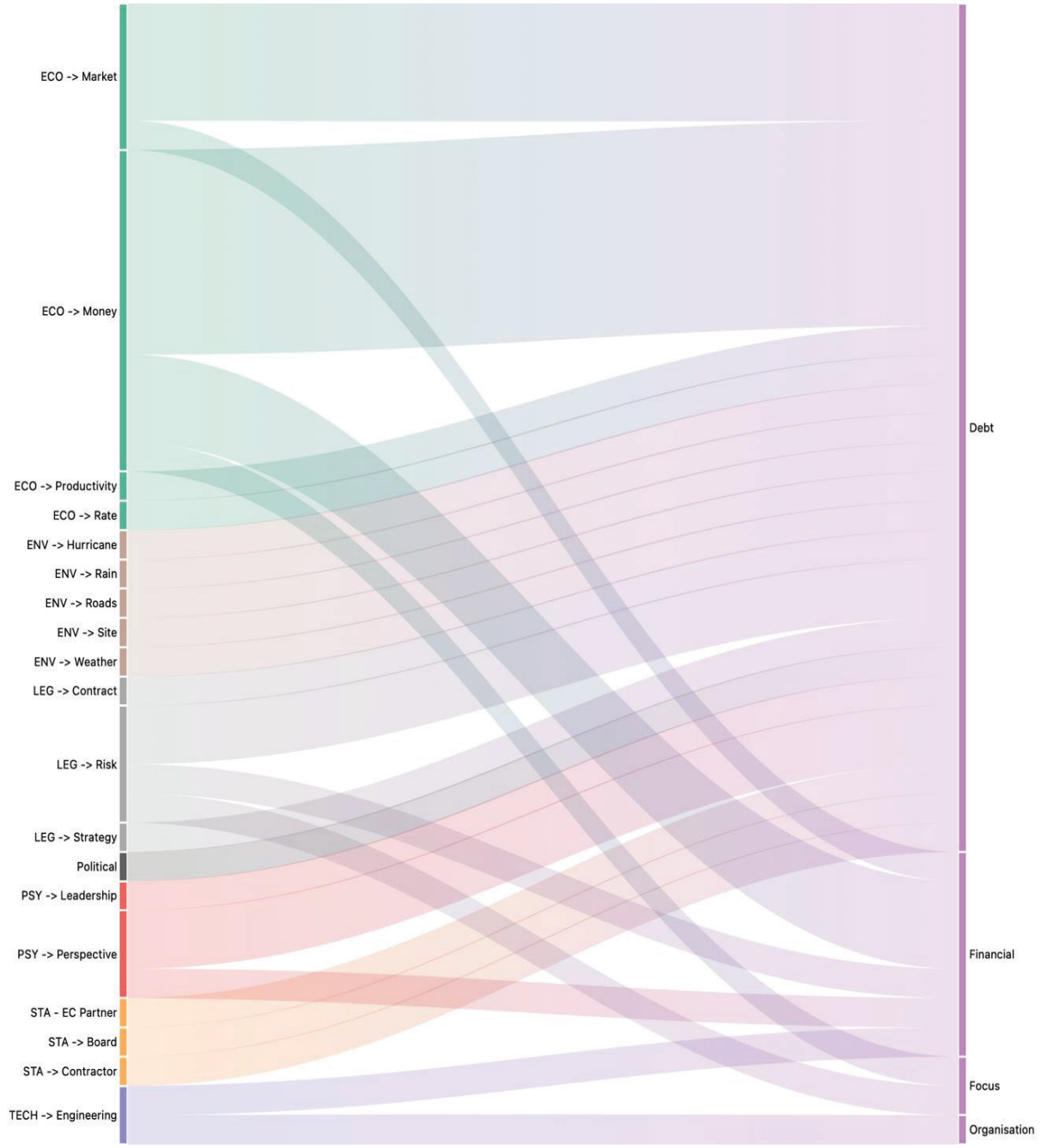


Figure 2: Sankey diagram – impact of cost overrun factors

The case study reveals that the megaproject cost overruns had several significant consequences for the private energy producer, including a negative impact on the company's share price, its capacity to generate revenue for debt servicing and the broader macroeconomic issues that further hindered revenue generation.

The financial impact experienced by the company due to the cost overruns resulted in reputation damage and impacted future megaproject investment. The consequences of cost overruns included financial losses, the disruption of internal operations, the diminishing of stakeholder trust and threats to the long-term sustainability of the company itself. Adam et al. [12] point out that cost overruns can threaten project sustainability, as organisations may

reduce quality or compromise standards to remain within budget, which may negatively impact the project's quality and long-term viability, Walsh and Walker [29] maintain that ongoing cost overruns can erode stakeholder trust, as public confidence in the project's feasibility and management capabilities shifts toward scepticism.

The inability to deliver the anticipated benefits emphasises the importance of realistic planning and though risk management [20]. A thorough understanding of these effects is critical for planning and managing megaprojects effectively, by addressing the root causes of cost overruns, the company should develop innovative strategies to manage these challenges more effectively in future megaprojects.

The analysis reveals that the case study faced external factors that contributed to the megaproject cost overruns like those in the seven studies discussed in the literature review, but to a greater extent, along with distinct internal challenges specific to the private energy producer. The participants noted that the decisions made by the leadership (senior executive, the board and other executives) had significant political repercussions, which negatively impacted the organisation's revenue status.

The financial burden of debt and the broader organisational consequences from the cost overruns demonstrate the need for stronger leadership, more strategic planning and independent project controls. These insights highlight the importance of organisational transformations and cautious future investment in megaprojects to avoid long-term financial strain and reputational damage.

The four identified organisational impacts extend the megaproject cost-overrun debate beyond the iron triangle of the project itself. Where existing scholarship largely stops at project-level consequences, the case itself demonstrates how project overrun can entrench a multi-year debt burden, erode profitability at prevailing market prices and force a defensive redesign of the project delivery function.

6 CONCLUSION

The purpose of this article was to determine (i) what factors influence cost overruns in megaprojects in general and specifically for the case study at hand and (ii) what impact is of cost overruns on an organisation. Forty-six factors were identified through a meta-analysis of relevant literature. Specific factors were mentioned by the interviewees and these were related to the identified factors. No new factors were identified but environmental factors played a bigger role in the case study than reported in literature. The impact of cost overruns can be summarised into four aspects of the company, i.e. debt, financial position, the change of focus of the organisation and the structure of the organisation itself.

Cost overruns in megaprojects are not a new phenomenon, as highlighted by the literature. What is interesting is that the causes of the cost overruns in the case study were all human-made, apart from the environmental factors. The environmental factors could have been addressed through proper due diligence. Principal-agent and institutional theories as well as the behavioural economics perspective highlighted that the causes could have been addressed, raising the question why this was not the case. This research contributes to the current body of knowledge indicating that human behaviour is the major cause of cost overruns in megaprojects.

This article's theoretical contribution supports the current thinking around the factors that influence megaproject cost overruns. It also indicates how theories can be used to explain this phenomenon. From a practical perspective, the article highlights the common reasons for cost overruns and negative impact it has on an organisation. The article qualifies the impact and provides insights into how cost overruns can cripple a financially healthy organisation.

By addressing the root causes of cost overruns and learning from past megaproject experiences, organisations can implement innovative solutions that improve project outcomes and enhance their ability to deliver successful, financially stable megaprojects in the future.

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The Impact Of Environmental Regulations On Oil And Gas Projects

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THE IMPACT OF ENVIRONMENTAL REGULATIONS ON OIL AND GAS PROJECTS

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ABSTRACT

Noncompliance with environmental regulations has become a major challenge in oil and gas projects due to financial, institutional, structural and legal barriers. This research aims to develop a guideline to help project managers mitigate the legal impacts of noncompliance. A qualitative approach was used, involving semi-structured interviews with project managers, project engineers and environmental officers in South Africa. Thematic analysis identified key challenges faced when planning and executing projects requiring environmental authorisation. High initial costs for permits, licences, and Environmental Impact Assessments (EIAs) were found to be major contributors to noncompliance. Additional costs include retrofitting older equipment to meet updated standards. Poor enforcement and limited coordination among internal departments and regulatory bodies are among other causes of noncompliance. Participants suggested streamlining authorization processes to reduce costs, improve timelines, and strengthen stakeholder engagement. The research links compliance behaviour to project performance and offers practical guideline to improve environmental governance and project execution.

Keywords: Environmental Compliance, Environmental Impact Assessment, Oil and Gas Projects, Project Management, Regulatory Barriers.

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1. INTRODUCTION

Sustainability emerged as a critical challenge of the 21st century, necessitating a global reassessment of industrial practices and environmental management. The environmental aspect of sustainability has become a crucial area of concern within this broad framework, largely due to legal compliance [1]. Since the oil and gas industry is known to contribute significantly to greenhouse gas emissions and environmental deterioration [2], it is under increased scrutiny and, as a result, there is a greater emphasis on following environmental laws [3]. A significant transition towards environmental sustainability is occurring in the oil and gas industry due to mounting demand from authorities, consumers, business associates, and employees.

In the oil and gas industry, environmental regulation is a crucial response to sustainability, encouraging the use of cleaner energy sources and technical innovation. Laws can encourage the development of more sustainable technologies, draw in foreign investment, and force Companies to lessen their environmental impact [4]. It is more important than ever to make sure that the natural environment is not negatively impacted by oil and gas policy and operations. As the oil and gas industry manages the dual challenges of supplying the world's energy needs and reducing its environmental impact, adherence to environmental regulations is a key factor in influencing how decisions are made in oil and gas project management [5].

The oil and gas industry prioritizes sustainability for a number of reasons, including the need to comply with an expanding set of environmental rules, pressure from employees and shareholders, and a desire to act responsibly for the future of the world [6]. Most oil companies aim to operate in a way that is both cost-effective and environmentally sustainable. The aim of this study is to investigate how the oil and gas industry is being impacted by evolving environmental regulations. It will examine how those regulations affect project management decisions and strategies used by companies to ensure adherence and optimize operational outcomes.

2. LITERATURE REVIEW

The oil and gas industry is vital to the world economy as it supplies the world's expanding energy needs, drives industrial growth, and brings in large sums of revenue for the countries that produce it [7]. There are a lot of environmental dangers connected to the industry’s operations, like greenhouse gas emissions, oil spills, water contamination, and habitat deterioration. Governments, regulatory bodies, and international organisations have implemented strict environmental rules and regulations in response to these environmental issues [8]. These rules and regulations are intended to reduce the negative effects of oil and gas operations on the environment and public health. Compliance with environmental laws has thus emerged as a key operational and strategic factor in the development, implementation, and administration of oil and gas projects worldwide.

In the oil and gas sector, environmental regulations are used to control the risks involved in exploring, extraction and processing of oil and gas [7]. The involvement of stakeholders, application of enforcement mechanisms and regulation of compliance monitoring systems are the key components of the environmental regulations [9].

Although regulations differ by region, the all aim to achieve the same goals, including conservation of biodiversity, pollution control, and reduction of emissions [10]. Some of the environmental regulations from different regions include the National Environmental Management Act (NEMA), which is the main environmental regulation in

South Africa. There is the Canadian Environmental Protection Act (CEPA) and in Nigeria they have the FEPA Act

2.1. Causes of noncompliance

To improve governance and sustainability performance in oil and gas projects requires an understanding of the root causes of environmental regulation compliance. Literature identified five barriers of compliance in oil and gas projects which include, financial, institutional, structural and legal barriers [11]. These major causes of noncompliance are summarised in Table 1 together with their implications. These barriers combined make it difficult to integrate environmental regulations into project planning and execution.

Table 1: Causes of noncompliance

Aspect of noncompliance	Description of barrier	Implications	References
Financial barriers	High costs of environmental impact assessments, emission monitoring technology, and pollution control equipment	• Increased project costs • Reduce investors' confidence • Reduced profits	[12]; [13]
Institutional barriers	Lack of enforcement, weak governance structures and companies' resistance to change	• Poor supervision • Lack of accountability • Limited Institutional learning	[14]; [6]
Structural barriers	Corruption and political interference	• Lack of transparency • Lack of enforcement	[15]
Legal barriers	Overlapping jurisdictions, inconsistent regulations and frequent legislation changes	• Delays in approvals • Contractual agreements uncertainty • Exposure to legal disputes	[16]

2.2. Guideline to overcome noncompliance

The guideline was developed addressing each barrier with mitigation measures by combining information from literature and interviews. This involved the understanding

of the regulations, identification of causes of noncompliance and development of practical solutions to overcome noncompliance.

Stakeholders, regulators and policymakers, with the help of the suggested guidelines can address the five areas of noncompliance identified in this research. By developing reasonable regulations that investigate industry realities and promoting innovation, financial barriers can be reduced. To guarantee environmental sustainability without putting financial pressure on stake holders, this involves creating practical compliance regulations.

Costs associated with compliance can be reduced significantly by having access to environmentally friendly funding and support for greener technologies, such as energy efficiency improvements and emissions reduction systems. Governments should support small and medium size businesses in implementing environmentally technologies by offering grants, subsidies and tax reductions [11]. To overcome institutional barriers the capacity and independence of the regulatory bodies that oversee oil and gas projects must be strengthened. Institutional structures can be improved by increasing funds allocation, hiring qualified people and creating departments dedicated to oil and gas regulations. Limiting political interference on the enforcement process can be achieved by implementing changes in government that support transparency and accountability. All the regulators who are independent and have adequate funding are in a good position to maintain the integrity of environmental governance and guarantee consistency in compliance with environmental regulations [17].

Anti-corruption initiatives and improved monitoring systems are required to get rid of structural barriers. Strict anti-corruption policies should be enforced by the government together with public systems that are transparent to expose corruption and third-party audits. Compliance portals that are made public and frequent inspections will help to improve accountability and will make the public have confidence in environmental governance. Using external auditors guarantees fair results and lowers the possibility of internal bias in evaluating compliance [15].

To resolve inconsistencies and overlapping of regulations across jurisdictions, there must be standardized regulations to avoid legal barriers. Clear legal guidelines pertaining to permits, environmental regulations and contract enforcements must be established to reduce uncertainties on the projects. These uncertainties are costly, and they result in delays. Investors' confidence can be brought back by the implementation of clear contractual obligations and transparent procedures that promote consistent compliance. National and regional regulations can be aligned by implementing regular legislative reviews and cooperative enforcement agencies [16].

3. METHOD

A qualitative research methodology was used to investigate the impact of environmental regulations on project planning and execution in the oil and gas sector. Eleven participants participated in semi-structured interviews, which included project managers, project engineers and environmental officers with experience of working on oil and gas projects in South Africa. The interviews ranged from 6-37 minutes, and they were conducted virtually via Microsoft Teams. Saturation was confirmed after additional interviews produced repetitive findings and no substantive changes to the thematic structure emerged during the analysis process. Table 2 provides an overview of the participants.

Table 2: Profiles of Interviewees

Participant	Position	Years of experience	Educational background	Duration of interview
1	Technical Health, Safety and Environmental Engineer	22	BEng (Hons), Environmental Engineering	17 minutes 44 seconds
2	Project Manger	15	Master's Degree, Chemical Engineering	14 minutes 30 seconds
3	Project Engineer	6	BEng, Chemical Engineering	37 minutes 42 seconds
4	Project Engineer	10	Master's Degree, Chemical Engineering	27 minutes 37 seconds
5	Project Engineer	8	BSc, Mechanical Engineering	11 minutes 25 seconds
6	Junior Environmental Engineer	3	BEng, Chemical Engineering	6 minutes 48 seconds
7	Chief Project Engineer	24	BEng, Chemical Engineering	15 minutes 11 seconds
8	Senior Environmental Engineer	11	BEng, Environmental Engineering	20 minutes 05 seconds
9	Senior Project Engineer	14	BSc, Civil Engineering	31 minutes 46 seconds
10	Project Manager	20	BSc, Chemical Engineering	17 minutes 54 seconds
11	Senior Project Engineer	15	BSc, Mechanical Engineering	29 minutes 48 seconds

Informed consent, interview protocol, transcription, coding and thematic analysis were part of data collection process. To choose participants with relevant experience, purposive sampling was used to recruit the participants [18]. The interviews were conducted in an ethical manner, informed consent was obtained from all participants and confidentiality was upheld throughout the interviews to ensure that participants sensitive information was not exposed [19]. The interview protocol was designed in such a way that it aligns with the research question and literature review. It consisted of 5

sections, which included introduction and consent, participants background, exploration of barriers to noncompliance, and solutions, then followed by closing remarks. For each barrier there were targeted questions to get more information from the participants and there were probing questions asked where necessary. The interviews were recorded, transcribed and analysed using thematic analysis. The thematic analysis process used, followed the steps below

- First reading of transcripts
- Deductive coding using categories derived from literature
- Inductive coding to capture new themes
- Theme development, review and improvement of themes
- Literature comparison
- Presentation of the findings

Finding patterns in participant responses allowed for derivation of themes. For example, the high cost of environmental impact assessments, retrofitting costs and insufficient funding for emission monitoring were common themes under financial barriers. Themes like lack of coordination, and lack of enforcement were found under institutional barriers. Data organization and coding were done by using Microsoft Excel, which allowed methodical comparison between the participants and the themes from literature

4. FINDINGS

The five main barriers to environmental compliance identified in the literature were supported and further developed by the results of the semi-structured interviews. The following is a thematic presentation of the analysis.

2.3. Financial barriers

The analysis of the interview responses revealed five major financial themes that appeared consistently across participants. These themes show how financial factors affect compliance in the planning and execution of oil and gas projects. The themes are illustrated in Figure 1.

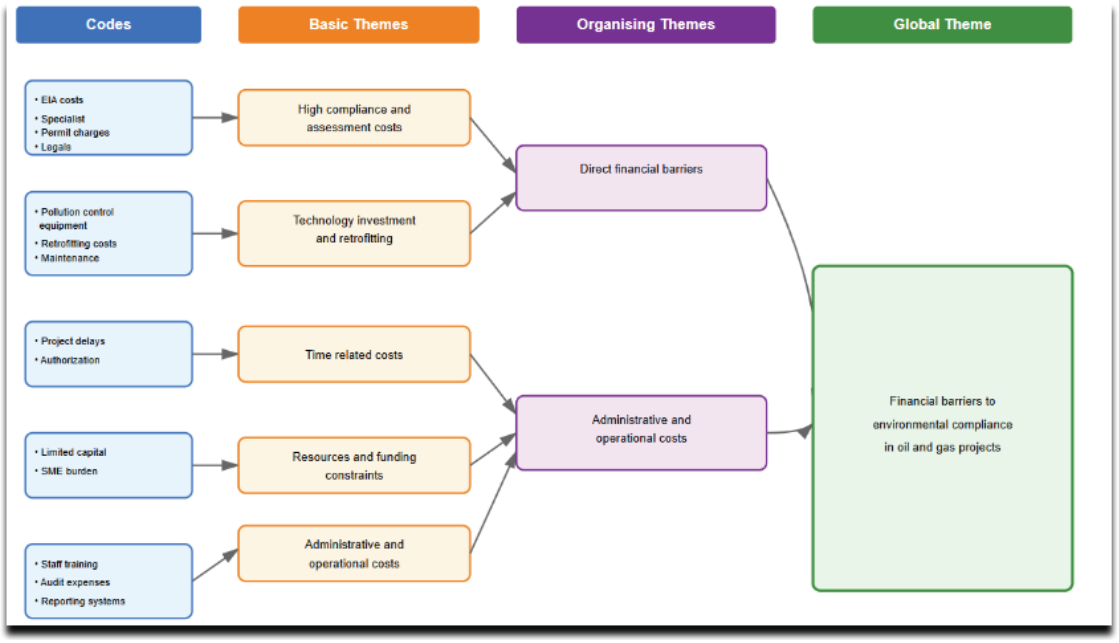


Figure 1: Financial Barriers

The cost of compliance and assessment processes, including environmental impact assessments (EIA), audits, permits, legal fees, and specialised consulting, are related to the high compliance costs. The requirement to invest in technology and retrofit existing plant infrastructure to comply with regulatory standards is the second significant cost barrier that has been identified. The second theme includes the retrofitting costs when outdated technology becomes non-compliant, maintenance costs as well as the initial investment in pollution control equipment. Participants also linked schedule delays brought on by prolonged environmental approval procedures to financial barriers. According to participant 3, "*getting the environmental authorisation can be lengthy, it slows down the project, the schedule gets pushed out, which means the cost is extended*". Similarly, Participant 4 stated that "*schedule is directly tied to cost. If a project takes longer to complete, it incurs costs.*"

These findings imply that cost and time are interconnected financial barriers to compliance. Approval process delays increase project cost, lengthen financial timelines and reduces investor confidence. The difficulty of obtaining funds for data systems and technologies that are environmentally friendly is another theme. Participant 3 mentioned that "*it's hard to actually invest or get funding for things, because we don't have the type of data systems to tell investors what to expect from environmental point of view*". Participant 10 highlighted that companies "*may not have the capital to make those investments into improving processes and equipment to meet compliance levels within the time limit.*" A company's ability to invest in cleaner technologies and compliance systems is hampered by financial limitations, particularly in developing nations. The limitation is made worse by the lack of reliable emission data and financial support, which creates the cycle of underinvestment and non-compliance.

The fifth theme concerns operational and administrative costs such as staff training, recurring audit costs and reporting systems. Participant 2 cited the need for environmental offset, explaining that "*your environmental regulation might require to do additional scope that you didn't plan for, they might require you to rehabilitate another area*". Similarly participant 9 said "*there's also direct costs such as audits, legal fees, staff training and this is difficult for small and medium enterprises.*" Financial barriers of compliance go beyond the visible capital expenses. High financial

costs are also highlighted in the literature as a major obstacle to compliance, particularly for SMEs and in developing nations with limited enforcement capabilities. The significant costs associated with environmental impact assessments, technology advancement, continuous monitoring and fines or penalties of non-compliance are detailed in both the collected data and the literature.

The results are consistent with the literature that expensive compliance can lead to operational delays and competitive disadvantages. The results offer new perspectives showing how structural, and institutional barriers combine with the financial barriers in actual project environment. While the results focus on lived project realities and real-world examples of financial barriers, the literature provides a broad global context and policy framework with specific regulatory attributes and regional comparisons. The results highlight specific participant quotes and emphasises how retrofitting and outdated technology contribute to increased financial burdens. This is a point that is not well explained in some literature sources. The results also emphasise how various cost components add up to create compliance issues, which is something that is covered in literature.

2.4. Institutional barriers

Participants' responses about institutional capabilities, regulatory frameworks, and organisational structures influence on the enforcement of environmental regulations are incorporated in the analysis. The effectiveness with which compliance requirements are fulfilled is largely determined by institutional dynamics, including enforcement capability, interdepartmental coordination, regulatory clarity, and bureaucratic efficiency. Recurring institutional barriers, such as complicated permitting procedures, fragmented governance, poor enforcement mechanisms, and little stakeholder coordination, were found throughout the thematic analysis.

Figure 2 illustrates the thematic analysis of the institutional barriers in oil and gas projects.

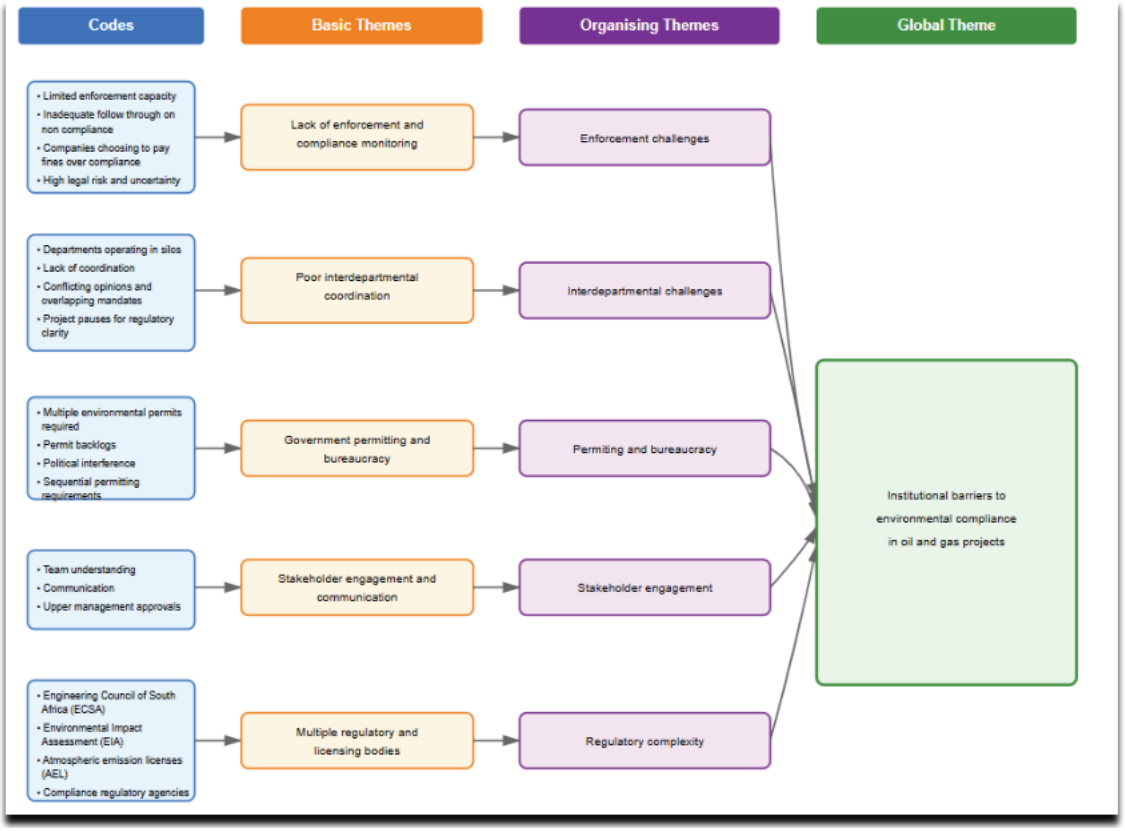


Figure 2: Institutional Barriers

On the theme of lack of enforcement and compliance monitoring participants expressed the opinion that institutional and governmental enforcement mechanisms are weak. Participants emphasised that although environmental regulations are in place, they are not effectively enforced because of a lack of institutional capacity and irregular implementation. Participant 3 observed that "*there is a limited capacity for enforcement. You don't have enough people trying to implement and record compliance or non-compliance amongst projects*". While participant 5 noted that "*companies would rather take a knock on the fines and keep moving, rather than rectifying their operational processes*". This implies that enforcement is lacking even though rules and regulations are in place. Fines are seen as operating expenses in a culture of non-compliance that is fueled by a lack of institutional resources and supervision.

The second theme, poor interdepartmental coordination, poor coordination between government departments is a significant institutional barrier. Conflicting mandates, procedural overlaps, and project delays were found to be caused by fragmented mandates and siloed operations. Participant 3 stated that "*departments operate in silos... you often get conflicting opinions and requirements from these different departments, and that can extend your timelines*". Participant 8 further reinforced this by saying that "*a fragmented regulatory framework where multiple departments have overlapping mandates*". Regulatory efficiency and clarity are hampered by institutional fragmentation. Lack of interdepartmental cooperation raises administrative complexity, discourages investors, and delays environmental approvals.

Although participants commonly mentioned bureaucratic barriers as challenges to timely project implementation, government institutions emerged as significant

stakeholders in environmental compliance. Due to administrative backlogs and limited government capacity, it was reported that obtaining multiple permits, covering environmental, land, water, and air use was challenging. Participant 4 mentioned that "*you have to get a lot of government permits... you can't just dig a pipeline today*" while participant 8 highlighted that "*capacity constraints within government departments lead to permit backlogs and political interference*". Inefficient institutions and drawn-out permit procedures lengthen project schedules and raise compliance expenses, which lowers project agility overall.

To ensure compliance, participants emphasised the importance for project teams to communicate and understand one another. Participant 2 explained that "*you need to make sure everybody on your project understands the record of decision and the environmental management plan*", while Participant 4 noted that sequential permit dependencies can affect engineering deliverables and schedule. Participant 7 cited internal barriers such as "*upper-level management and shareholders decision making processes*" that can delay compliance investment. The findings imply that organisational awareness and communication are just as important to institutional effectiveness as governmental regulation. Delays in reaching compliance milestones or rework can arise from poor stakeholder coordination at the project and management levels.

Multiple regulatory organisations and professional regulators is another institutional trend. Participants mentioned entities such as departments of trade, industry and competition, Engineering Council of South Africa (ECSA) and environmental agencies. Participant 4 noted that "*ECSA accreditation ensures that engineers are competent in environmental compliance*", while participant 9 referred to "*atmospheric emission licenses and compliance institutions line the CIPC that enforce relevant laws*".

The overlap between these organisations results in administrative fatigue and redundant procedures. The complexity of institutional governance in environmental compliance is reflected in the diversity of regulators, which calls for improved integration and coordination systems. Participant 8 summarised this relationship by stating that "*those barriers might tend to have a typical project extension... impacting project cost and investment decisions*" while Participant 3 mentioned "*project pauses while clarity between parties is found*". These responses show that institutional flaws raise operating expenses, reduce investor confidence, and delay environmental authorisations. Thus, institutional barriers put pressure on project implementation from a financial standpoint.

The results support the findings of [11] that institutional flaws, in particular insufficient enforcement and improper interdepartmental coordination continue to be among the biggest obstacles to successful environmental compliance. Participants observed that overlapping departmental mandates and enforcement agencies limited capacity cause regulatory uncertainty and delay authorisation procedures. This supports [14] argument that African states' capacity to successfully implement environmental laws is weakened by institutional division and lack of administrative capacity. The participants' experience with political interference, bureaucratic inefficiencies, and backlogs in permits also align with [20] findings that resource-based projects' environmental approval processes are slowed down by ambiguous mandates and weak institutional structures. The identification of numerous government departments and agencies engaged in compliance procedures is also consistent with [21] who point out that irregular regulatory procedures and institutional complexity frequently cause coordination issues and project delays.

2.5. Structural barriers

Four key themes came out from the analysis: (1) lack of transparency in decision making processes; (2) lack of enforcement and accountability; (3) corruption and (4) limited access to information. Figure 3 illustrates the thematic analysis of the structural barriers in oil and gas projects.

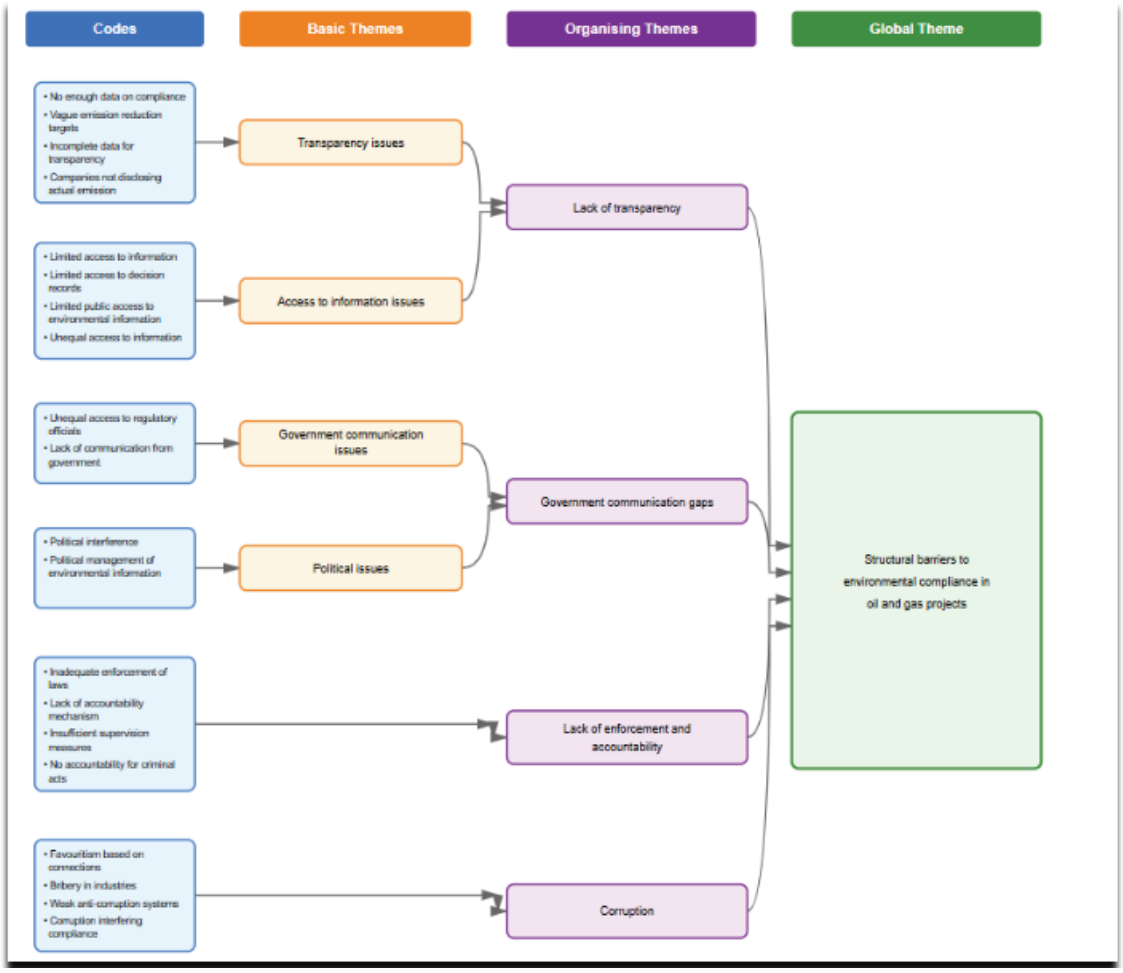


Figure 3: Structural Barriers

Participants cited lack of transparency as the most common structural barrier. According to Participant 8 regulatory decision-making is not transparent as "*the lack of transparency in decision-making processes mostly the unequal access to regulatory officials based on the company size or connection*". This indicates that disclosure of information is only one aspect of transparency issues, other aspects include differential treatment according to company attributes. This means that companies with larger or more political connections might have easier access to regulatory bodies.

Participant 3 linked data availability and transparency limitations. "*There is not always sufficient data to indicate the requirements for impacts, compliance, or assessments. This lack of transparency can often lead to corruption*". This suggests that the lack of information restricts transparency and lessens scrutiny, which leads to acts of corruption. Participant 10 highlighted some transparency failures by saying that the government need to be transparent about communicating the information about any changes in regulations that might be in the pipeline. This observation shows a structural disconnect between the development of regulations and the input from the industry,

where lack of transparency on communication about any change in regulations may lead to compliance requirements that are impossible to meet.

Participants provided observations regarding the flaws in supervision and consequence mechanisms in relation to lack of enforcement and accountability as crucial structural barriers. Participant 5 noted that "*so maybe not lack of transparency, but again a lack of awareness is something that that's an issue that we we're confronted with and again the inadequate enforcement of the laws. I think that's those are, those are the normal impacts that we see in the oil and gas*". The idea that lack of enforcement is 'normal' implies that this is a structural issue of the regulatory environment that happens more often rather than happening occasionally.

Corruption was stated as a structural barrier, but some participants mentioned that they have never experienced corruption in their line of work. The difference in observations suggest that corruption as a structural barrier may be present in some areas while remaining unnoticed depending on the involvement of the individuals in decision-making or their line of work.

2.6. Legal barriers

Legal barriers significantly impact project execution and completion. Participants frequently mentioned that updates to environmental laws, project rules, and permit requirements can cause delays and higher expenses. To comply with new regulations, legal considerations often require updating equipment, monitoring systems, emission baselines, and stakeholder engagement plans. Changes in the law may also result in project scope modifications, redefinitions, or cancellations. Engaging stakeholders' processes are also impacted, necessitating regular updates to participation plans to conform to changing legal requirements. Overall, the changing laws and regulations make it challenging to plan, carry out, and comply with projects, highlighting the need for flexible approaches to manage legal risks. Key themes include changes in regulations, stakeholder engagement requirements, EIA costs and delays, project scope redefining, contractual implications, and permit conditions. Figure 4 illustrates the thematic analysis of the legal barriers in oil and gas projects.

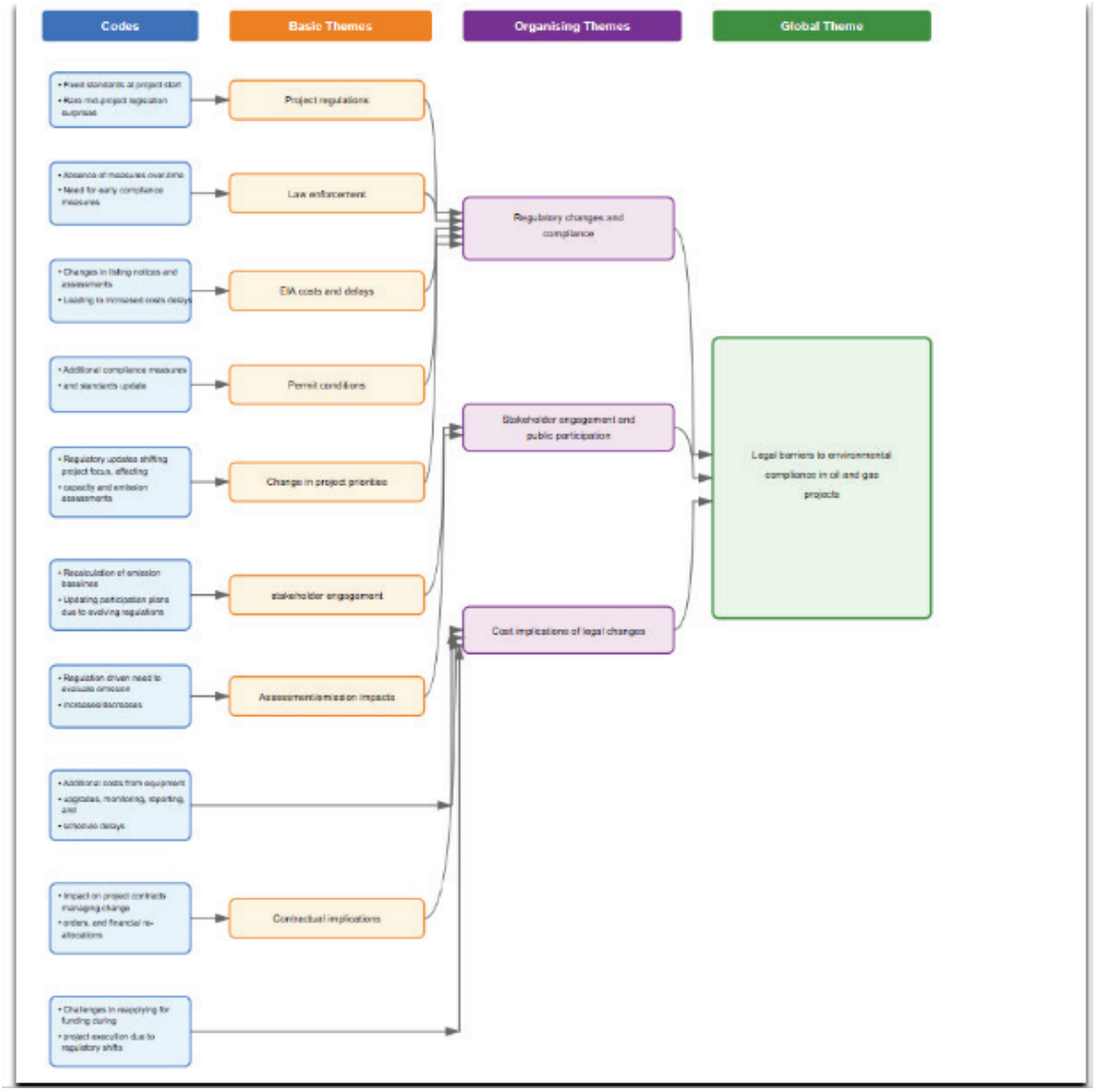


Figure 4: Legal Barriers

Participants highlighted that updated environmental laws and standards require recalculating emission baselines and updating plans. As Participant 3 said "*we've had to recalculate emission baselines for that and I think we've also, even though we might not be the stakeholder for the types of things, we've had to make sure that stakeholder, the engagement with the public*". Project budgets and schedules may be greatly impacted by these changes, which call for additional time and resource expenditures. Participant 6 commented an "*increased compliance cost. New regulations often require upgrades to equipment, enhanced monitoring and stricter reporting, for example, the US EPA's methane rules under the Inflation Reduction Act*".

Legal barriers affect stakeholder engagement processes. To meet changing legal requirements, public participation plans and emission baselines must be updated. To navigate legal complexities successfully, it is important to have proactive stakeholder communication channels.

Another theme that was found is EIA costs and delays, where the change in regulations like listing notices may result in higher assessment costs and delay projects. Participants indicated that changing regulations require upgrading assessments from basic to full

EIAs, which may result in high costs and delays project timelines. Participant 3 noted: "*So like if they change the listing notice and you've gone from needing to do a basic assessment to not doing needing to do an EIA. Those listing notice changes affect that classification and again this cost, I mean this, it requires additional time budget*". The legal barriers frequently make agreements more difficult to understand and place extra restrictions on permits, which emphasises the need for adaptable contractual structures and careful permit administration.

5. DISCUSSION

The findings from the research confirm that project management decisions are influenced heavily by environmental compliance. Previous research has identified four main barriers of compliance, namely financial, institutional, structural and legal [11]. Through thematic analysis of the interviews with professionals working in South African oil and gas industry, this research validates these barriers and confirms what was mentioned previously. Investor confidence increases as companies incorporate compliance early in the planning phase as this results in less disruptions and projects get completed with allocated budget [22]. According to theory, this supports current sustainable project governance models demonstrating the connection between operational performance and regulatory structures [23]. By directly integrating compliance with environmental regulations with project performance and sustainability governance, the guideline will improve project management. It will provide professionals with practical methods to reduce project delays, control operating costs and reduce compliance risks, which will improve project results. The guideline offers an innovative framework that aligns with project management by encouraging stakeholder engagement, strengthening of institutional capacity and technological changes. By using the guidelines, project managers can promote regulations coordination, increase transparency, and improve investors and community confidence. Table 3 is the proposed guideline for project managers to mitigate compliance issues.

Table 3: Guideline to overcome noncompliance

Theme	Description	Project impact mitigation plan				
		Costs	Institutional	Structural	Legal	

Environmental impact assessments (EIAs)	This involves all the environmental assessments that needs to be done at the initial stage of projects	X	X	X	X	• Start EIAs at the initial stages of the project • Consult environmental regulators to verify list of notices and applicable project specific regulations • Include suggested EIAs into project management plan.
Environmental standards & specification	Understanding and following rules and regulations specific to projects	X	X	X	X	• Develop project standards and specification index to make sure that the agreed project requirements are fixed to a date and the revision of the index • Allow design margins that are flexible for unplanned changes on the project • Recruit ECSA accredited professionals to meet EIA requirements

Permitting & Licensing	Complicated permits and licenses requirements and procedures	X	X	X	X	• Develop clear deadlines for applications • Create online portals to show permit status and decisions • Combine licensing instead of separate licenses for air, water and waste • Create a consolidated service for environmental authorization • Provide clear permit application procedures and guidelines • Make sure that there are enough skilled employees to process applications
Project schedule & planning	Project budgets and schedules affected by prolonged assessment processes	X	X		X	• Set up assessments timelines that are linked to the project schedule • Integrate environmental management plans monitoring within project operations and budget for long-term implementation. • Conduct internal training sessions for record of decision and management plan

Regulatory coordination & enforcement	Poor coordination between departments and regulations enforcements on projects		X	X	X	• Implement consistent environmental education initiatives • Promote faster administrative penalties • Introduce independent enforcement bodies
Stakeholder engagement & communication	Insufficient stakeholder involvement on projects and limited access to information on environmental regulations		X	X		• Implement consistent environmental education initiatives and collaborate with academic institutions to foster future skill development. • Promote open channels of communication with environmental authorities for ease of access to information and compliance directives • Create programmes that are beneficial to community members, so that they can have interest to engage on projects

Transparency & anticorruption	No transparency in the process of making decisions, favouritism which leads to corruption and poor access to information based on company size			X	X	• Develop systems that will not discriminate companies according to their size or the nature of business they do. • Develop strict and fair adjudication processes • Have open channel policy for access to information • Have regular audits and legal reviews for compliance

6. CONCLUSION

To develop a practical guideline to reduce the operational and legal risks associated with noncompliance, this research aimed to examine how environmental regulations affect project planning and execution in the oil and gas industry. By means of a qualitative analysis of interviews conducted with professionals in the industry, the study verified that effective compliance is severely challenged by financial, institutional, structural and legal barriers.

These findings show that environmental compliance is a strategic necessity for improving sustainability and operational efficiency in addition to being a legal requirement. By providing focused mitigation strategies, such as early environmental impact assessments integration, expedited permitting procedures, improved regulatory coordination, and increased stakeholder engagement, the developed guideline directly addresses each of the barriers that have been identified. The guideline gives project managers the ability to proactively manage compliance risks, shorten project delays, and increase investor and increase investor and community confidence by coordinating project management practices with environmental governance requirements. The oil and gas industry's general objective of sustainable project delivery is supported by this alignment.

The interviews were conducted with participants involved in oil and gas projects within South Africa. Therefore, the findings cannot be generalised as the data gathered is not necessarily global. There were only three participants working as environmental officers interviewed, the rest of the participants were project managers and project engineers. This could have affected not getting enough firsthand information on environmental regulations, because some participants did mention that source out environmental specialists to conduct EIAs.

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The Start-Up As A Project: A Risk Management Framework For New Ventures

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THE START-UP AS A PROJECT: A RISK MANAGEMENT FRAMEWORK FOR NEW VENTURES

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Abstract

Small businesses drive employment and innovation in developing economies but fail within 42 months in 70–80% of cases. This mixed-methods study of 57 South African entrepreneurs identified personal challenges, business-plan difficulties, management gaps, and financial constraints as key start-up risks. Sixty-five percent used no formal risk management because of low awareness and limited training. Recognising start-ups' liabilities of newness and smallness, the study proposes a blended training tool (workshops plus post-training support) grounded in project risk management. The tool maps risk identification, assessment, and response planning to developmental stages. It contributes empirical evidence from a developing-country context and bridges project management and entrepreneurship scholarship. Practical implications extend to entrepreneurs, support agencies (SEDA, NYDA), policymakers, and entrepreneurial educators.

Keywords: Business start-up, Entrepreneurial training, Project risk management, Risk mitigation, Small business, South Africa

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1 INTRODUCTION

Small businesses have become increasingly important in terms of employment, wealth creation, and innovation development in the global economy. In South Africa, the small business sector contributes approximately 35% to the gross domestic product and is viewed by policymakers as a primary vehicle to address persistent challenges of unemployment, poverty, and inequality [1], [2]. However, the sector faces significant challenges, with infrastructure failures and economic volatility compounding the difficulties inherent in the creation of new ventures.

Empirical evidence consistently indicates that between 70 and 80% of new small businesses fail within the first 42 months of operation [3], [4]. A recent systematic review confirms that 90% of start-ups ultimately fail, with 10% failing within the first year and 70% within two to five years after the foundation [5]. Among the competencies most often identified as lacking among small business owners is risk management—the capacity to identify, assess, and respond to the uncertainties inherent in the creation of new ventures [6].

The conceptualisation of business start-ups as projects offers a promising avenue for addressing this competency gap. Venczel et al. [5] argue that, considering start-ups as temporary endeavours undertaken to create unique value, "a much more mature methodology is available for solving the problems that typically affect new ventures" (p. 1). The Project Management Institute [7] defines a project as "a temporary effort undertaken to create a unique product, service, or result" (p. 5), a definition that aligns closely with the nature of business start-ups, which possess a definite beginning (the conception of a business idea) and an end (the transition to full operational status). This conceptual alignment suggests that project management methodologies, particularly project risk management, can be adapted to address the challenges facing new ventures.

This study aimed to propose a risk management training tool to help start-ups mitigate their risks, enabling higher success rates. The research addressed three questions: (1) What are the typical risks per start-up phase for small businesses? (2) How can these risks be mitigated per phase? (3) How best can entrepreneurs be taught to identify and manage the risk of start-up businesses per phase? The study contributes to the literature by providing empirical evidence on start-up risks in a developing country context and offering a structured intervention framework that bridges project management and entrepreneurial scholarship. Furthermore, the findings have practical implications for entrepreneurial training, policy development, and support programme design in South Africa.

2 REVIEW OF THE LITERATURE

2.1 The role of small business start-ups in the South African economy

The contribution of small businesses to the generation of jobs and their role in the economies of many countries has become increasingly recognised around the world [8], [3]. Policy makers widely agree that entrepreneurs and the new businesses they establish play a critical role in the development and well-being of their societies [9]. The South African government adopted the White Paper on the National Strategy for the Development and Promotion of Small Businesses in 1995, recognising the creation and promotion of small businesses as one of the best ways to address high unemployment and poverty [1].

To ensure that small businesses continue to fulfil their role as drivers of national economic growth, the government has established formal support measures through the Department of Trade and Industry, including agencies such as Khula, Ntsika, the National Youth Development Agency (NYDA), and the Small Enterprise Development Agency (SEDA) [10]. Despite these efforts, the total rate of early-stage entrepreneurial activity (TEA) of 7% remains below the average (10%) of participating countries in the Global Entrepreneurship Monitor, reflecting persistent challenges facing entrepreneurship in South Africa [11].

2.2 Developmental stages of small businesses

Researchers have defined different developmental stages for small businesses, reflecting the varying ways business founders create their businesses. Churchill and Lewis [12] developed a five-stage model that includes existence, survival, success, take-off, and resource maturity. Witt [13] proposed a five-stage framework that includes idea, planning, creation, proving, and growth. Bhave [14] identified three phases: opportunity, technology setup and organisation, and exchange. Kazanjian [15] described four stages: conception and development, commercialisation, growth, and stability. Block and MacMillan [16] developed a ten-phase milestone model that tracks specific developmental achievements, from concept development to major price adjustments.

Despite the variety among these models, they consistently depict new ventures moving through a sequence of stages, beginning with the initial generation of an idea and continuing through planning, gathering resources, launching, and subsequent growth. This developmental structure provides a foundation for mapping start-up phases to project phases, allowing the application of project management methodologies to the entrepreneurial context.

2.3 Challenges facing small businesses

The literature consistently identifies a range of challenges facing small businesses that can be translated into a risk of failure [6], [17], [3], [18], [19]. These challenges are typically classified as internal and external. Olawale and Garwe [3] identified financial challenges as the main internal risk factor, followed by factors in economic, market, management, and infrastructure. Bezuidenhout and Nenungwi [6] identified risk management as the most lacking skill among small business owners, ranking it ahead of financial management, industry awareness and project management.

Financial challenges include difficulty in obtaining funds or credit for business start-up, high operating expenses, poor financial planning, and poor cash flow management [20], [3]. Management challenges encompass deficiencies in marketing, financial, human, business planning, sales, and advertising skills [21], [19]. Herrington and Wood [21] noted that the lack of education and training reduces management capacity in new businesses, contributing to low entrepreneurial creation and high failure rates.

External challenges, largely uncontrollable by businesses, include economic factors (high interest rates, taxes, inflation), market factors (inadequate location, competition, transport costs), infrastructure deficiencies (poor electricity, transport, roads, water, telecommunication) and crime and corruption [3]. These external factors increase operational costs and uncertainty, compounding the challenges faced by new ventures.

2.4 Start-up as a oroject

The conceptualisation of a business start-up as a project represents a significant theoretical contribution to entrepreneurship research. Venczel et al. [5] argue that considering start-ups as projects allows the application of a much more mature methodology to solving the problems that typically affect new ventures. This framework shifts analytical attention from the idiosyncratic nature of entrepreneurship to the structured, process-oriented approaches that characterise project management.

Projects, like business start-ups, go through developmental stages called the project life cycle. Various project life cycle models exist, ranging from 5 to 6 phases. Michael [22] proposed a five-phase model consisting of determining need and feasibility, creating a project plan, developing product specifications, building a prototype, and testing and implementing. The Project Management Institute [7] framework includes initiating, planning, executing, controlling, monitoring, and closing. Pennock and Haimes [23] proposed a five-phase model: requirements, design, prototype, production, and phase-out. The applicability of project management principles to start-ups is supported by the shared characteristics between projects and new ventures: both are temporary endeavours, both aim to create something unique, both operate under conditions of uncertainty, and both require structured planning and resource allocation. However, start-ups differ from traditional projects in their resource constraints, the coherence of ownership and control, and the need for rapid adaptation [25]. These differences necessitate a lean, targeted approach to risk management that is responsive to the specific conditions of new ventures.

2.5 Project risk management

The Project Management Institute [7] defines project risk management as the process that includes risk planning, risk identification, risk analysis and evaluation, risk response planning, and monitoring and control in a project. Risk is defined as the effect of uncertainty on the objectives, expressed in terms of the combination of the consequences of an event and the associated likelihood of occurrence [24].

Schulte [25] provides a comprehensive theoretical framework for the management of new venture risk, identifying three levels of characteristics that distinguish start-ups from established firms: resource limitation, coherence of influence, and the process of venture development and growth. Resource limitation encompasses financial, personnel, and other constraints, resulting in a higher risk of exiting the market. The coherence of influence denotes the unity of ownership and control, which reduces agency conflicts but can also limit the adoption of formal risk management mechanisms. The process of venture development and growth requires that risk management approaches evolve as start-ups mature [25].

The International Standards Organisation identifies key principles of risk management that apply to start-up businesses: risk management should add value, be an integral part of decision-making, explicitly address uncertainty, fit the specific project, take into account human factors, cover all aspects, be transparent, dynamic and adaptable, and systematic and structured [24].

The successful application of risk management principles is expected to increase confidence levels and improve the management style of entrepreneurs [26]. The primary reasons for conducting risk management in start-up business projects are to reduce future damage and

loss, minimise the total cost of possible risk events, and identify, control, and limit the impact of risks by increasing the probability and impact of positive events [26], [7].

3 METHODOLOGY

3.1 Research design

This study used a mixed-methods design that integrates qualitative and quantitative approaches. The mixed-methods approach was selected to allow for both answer of both the 'what' and 'how' research questions and to cross-check qualitative expectations against quantitative results [27]. The research design followed a structured process that included literature review, questionnaire development, data collection, analysis, and tool proposal.

3.2 Data collection

Primary data were collected using a structured questionnaire administered to entrepreneurs from start-up businesses. The questionnaire comprised five sections: participant invitation and study information, demographic data, business identification, understanding of challenges, and risk management practices. The challenges section included open-ended questions where participants were asked to describe the main challenges they faced in each start-up phase (idea, planning, creation, proving/prototype testing, and operation). These open-ended responses constituted the qualitative data for the study. The risk management practices section included both closed-ended questions (with Likert-scale and categorical response options) and open-ended questions about participants' understanding and use of risk management methods.

The questionnaire was pre-tested to ensure that it collected data relevant to answering the research questions. The pretest addressed the comprehension, burden, interest, logical flow, and effect of the order of the questions [28]. The questionnaire was refined based on pre-testing feedback.

3.3 Sampling and participants

Snowball sampling was used to identify participants from lists of small start-up owners obtained from SEDA (operating in Kroonstad, Edenville, and Heilbron in the Free State province) and NYDA (Johannesburg branch), with one participant from the Netherlands. Snowball sampling was chosen due to the difficulty in obtaining complete lists of participants from support agencies [29]. Participants were recruited through initial contact with support agency staff, who referred researchers to entrepreneurs who had received their services.

A total of 59 completed questionnaires were gathered, of which 58 were valid for analysis. One participant from the Netherlands was excluded from the analysis to ensure a consistent South African context, resulting in 57 valid responses for analysis. The sample comprised entrepreneurs from both urban areas (Johannesburg) and rural areas (Edenville, Heilbron, Kroonstad). The participants ranged in age from 20 to over 50 years, with the majority (84%) aged 40 years or younger. The sample was predominantly black (93%), and white participants comprised 7%. Education levels varied, with 57% having a high school education as the highest level, 30% having a college education, and only 7% having a university bachelor's education.

3.4 Data analysis

Data analysis used both descriptive and inferential statistics using IBM SPSS Statistics 22. The descriptive statistics included percentages, frequency distribution tables, histograms, and graphs. Inferential statistics included cross-tabulation, chi-square tests, and Pearson correlation. The data transformation method was used to integrate quantitative and qualitative data during analysis [30]. Qualitative responses from open-ended questions were coded into thematic categories (e.g., personal challenges, financial challenges, management challenges) and then quantified to produce frequency counts and percentages for each challenge type per phase.

3.5 Validity and reliability

Face validity was used to evaluate the measurement instrument, and experts in the field ruled on whether the measure reflected the concept involved [31]. Triangulation—using several types of methods or data—was employed to improve validity and reliability, providing corroboration and correspondence of results between different methods [32]. The integration of quantitative frequencies with qualitative thematic analysis provided cross-verification of findings.

3.6 Ethical considerations

Ethical approval for this study was granted by the institutional research ethics committee. All 59 participants provided written informed consent before data collection. Participation was voluntary, and participants could withdraw at any time. No personally identifiable information was collected; all data were anonymised and stored securely on a password-protected server accessible only to the research team. Permission to recruit participants was obtained from SEDA and NYDA. The authors declare no conflict of interest.

4 RESULTS

4.1 Participant demographics

The demographic analysis revealed that most of the participants (84%) were 40 years or younger, with 47% in the 20–30 age bracket and 37% in the 31–40 age bracket. The gender distribution showed 64% male and 36% female participants. The sample was predominantly black (93%), and white participants comprised 7%. Education levels indicated that 57% had a high school education as the highest level, 30% had a college education, and 7% had a university bachelor's education. A Pearson correlation coefficient of -0.10 indicated a weak negative correlation between the age of the entrepreneur and the level of education, suggesting that age had no noticeable impact on the level of education in this cohort. Table 1 presents the age distribution of the participants.

Table 1: Summary of age groups of participants

Age Group	Number	Per centage
20–30	27	47%

Age Group	Number	Per centage
31-40	21	37%
41-50	7	12%
≥ 50	2	4%
Total	**57**	**100%**

4.2 Business identification

The participants had started businesses in various sectors, the majority operating in agriculture, construction, and manufacturing. Regarding business training, 63% of participants had completed business training, with 62% of these having completed introductory (awareness) level training, 14% advanced training, 14% other training and 11% formal qualification-based training.

A Pearson correlation of 0.79 ($p < 0.001$) indicated a strong positive linear relationship between the number of active start-ups and the number of closed businesses. The coefficient of determination ($R^2 = 0.620$) indicated that 62% of the variance in closed businesses was associated with the number of active start-ups. This suggests that entrepreneurs who start more businesses also tend to close more businesses, though correlation does not imply causation. This finding may indicate that entrepreneurs with multiple ventures have higher overall exposure to business failure risk.

4.3 Understanding entrepreneurs' challenges

Participants defined success for their start-up businesses as achieving full operational status, with clients funding operational expenses and creating positive cash flow regularly; expanding to a level of satisfaction, with the ability to pay day-to-day operational costs and generate profit; having necessary resources and proper business management structures; and winning customer trust and meeting their needs.

The analysis of challenges per start-up phase revealed distinct patterns. During the idea phase, personal challenges dominated (60% of responses), including scope creep, lack of creativity, fear of starting, ignorance of market research, and lack of discipline. During the planning phase, the development of the business plan was identified as the main challenge (65% of responses), with participants citing difficulties in defining value propositions and compiling detailed winning business plans. During the creation phase, management (30%), financial (27%), and infrastructure (20%) challenges were predominant. During the test phase, management challenges (40%) led, followed by financial and infrastructure (20% each). During the operation phase, management challenges (54%) remained dominant, followed by financial (21%) and market (13%) challenges. Table 2 summarises the main challenges identified per start-up phase with frequency data.

Table 2: Summary of challenges per start-up phase

Start-Up Phase	Main Challenges Identified	Frequency (% of participants identifying this as main challenge)
Idea	Personal, financial, infrastructure, management, economic, market, and business plan development	Personal: 60%; Financial: 15%; Infrastructure: 10%; Management: 8%; Economic: 4%; Market: 2%; Business plan: 1%
Plan	Financial, infrastructure, management, market, and business plan development	Business plan: 65%; Financial: 15%; Management: 10%; Infrastructure: 7%; Market: 3%
Create	Personal, financial, infrastructure, management, economic, market, and social	Management: 30%; Financial: 27%; Infrastructure: 20%; Personal: 12%; Economic: 6%; Market: 3%; Social: 2%
Prove	Personal, financial, infrastructure, management, market	Management: 40%; Financial: 20%; Infrastructure: 20%; Personal: 12%; Market: 8%
Operation	Financial, management, economic, market, and social	Management: 54%; Financial: 21%; Market: 13%; Economic: 7%; Social: 5%

4.4 Risk management in small business start-ups

The study revealed that 65% of the participants did not apply formal risk management methods when starting their businesses. The primary reasons were a lack of awareness of such methods and the inaccessibility of teaching about risk management. Participants who used risk management methods reported that they were beneficial, providing an indication of possible negative impacts and helping plan responses. The most common risk method mentioned was SWOT (strengths, weaknesses, opportunities, threats) analysis.

Regarding risk management in job descriptions, 63% of participants did not include risk management in key employees' job descriptions, primarily because participants were themselves the founders of their businesses, were not aware of risk management, or had not yet commenced operations. Table 3 presents the self-rated usage of specific risk management actions by the participants.

Table 3: Self-rated usage of risk management actions (percentage of participants)

Risk Management Action	Not Used	Fairly	Well,	Very Well	Optimally
Identify risks	35%	9%	28%	7%	21%

Risk Management Action	Not Used	Fairly	Well,	Very Well	Optimally
Assess potential impact	19%	14%	33%	28%	6%
Plan risk response	24%	12%	21%	12%	31%
Monitor and control risks	28%	9%	23%	7%	33%

Self-rated understanding of risk management showed that 39% rated their understanding as average, 22% as good, 17% as poor, 11% as excellent, and 11% as not knowing.

When asked what they would do differently in their next start-up business, the participants indicated: include risk assessment during business planning and risk management actions throughout operations; conduct more research on business ideas and market opportunities; establish networks and communicate with successful business people; attend business training and workshops; employ skilled people; maintain openness; and prepare not to rely on external funds.

5 A PROPOSED RISK MITIGATION TRAINING TOOL

5.1 Mapping start-up phases to project phases

Based on the literature review and empirical findings, the study mapped start-up phases to project phases to allow the application of project risk management principles. This mapping is grounded in the shared characteristics of start-ups and projects: both are temporary endeavours aimed at creating unique value, both operate under conditions of uncertainty, and both require structured planning and resource allocation. The mapping adopted Witt's [13] five-phase start-up model and aligned it with the project phases derived from the Project Management Body of Knowledge [7]. This alignment enables entrepreneurs to apply established project risk management techniques to the specific challenges they face in each phase of venture creation. The rationale for this mapping is threefold. First, it provides entrepreneurs with a structured vocabulary and framework for thinking about their venture as a manageable process rather than an overwhelming and chaotic experience. Second, it allows entrepreneurs to leverage the extensive body of knowledge and tools developed in project management, adapted to the resource-constrained context of start-ups. Third, it enables the identification of phase-specific risks and the development of targeted mitigation strategies, addressing the finding that entrepreneurs face distinct challenges in different phases of venture creation. Table 4 presents this mapping alongside the main challenges identified in each phase of the empirical survey.

Table 4: Mapping of start-up phases to project phases

Start-up phase	Suggested project phase	Main challenges from the empirical survey
Idea: Develop a business idea and determine the need and feasibility	Initiate project: Conception; determine the need and feasibility	Personal, financial, infrastructure, management, economic, market, and business plan development
Plan: Develop a detailed business plan	Plan project: Requirements analysis; identify solution; create project plan; identify risks and mitigation plan	Financial, infrastructure, management, market, business plan development
Create: Set up the business.	Execute project plan: obtain the required resources; create and implement the product; monitor and manage risks	Personal, financial, infrastructure, management, economic, market, and social
Prove: Test and refine business operations.	Test and validate	Personal, financial, infrastructure, management, market
Growth: Full business operation, survival, and growth	Hand over to operational users; project close-out	Financial, management, economic, market, and social

5.2 Structure of the proposed training tool

The proposed training tool adopts a blended model that combines facilitated workshops with post-training application-based support. This structure addresses the finding that entrepreneurs lack awareness of risk management methods and require ongoing support after initial training.

Workshop Component. The workshop aims to teach entrepreneurs to view a start-up as a project and to develop skills related to start-up risks. Based on empirical findings, the following skills were identified as lacking: risk management skills, entrepreneurial skills, people management skills, business management skills, and financial management skills. The workshop is proposed to take the form of an interactive facilitated session that incorporates experiential learning principles. Research on serious games and gamification in entrepreneurial education has demonstrated that experiential approaches enhance learning outcomes by providing hands-on, immersive experiences that traditional didactic methods cannot replicate [33], [34].

Application-Based Post-Training Support. The second component is designed to support users in managing risk after the workshop. The application would assist entrepreneurs in performing industry-relevant risk identification and probability-impact-based assessment of each risk. The

application would alert users to critical actions needed for each identified risk, using a risk treatment key that categorises risks as major (requiring immediate action) or minor (requiring monitoring and further reduction where practical).

6 DISCUSSION

The findings of this study contribute to the literature on entrepreneurial risk management in several significant ways. First, the study provides empirical evidence from a developing country context on the specific risks entrepreneurs face in start-up phases. The identification of personal challenges as predominant during the idea phase extends previous research that has focused primarily on financial and management challenges [3], [6]. The finding that 60% of the participants identified personal challenges—including lack of creativity, fear, and lack of discipline—during the idea phase suggests that interventions must address psychological and motivational factors alongside technical skills.

Second, the study confirms previous findings regarding the prevalence of management challenges in all start-up phases [19], [21]. The consistent dominance of management challenges, ranging from 30% in the creation phase to 54% in the operation phase, underscores the need for comprehensive management skills development in entrepreneurial training programmes. This finding aligns with Bezuidenhout and Nenungwi's [6] identification of risk management as the most severely lacking competency among small business owners and with Schulte's [25] theoretical framework that highlights the limited diversification opportunities and risk buffers characteristic of start-ups.

Third, the study provides evidence of the gap between the acknowledged importance and the actual implementation of risk management practices. With 61% of the participants not applying formal risk management methods, primarily due to a lack of awareness, the findings support the need for structured training interventions. The beneficial effects reported by 35% of those who applied risk management methods—including indication of possible negative impacts and help in planning responses—suggest that awareness and training could produce significant improvements in entrepreneurial outcomes.

Fourth, the study contributes to the theoretical literature by operationalising the conceptualisation of start-ups as projects [5]. The mapping of start-up phases to project phases (see **Table 4**) provides a structured framework for applying project risk management principles to the entrepreneurial context. This framework acknowledges that risk profiles evolve as the ventures mature and that risk management interventions must respond to these changes [25].

The proposed blended training tool addresses the finding that entrepreneurs require both initial awareness and ongoing support. The workshop component, which incorporates experiential learning principles, responds to research indicating that immersive hands-on learning experiences facilitate deeper understanding and skill development [33], [34]. The post-training application-based support component addresses the need for continuous risk management after initial training, recognising that risk management is an ongoing process rather than a one-time activity [7].

6.1 Practical recommendations for entrepreneurs, trainers, and policymakers

Based on the empirical findings, this study offers the following practical recommendations. It should be noted that these recommendations are based on exploratory findings from a limited

sample and should be validated through further research. Nonetheless, they provide indicative directions for practice and policy.

First, for entrepreneurs and start-up founders, the findings demonstrate that formal risk management methods are significantly underused (65% of participants). To address this gap, entrepreneurs should integrate risk identification and assessment into the business planning phase, as recommended by Kendrick [35], who argues that proactive risk planning is essential for "failure-proofing" projects. The proposed blended training tool offers a structured, phase-specific approach that entrepreneurs can adopt without requiring extensive prior risk management expertise.

Second, for entrepreneurs and support agencies such as SEDA and NYDA, the study recommends incorporating project risk management modules into existing SME development programmes. The South African Insurance Association [36] has demonstrated the effectiveness of such interventions through its Building Resilient Businesses programme, which reached 770 SMMEs in eight provinces in 2025, and participants reported increased confidence in financial decision-making and risk management. This model of workshop-based training, combined with practical tools, provides a replicable framework for scaling risk management education. In particular, only 18% of South African small businesses are insured [37], highlighting the urgent need for risk awareness training.

Third, for policymakers at the Department of Trade and Industry, the findings suggest that funding and support mechanisms for start-ups should condition assistance on the completion of formal risk management training. Given the low penetration of insurance among SMEs [37], policymakers should also explore the links between risk management training and access to micro-insurance products, thus creating financial incentives for risk-aware behaviour.

Fourth, for curriculum developers and trainers, the study recommends adopting experiential learning methods, including serious games and scenario-based simulations, rather than didactic teaching approaches. This aligns with evidence that immersive hands-on learning facilitates deeper understanding and skill retention [33], [34]. The blended model—combining facilitated workshops with post-training application support—directly responds to the stated need of participants for ongoing guidance rather than one-time instruction.

7 LIMITATIONS, FUTURE RESEARCH, AND RECOMMENDATIONS

Several limitations of this study should be acknowledged. First, while the sample was adequate for exploratory analysis, it was limited to 57 entrepreneurs from specific geographic locations in South Africa, which may limit generalisability to other contexts. Most of the participants were black entrepreneurs from rural and peri-urban areas, reflecting the specific population accessible through SEDA and NYDA support agencies. The exclusion of the Netherlands participant, while ensuring contextual consistency, further reduced the sample size. Future research should extend the sample to include entrepreneurs from diverse regions, sectors, and demographic backgrounds.

Second, the study relied on self-reported data, including self-rated understanding of risk management and retrospective accounts of risk management practices. Self-reported data may be subject to recall bias and social desirability bias. Future research could employ longitudinal designs to observe risk management practices over time and to assess the causal impact of training interventions on entrepreneurial outcomes.

Third, the proposed training tool requires development and empirical testing. While the tool is grounded in the empirical findings and theoretical literature, its effectiveness has not yet been demonstrated. Future research should focus on developing the workshop curriculum, designing the application, and conducting controlled studies to evaluate the effectiveness of the tool in improving risk management practices and entrepreneurial outcomes. Randomised controlled trials would provide the strongest evidence for the tool's effectiveness.

Fourth, the study identified a strong positive correlation between the number of active start-ups and the number of closed businesses ($r = 0.79$, $p < 0.001$). However, as noted in Section 4.2, correlation does not imply causation. This association suggests that entrepreneurs who start multiple businesses do not necessarily learn from previous failures, or that they face higher overall exposure to business failure risk. This finding aligns with Toft-Kehler et al. [38], who demonstrated that serial entrepreneurs face a "high-noise, low-signal" learning environment where deterministic learning is less feasible. However, in emerging market contexts such as Nigeria, Amankwah-Amoah et al. [1] found that prior failure can shift from a liability to an asset through processes of entrepreneurial resilience and anti-fragility development. This warrants further investigation of the mechanisms of entrepreneurial learning in the South African context and the conditions under which failure experience translates into improved future performance. Future research should employ regression modelling to explore the predictive relationship between start-up experience and business outcomes.

Fifth, external risk factors require systemic intervention. Chimenya and Bowen [40], in their recent South African study using interpretive structural modelling, identified skills shortages and natural disasters as the main risk factors affecting the survival of small companies, with these factors exacerbating all other risks in the system. This suggests that individual-level training interventions, while necessary, must be complemented by ecosystem-level reforms addressing skills development and infrastructure resilience. Future research should employ systems thinking methodologies to map the interrelations among risk factors and identify leverage points for policy intervention.

8 CONCLUSIONS

This study addressed the persistent challenge of high failure rates among small business start-ups by applying project risk management principles to the entrepreneurial context and proposing a structured training tool. The findings revealed that entrepreneurs face distinct challenges across the start-up phases, with personal challenges dominating the idea phase, business plan development challenges in the planning phase, and management challenges persisting throughout. The study found that most entrepreneurs do not use formal risk management methods, mainly due to a lack of awareness and a lack of training.

The proposed training tool adopts a blended model that combines facilitated workshops with post-training application-based support. The tool is grounded in the conceptualisation of start-ups as projects and maps start-up phases to project phases (see Table 4) to enable the application of project risk management principles. The tool addresses the specific skills identified as lacking in the empirical study: risk management skills, entrepreneurial skills, people management skills, business management skills, and financial management skills.

Recent scholarship confirms that start-ups face distinct liabilities of newness and smallness that require targeted lean risk management approaches [25]. The integration of project management principles with entrepreneurial training represents a promising direction for addressing the high failure rates that have persistently characterised the creation of new

ventures. As small businesses continue to be viewed as critical vehicles for economic development, poverty alleviation, and job creation in South Africa, the development and implementation of evidence-based risk management training tools are increasingly urgent [36], [40].

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The Development Of A Conceptual Model To Map Stakeholder Collaboration Through Building Information Modelling (BIM) Across The Project Lifecycle

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THE DEVELOPMENT OF A CONCEPTUAL MODEL TO MAP STAKEHOLDER COLLABORATION THROUGH BUILDING INFORMATION MODELLING (BIM) ACROSS THE PROJECT LIFECYCLE

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ABSTRACT

The Architectural, Engineering, and Construction (AEC) industry is currently undergoing digital transformation, driven by the adoption of Building Information Modelling (BIM). Despite the potential benefits of BIM, success depends on the understanding that BIM is a socio-technical system that requires stakeholder collaboration. Recent work has begun to integrate BIM and collaboration maturity, but does so as a static organisational assessment rather than across the project lifecycle. This isolation overlooks the dynamic nature of capital project lifecycles. To address the gap, this study presents a conceptual model that synthesises BIM and collaboration maturity across the project life cycle. Ultimately, the study introduces a concept of maturity threshold, positing that both BIM and collaboration maturity must simultaneously reach a threshold to realise the benefits of digital investments and improvements to overall project performance.

Keywords: BIM Maturity, Building Information Modelling, Collaboration Maturity, Project Life Cycle, Stakeholder Collaboration

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1 INTRODUCTION

The Architectural, Engineering, and Construction (AEC) industry is currently undergoing digital transformation, driven by the adoption of Building Information Modelling (BIM). BIM has emerged as an industry-disruptive tool that promises to resolve historic fragmentation, break down silos, and foster a transparent environment for information sharing, resulting in improved project performance. However, because BIM is a socio-technological system, it encompasses both the technical and digital tools and critical social elements such as industry and organisational culture, organisational behaviour, and trust among stakeholders. It is evident that the adoption of technology alone is often insufficient to guarantee success on a capital project.

The extant literature debates the relationship between BIM and collaborative practices. Two opposing views are presented: does the implementation of BIM intrinsically improve stakeholder collaboration, or must a strong foundation of collaboration exist first for BIM to be successful, which in turn leads to improved project performance? Despite this connection, existing maturity frameworks assess these maturities as organisational properties at a single point in time. Furthermore, these models frequently overlook the dynamic, phased nature of the project lifecycle, failing to account for stakeholder configurations and complexities that shift from project inception to operation.

To bridge the specific gap in literature, this paper proposed a conceptual model that synthesises both BIM maturity and collaboration maturity across the capital project lifecycle. By mapping the continuous evolution of stakeholder arrangements, project complexity, and information exchange, this paper explores how these socio-technical factors interact. Ultimately, the conceptual model introduces the concept of a maturity threshold, positing that both BIM and collaboration maturity must reach this threshold together to fully realise the benefits of digital investment and achieve sustained improvements in project performance.

2 BACKGROUND AND LITERATURE REVIEW

2.1 Building Information Modelling (BIM) and the collaboration promise

The AEC industry in recent years has undergone digital transformation, with Building Information Modelling (BIM) as one of the main tools to facilitate the process. Throughout the literature, the benefits of BIM are seen as an industry-disruptive tool and promise several benefits.

BIM has been presented as a solution to resolve the industry fragmentation and limit the formation of silos, and fosters an open and transparent environment for information sharing S. Integration of multi-disciplinary project stakeholders with a specific focus on information sharing [1-3]. Facilitating interoperability of information that is shared among project stakeholders in a common data environment standard [3-5]. This introduces a new paradigm of project stakeholder interaction through the project lifecycle [6, 7]. The generation and sharing of information from inception to operation of the capital project [7, 8]. And promotes inter-organisational collaboration throughout the project lifecycle [9, 10]. One key aspect that is present in the literature is the collaborative themes.

Several perspectives on how to view the relationship between BIM and collaboration were studied by Abbasnejad, et al. [11]. They presented the relationship between BIM and collaboration in two opposing views. Firstly, how BIM contributes to improving stakeholder collaboration and secondly, how stakeholder collaboration supports the successful

implementation of BIM. This is further supported by Homayouni, et al. [9] that identified that the relationship between BIM-enabled projects and stakeholder collaboration is underpinned by similar theoretical themes. These include the temporary formation and arrangement of integrated teams, the use of agreed systems and technologies that foster clear communication, as well as open and accountable use of technology. They argued that project failure is still likely even if the aforementioned is adhered to. Instead, the correct social and organisational foundations should be established that promote both stakeholder collaboration and implementation of technology [9].

BIM further promises to encourage the integration of stakeholders throughout the project lifecycle, which in turn results in improved efficiency and project performance [6]. Toan, et al. [7] further noted that 'BIM has great potential for useful adoption at all stages of the project life cycle.', where project needs are better understood by the clients/owners, improved design efficiencies with fewer clashes, improved construction management, and improved facility management. However, the complex, fragmented and adversarial nature of the industry hinders a collaborative environment from forming [9].

Literature notes that BIM is not software; it is a socio-technical system [12] that encompasses both the social (industry culture, organisational culture, trust) and technical (software, hardware, digital systems) aspects. In recent years, the focus of academic research into BIM has predominantly focused on the latter part of the socio-technical system, i.e. technocentric [13], which seems to suggest that the social aspects have been sufficiently studied.

2.2 Existing models and frameworks

In line with the previous section regarding the opposing view where BIM or collaboration is first, this study focused on two specific areas where maturity models and frameworks were developed for both BIM and collaboration. Kasul and Halicioglu [14] noted that BIM collaboration should not be considered as a one-dimensional endeavour with a central focus on technology. It is an ever-changing dynamic between digital tools, organisational and stakeholder configurations, sociotechnical systems, and critically human behaviours. The relationships and configuration are constantly evolving. They further posit that, with the introduction of ISO19650, not only technological standardisation will be required, but also a reconfiguration of institutional and organisational structures will be needed to cope with the complex dynamics of BIM-enabled capital projects. Furthermore, 'organisational readiness, role clarity, and trust-building mechanisms' are vital components in realising the full benefit of investment in technologies such as BIM.

Several approaches have been implemented to study the collaborative relationships, as referred to

Table 1. The two prolific models are the and the BIM maturity wedge [15, 16], and BIM maturity matrix [4]. The BIM maturity model considers aspects such as technology, process and policy. It includes some social aspects, such as stakeholder identification and involvement, but is predominantly focused on the technological aspects of BIM. It further suggests that collaboration is a result of implementing BIM and can be achieved at an advanced BIM maturity state. A further observation is a model that focuses on a project without specific allowances made for project phases.

Table 1: BIM Maturity Models and Frameworks

Author(s) and Year	Year	Model/Framework Name/Description
Bew, et al. [16] ISO [15]	2008 /2018	BIM Maturity wedge (BIMmw)

Succar [4], Succar, et al. [17]	2008, 2013	BIM Maturity Matrix BIM Framework
Oraee, et al. [18]	2017	Collaboration pentagon
Oraee, et al. [19]	2017	Conceptual model of collaboration barriers in BIM-based Construction Networks (BbCNs)
Papadonikolaki, et al. [10]	2019	Structural view of collaboration with BIM.
Wang, et al. [20]	2020	Social network analysis
Sun et al. [21]	2021	Building Information Modeling Application Maturity Model (BIM-AMM)
Edirisinghe, et al. [22]	2021	Life Cycle BIM Maturity Model (LCBMM)
Oraee, et al. [23]	2022	Qualitative model of influential factors on BIM-based Construction Networks (BbCNs)
Chen, et al. [24]	2023	Optimised decision support for BIM maturity using LSGDM
Rashidian, et al. [25, 26]	2023 /2024	BIM, Integrated Project Delivery, Lean Construction (BIM-IPD-LC, BIL)
Succar, et al. [27]	2025	BIM maturity at scale (BIMas)

The Bew and Richards maturity model, commonly known as the BIM maturity wedge (BIMmw) [16], provides a wedge-shaped diagram indicating the BIM maturity levels from 0 to 3, refer to Figure 1. The four levels include: Level 0 denotes the traditional two-dimensional drafting, paper-based level of the AEC industry, with minimal digitisation. Level 1 sees a mix between two-dimensional drafting and three-dimensional modelling. A central repository of a common data environment is used to share information; collaborative model sharing is limited. Level 2 moves into a collaborative BIM environment where 3D models are generated and shared among project stakeholders; it is also federated into a single model. Level 3 is the ultimate level where the concept of integrated BIM (iBIM) is proposed. This level is fully integrated with an interpretable model, hosted in a common data environment and accessible by all stakeholders across the lifecycle.

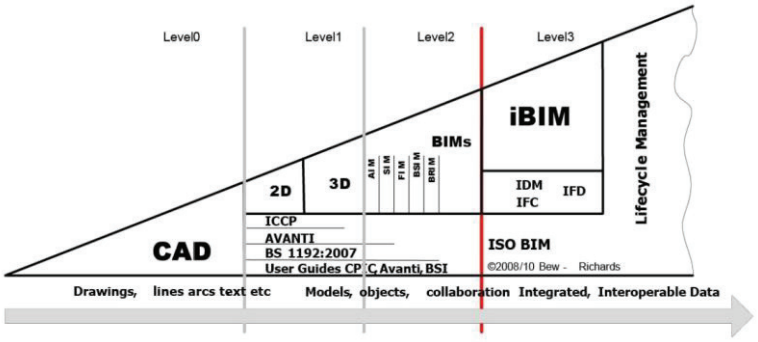


Figure 1: Bew and Richards BIM Maturity (BIM Maturity Wedge) [16]

The wedge was intended to depict the BIM maturity improvement in each of the levels; it treats collaboration as a by-product of information exchange mechanics. It further does not indicate the level of collaboration maturity among stakeholders; it infers that at a certain level, collaboration will be achieved. In essence, the BIMmw is leaning towards a technocentric approach to BIM and is avoiding the social aspects. It should be noted that the BIMmw was developed from a policy and strategy perspective and received criticism that it's not based on all of the components of a maturity model [28, 29].

Succar [4] presented the BIM maturity matrix (BIM3) (framework) that introduces a more complex view of BIM maturity. He introduced three main concepts: BIM fields, BIM stages, and

BIM lenses. The BIM fields include three intersecting fields i.e. technology (hardware, software etc.), process (people and organisations), and policy (contractual, regulatory etc.). The overlap of these fields indicates where BIM activities occur. The BIM stages, similar to the BIM wedge, present the maturity progression. Lastly, the BIM lenses are used to provide a new perspective when applied to the field and stages. The BIM stages include: Pre-BIM stage is similar to Level 0 of the BIMmw, which indicates a traditional approach and relies on two-dimensional drafting. BIM Stage 1 (object-based modelling), the project information is both in two dimensions (traditional CAD) and three-dimensional models; however, the model generation is largely generated in isolation. BIM Stage 2 (model-based collaboration), sees an active collaboration between project stakeholders. BIM Stage 3 (network-based integration), includes the entire project lifecycle. The model is generated collaboratively, shared, and becomes an important tool that is used at every stage of a project. Integrated project delivery (IPD), presents the ultimate end-state of a project where the three fields operate in unison, where technology, the collaborative process and supportive policies are aligned.

This framework, as well as the BIMmw, suggests that collaboration is an outcome of climbing the maturity stages/levels. The literature review indicated that a vast majority of the BIM maturity models are based on the BIMmw as well as the BIM Maturity Matrix.

Several collaboration maturity models have been developed and presented in the literature. The majority of these models do not consider the technological aspects of our ever-increasing digital society. Some models do, however, make mention of technology, but only as a contributing factor and in parallel with collaboration. The collaboration maturity model is based on an organisational or process phenomenon, in which technology plays only a supporting role. Technology is viewed as a tool used by the stakeholders and not as a key component that is vital for collaboration.

Collaboration maturity is not a new concept; it emerged in the early 2000s, and has been studied from several perspectives and industries. Each model provides a specific framing regarding collaboration, depending on the industry; for example, the engineering maturity model focuses on engineering collaboration [30], collaboration in enterprise systems [31], e-collaboration [32], knowledge management as well as process improvements [33], strategic collaboration enhancements [34], and group support systems [35]. Even though the models were developed in different industries and perspectives, a core focus remains: the gradual levels of collaboration capability across organisational dimensions.

These models provide insight into the social-organisational phenomenon with a focus on stakeholder collaboration within inter- or intra-organisational structures and arrangements, where technology plays a supportive role. The models consider shared dimensions which include governance, leadership, communication protocols and systems, behaviours of stakeholders as well as teams, knowledge sharing, trust, and culture. In the cases where technology is mentioned, it is used as an enabler among stakeholders and not the main driver of collaboration [32]. A common theme among the models indicates that collaboration matures over a period of time.

Table 2: Collaboration Maturity Models and Frameworks

Author(s) and Year	Year	Model/Framework Name
CMMI [36]	2000/2021	Capability Maturity Model Integration (CMMI)
Farrukh, et al. [34]	2003	Collaboration Maturity Matrix/Grid
Santanen, et al. [30]	2006	Collaboration Engineering Maturity Model
Magdaleno, et al. [37]	2009	Collaboration Maturity Model (CollabMM)
Alonso, et al. [31]	2010	Enterprise Collaboration Maturity Model (ECMM)
Boughzala and de Vreede [35]	2013	Collaboration Maturity Model (Col-MM)

Reeb [38]	2023	Intra-organisational online collaboration maturity model (IOC-MM)

It is evident from the aforementioned maturity models and frameworks that both BIM maturity and Collaboration maturity are not considered in an overall maturity model, nor does it focus on the project life cycle approach. This is a specific gap in the literature that this paper seeks to approach from a conceptual model development perspective.

3 METHODOLOGY OF CONCEPTUAL DEVELOPMENT

In this study, the conceptual model is based on synthesising BIM maturity and collaboration maturity along the project lifecycle to assess the potential performance improvements of BIM-enabled collaboration projects.

3.1 Conceptual model introduction

The conceptual development process is informed by a literature review, conceptual framework analysis and theory-building logic. The conceptual analysis framework is required to combine knowledge from several different bodies of knowledge, which include BIM maturity, collaboration maturity, digital delivery, project life cycles, socio-technological systems, and project performance. Jabareen [39] defines a conceptual framework "as a network…of interlinked concepts that together provide a comprehensive understanding of a phenomenon or phenomena". This definition fits with the current narrative as well as the number of concepts that are required to develop the conceptual model. Jabareen [39] further provides seven features of a conceptual framework; refer to Table 3 below.

Table 3: Conceptual framework features as per Jabareen [39]

#	Main Feature as per [39]	This study
1	It is not a collection of concepts; each concept contributes to the understanding of the conceptual model.	Includes concepts such as BIM maturity, collaboration maturity, project lifecycle management, stakeholder integration, stakeholder management, and socio-technical systems.
2	Social reality is depicted in a revelatory approach, and is not a causal relationship between concepts.	The social aspect of BIM-enabled projects is generally acknowledged but not central to the maturity model.
3	The model provides understanding,	This study aims to provide a deeper understanding of the relationship between BIM maturity and collaboration maturity on BIM-enabled capital projects.
4	The conceptual frameworks depict "soft interpretations of intentions" and avoid hard facts.	Literature has extensively researched BIM maturity, project performance and collaboration in the industry, albeit separately.
5	Conceptual frameworks do not predict outcomes,	It is not the intention to predict an outcome, but rather to depict the concepts as well as their relationship to present improvement strategies that could have a positive impact on project performance.
6	Qualitative analysis is used to develop conceptual frameworks.	For this study, a detailed literature study (qualitative approach) will inform the creation of a conceptual framework.

#	Main Feature as per [39]	This study
7	The conceptual framework is developed from empirical data obtained from a variety of discipline-specific theories.	Several literature sources from a wide range of concepts were used in formulating the conceptual framework.

The design is conceptual and theory-building in nature, and at the time of the study, it was not tested and verified. It is based on the findings of the literature and models and frameworks developed, as noted in the previous section. It is developed through a sequential process that involves extracting and synthesising findings from literature, the extraction of concept models and frameworks presented in the literature, mapping of concepts along the project lifecycle, relationship modelling of the concepts, and finally model generation. The final result will depict how BIM maturity and collaboration maturity interact along the project lifecycle.

3.2 Data collection strategy

A keyword search was conducted using the SCOPUS database, with several filters applied, including publications in the English language and publication types such as articles, conference papers, and reviews. A broad range of core terms and keywords was used, which were obtained from the core concepts presented in this study, such as BIM, maturity, collaboration, lifecycle, and thresholds. To facilitate a more comprehensive search, each core term included variations in spelling and acronyms used. From these facets, several keywords were identified from terminology observed in literature, as shown in the table below (Table 4).

Supplementary terms were included to refine the search criteria; this was due to the vast amount of search results that were obtained using the core terms. The core as well as supplementary terms and keywords were combined with Boolean operators to ensure a detailed analysis of the corpus. Refer to Annexure A for the detailed SCOPUS search string.

Table 4: Scopus database search terms and keywords (non-exhaustive)

Facets	Core terms and keywords	Supplementary terms and keywords	Results obtained Filtered
BIM	"building information model*", BIM		35 187
Maturity	Maturit*	capabilit*, readiness, competenc*	2 262 919
Collaboration	Collaborat*	"integrated project delivery", IPD, partnering, "lean construction", cooperat*, coordinat*, "team integration", "supply chain integration", "relational contract", inter-organisational variants.	2 843 897
Lifecycle	"project life cycle"	"project phase*", "project stage*", "delivery phase*",	327 710
Threshold	Threshold*	complementar*, "critical mass", "tipping point"	1 873 938

To further investigate the relationship between the core terms/keywords, the SCOPUS search string was combined with an AND Boolean in Table 4 below.

Table 4: Keyword Combinations

Core term/keyword combination	Results (without filter)	Results (with filter)	Results 2020 to present
BIM + Maturity	3 099	2 785	2 136
BIM + Collaboration	7 117	6 132	4 420
BIM + Maturity + Collaboration	867	769	552
BIM + Maturity + Project Life Cycle	484	432	334
BIM + Maturity + Collaboration + Project Life Cycle	142	125	104
BIM + Maturity + Collaboration + Threshold	110	98	76
IPD/Lean + Maturity	27	25	18

The SCOPUS results were further refined by applying the subject areas relating to AEC industry, which lead to a final search that combines two specific terms that forms the focus of this study, i.e. BIM Maturity and Collaboration maturity, returned zero results. (TITLE-ABS-KEY(("BIM maturity" OR "BIM capability" OR "BIM readiness"))AND TITLE-ABS-KEY(("collaboration maturity" OR "collaborative maturity" OR "collaboration capability" OR "collaboration readiness"))). This seems to indicate that the two concepts have not been collectively studied.

4 THE CONCEPTUAL MODEL

4.1 Identification of concepts

4.1.1 BIM and collaboration maturity

The BIM maturity, coupled with collaboration maturity, is a critical concept in this study. Recent work has begun to integrate these constructs [25, 26] and the relationships as been tested empirically. These contributions assess maturity as an organisational property as a single point in time.

Two contradicting views have been presented in the literature, where the application of BIM is seen as the key to improving collaboration, whereas other authors indicate that collaboration should first be established before BIM is effective. One proposed approach is to focus on BIM implementation and collaborative environments in parallel [9].

4.1.2 Project lifecycle

The inherent nature of capital projects is a set of activities that needs to take place in a stage-wise approach to complete the overall objective. This is best defined by the Project Management Institute (PMI) [40] as “the series of phases that a project passes through from its start to its completion.” Several project lifecycle stages have been presented in the literature as well as in the industry, including: ISO 22263:2008 - inception, brief, design, production, maintenance, and demolition [41]. ISO 29481:2016 - portfolio requirements, conception of need, outline feasibility, substantive feasibility, outlined conceptual design, full conceptual design, coordinated design, producing information, construction, operation, maintenance and disposal. ISO 19650-1:2018 - delivery phase and operational phase [15]. RIBA Plan of Work 2020 – strategic definition, preparing the brief, concept design, spatial coordination, technical design, manufacturing and construction, handover and use [42].

The AEC industry has various ways to depict the project lifecycle, due to the number of stakeholders involved, and this study will consider a more detailed project lifecycle phase approach. This approach will assist with defining stakeholder configuration per phase, as well as the level of collaboration and BIM maturity.

4.1.3 Project performance

Project performance is a well-researched topic in the field of project management and the AEC industry. The AEC industry is temporal, high-paced, fractured, and project-based. Furthermore, the involvement of diverse stakeholders and high capital investments necessitates the monitoring and management of their performance to ensure successful project delivery. Project performance, and in turn, when collectively considering all projects to obtain an industry overview, is measured through a multi-dimensional construct. The traditional triple constraint, as popularised in project management practices, focuses on key performance areas (KPI) such as time, cost and quality. The AEC industry is ranked as one of the lowest productivity rate when juxtaposed with other sectors, such as manufacturing, as shown in Figure 2 and confirmed by the literature [43] [44].

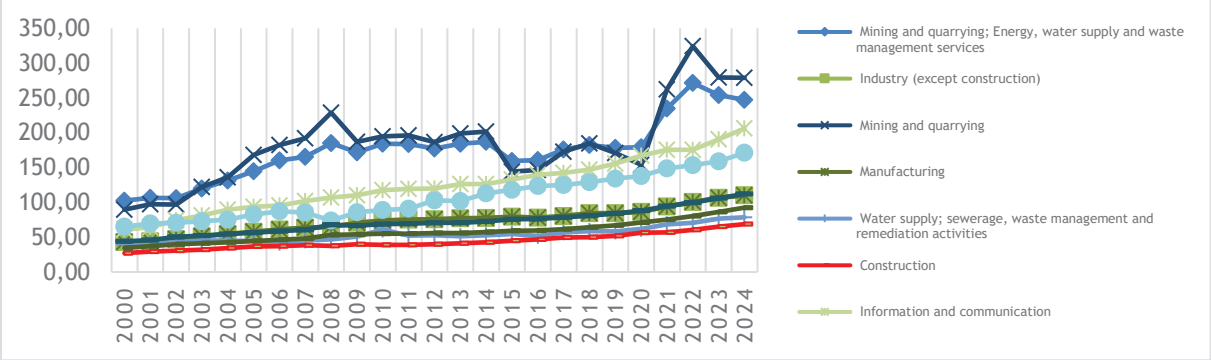


Figure 2: Productivity measured as real value added per hour worked (labour productivity) [USA, Annual, Period from 2000 to 2024]

It is estimated that 90% of the world's capital projects suffer from productivity issues related to projects being late and/or over budget [45]. Some productivity challenges can be attributed to fragmented workflows, inadequate information exchange and reliance on traditional methods [46]. This reliance on traditional methodologies has resulted in frequent clarifications and change orders, which directly impact the project costs. Innovative technologies that could improve traditional project delivery methodologies are available in the industry; however, the impact of innovation has not yet been realised in overall project performance improvements across the industry. Some of the more notable digital delivery frameworks include Building Information Modelling (BIM), Integrated Project Delivery (IPD), and Lean Construction (LC).

It should be noted that projects that have implemented digital delivery strategies and frameworks such as BIM, IPD and LC have seen varying degrees of success. This is exemplified by case studies conducted by Braun et al. [47] where, in two similar projects that started with similar conditions, focus on digital delivery and BIM implementation, two opposing results were achieved, i.e. success and failure. In the case of the failed project, the construction of a large office building, BIM was implemented during the design phase and abandoned during the construction phase. The implementation of BIM during the construction phase contributed to instability in the project and subsequently reverted to traditional delivery methods. Braun et al. [47] further posited that digital tools have a double-edged role where both the technological and relational aspects should be managed.

In a comparative study conducted by [48]. They concluded that, when considering the project as a whole, both traditional and collaborative construction projects can achieve their desired end goal. Furthermore, several authors have identified that the probability of project delivery success increases to the degree that levels of collaboration, trust, and collaborative problem-solving increase [49, 50]. Moradi et al. [51] identified that key success factors on projects that

implement collaborative delivery models (including IPD, partnering, etc), include "appropriate and relevant contract, commitment to win-win philosophy, collaboration and coordination, equality, incentive system, open communication, mutual trust, and selecting competent people for the project are the core success factors". Collaboration, as detailed in an empirical study by Haaskjold et al. [52], includes elements of coordination, trust and teamwork. They further found that projects perform better when collaboration is strong, and that it is considered a remedy for poor project performance. Several of these factors are not considered in the current BIM maturity models or frameworks.

4.1.4 Socio-technical systems

The socio-technical systems theory is a conceptual framework that underscores relationships and interactions between social and technical elements within an organised system. The theory hinges on two subsystems, i.e. the social system, which involves people, values and motivation; and the technical system, which encompasses tools and technologies. The AEC industry operates within a socio-technical system that exhibits interactions among processes, technologies, and people, yet even though the maturity models acknowledge the social aspects, they lean heavily towards the technocentric aspects.

4.1.5 Complexity

Several authors have studied the complex nature of capital projects in the AEC industry. The following sources of complexity were identified: structural and project-specific, which involve the interdependence between multi-disciplinary teams and multi-organisational involvement [53] [54, 55], organisational and stakeholder diversity that leads to contractual misalignments and fragmented supply chains [56], legal and political requirements and regulations [57, 58], and finally, technological aspects that face difficulties in interoperability, data silos and lack of standardisation [4, 5]. The authors listed the complexities but have not provided a conceptual description of the divergent and convergent nature of complexity along a project lifecycle.

Hasse [59] presented nine archetypes of chaos that depict the divergence and convergence along a project lifecycle. This depiction indicates several ways in which the level of disorder can be described, varying from a state of randomness, traversing through chaos, complexity, to order. This study will adopt the concept of the nine archetypes to depict complexity as well as the convergent and divergent nature of collaboration.

4.2 Existing technology acceptance and adoption models

The technology acceptance and adoption models have been extensively researched. From the plethora of models and theories, this study will focus on only four. The Technology Acceptance Model (TAM) is the most widely used model in the literature. Due to its core focus on individual users, this is a useful model to understand individual users' propensity to adopt technology; however, for this study, it was not considered the main model. This consideration is applied to the extension of the Technology Acceptance Model (ETAM). For this study, the Social Cognitive Theory (SCT) and Diffusion of Innovations theory (DOI) were considered, as it can be applied to individual users as well as groups or organisational level. This provides a broader view of the industry and not on individuals. Furthermore, with the inclusion of the collaboration maturity concept, specific focus is required on the behaviours of individuals as well as groups.

4.3 Threshold models and theories

As discussed in this study, when considering maturity models, certain conditions should be in place to progress through the maturity stages. The movement indicates an enhanced level of maturity, or, in other words, a series of thresholds that will need to be crossed to change

maturity levels. A distinction is necessary. Existing maturity models specify thresholds for classification, in other words, the criteria an organisation must satisfy to be addressed at a given level. The proposed threshold addresses benefit realisation, the condition that must be met before investment in BIM translates into project performance improvements. These are different claims, and the latter does not follow from the former. Several threshold models and theories have been proposed in the literature, including: Necessary Condition Analysis (NCA) [60], Absorptive Capacity Theory (AC), Critical Mass Theory (CM), and Stage Gate (SG). The core premise centres on a set of conditions that must be met for a certain outcome to be achieved. The logic that best fits this study is NCA, which expresses necessity without implying sufficiency. Each condition is assessed separately against the outcome. For example, the required levels of BIM maturity and collaboration maturity can be established independently and then read together, so neither is assumed to compensate for the other, but as a combination, could realise the full benefit of the digital delivery method.

4.4 The conceptual model

The conceptual model will be viewed from the perspective of a capital project's life cycle, giving due consideration to stakeholder involvement and arrangements, complexity, and maturity models, considering both socio-technological aspects, i.e., collaboration maturity and BIM maturity. To simplify the PLC, the model only considers four project phases: inception, design, construction, and operations. The PLC perspective is graphically depicted in Figure 3. The threshold is not held to be constant; it is proposed to follow the complexity and stakeholder configuration shown in the tracks below. In general, capital projects progress through various phases, as shown in the bottom track. Each phase has a unique stakeholder configuration network and specific stakeholder involvement (refer to the 3rd and 4th tracks). As the project progresses along the PLC, it faces varying levels of complexity that move it from order to chaos (refer to the 5th track). The first two tracks introduce the core of the conceptual model. The level of BIM (based on the BIM maturity matrix) and collaboration maturity varies throughout the PLC. The numeric value relates to the level achieved; the depiction is purely conceptual. It is affected by a multitude of factors, some mentioned above, as well as a plethora of industry-specific ones.

The conceptual model, indicated in Figure 4**.** It has two distinct sections. The upper diagram depicts the relationships among various factors, including BIM maturity, collaboration maturity, and influencing factors on project performance. The lower portion presents the relationship of the aforementioned factors within the PLC. The combination provides the main theme of the conceptual model.

The empirical investigation is structured through five main propositions.

1. Proposition One (P1) posits that project performance is positively affected by higher BIM maturity, which is consistent with academic literature. This is consistent with the benefits derived from the reviewed literature [5, 17, 27, 61].
2. Proposition Two (P2) asserts a similar claim about collaboration maturity: at a high level of collaboration maturity, project performance improves. This follows from evidence that delivery success increases with levels of collaboration, trust, and collaborative problem solving [49, 50], and that projects with strong collaboration perform better [52].

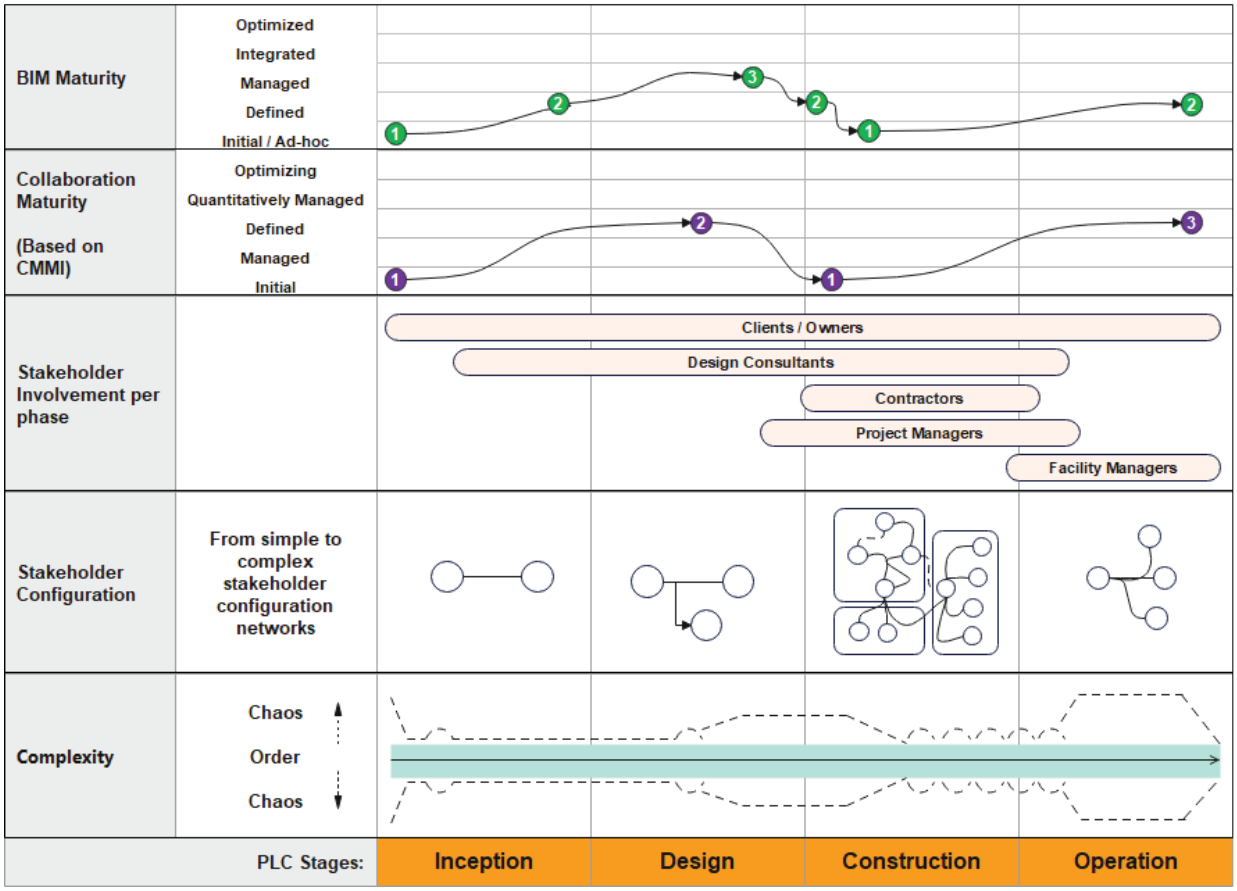


Figure 3: Conceptual model setting based on project life cycle perspective

3. Proposition three (P3) posits that the stakeholder collaboration maturity moderates the BIM performance relationship. This relationship is subject to moderation, which has been demonstrated empirically by >>>, who found that BIM diffusion and moral hazard moderate the effect of BIM capability maturity on collaborative delivery. P3 extends that finding by proposing collaboration maturity as the moderator.
4. Proposition four (P4) advances the claim distinct from P3. Where P3 concerns the strength of the relationship between BIM maturity and performance, P4 concerns the conditions under which the relationship operates. It points out that BIM maturity and collaboration maturity are each necessary conditions for benefit realisation. For example, both must meet or exceed a threshold for benefit realisation to occur, and neither compensates for the other.
5. Proposition five (P5) posits that project performance can be partially mediated by influencing factors, which include, among others, project type, project size, project complexity, stakeholder configuration, stakeholder integration, delivery methods, ways of working, etc.

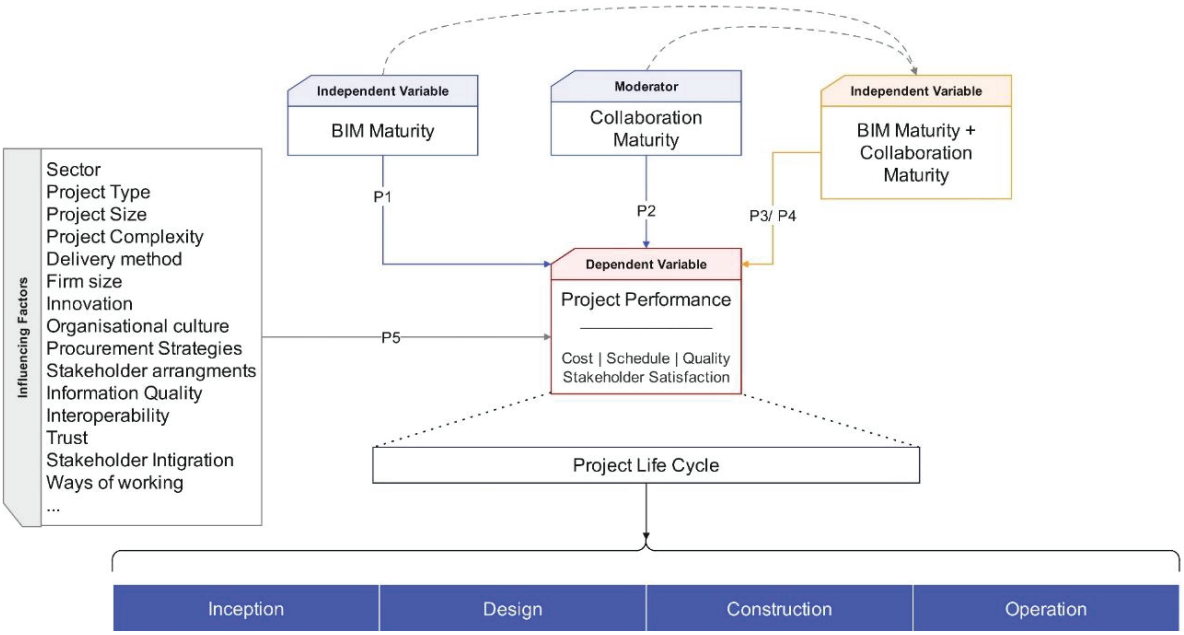


Figure 4: Conceptual Model Diagram

5 CONCLUSION

The AEC industry is evolving from a traditional non-digitised industry towards a socio-technical industry. This process is made possible by the development of new technologies that can be implemented in industry. One of the most prolific digital tools is Building Information Modelling, which is not a technology in itself but rather a way of working that integrates technology, people and processes. Projects beginning under comparable conditions, with comparable commitments to digital delivery, have nonetheless diverged into success and failure [47], suggesting that maturity alone does not explain whether investment into BIM is repaid. This phenomenon raises the question: do we need to implement BIM to facilitate collaboration, or do we first need a foundation for collaboration for BIM benefits to be realised?

This study investigated BIM and collaboration maturity across the project life cycle of a capital project. The lifecycle provided a unique view, as each phase has its own challenges, stakeholder configurations, complexity, and maturity level. The conceptual model introduces a maturity threshold. This threshold is influenced by several factors, and the potential for project performance improvements and the realisation of BIM benefits is achieved once the minimum threshold is met.The contribution is twofold. First, the model treats BIM and collaboration maturity as a joint condition for benefit realisation, which existing maturity models do not provide. Second, it proposes that the required maturity varies across lifecycle phases with complexity and stakeholder configuration, as the project may satisfy the condition in one phase and fail in another.

The model is conceptual and has not been empirically tested; threshold values are not calibrated, and the analysis rests on a synthesis of published work rather than primary data. Validation will proceed in three stages: expert consensus to confirm the maturity attributes and the phase structure using the nominal group technique (NGT); a structured survey to operationalise each proposition; and statistical testing of the necessity proposition through necessary condition assessment. Establishing whether the threshold varies across phases, as proposed and by how much, is the principal empirical question this study leaves open.

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A Review Of Project Management As A Profession In South Africa

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A REVIEW OF PROJECT MANAGEMENT AS A PROFESSION IN SOUTH AFRICA

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ABSTRACT

This paper reviews the status of project management as a profession in South Africa by comparing its professionalisation requirements with those of established professions such as law, medicine, accounting, and engineering. The study examines the characteristics traditionally associated with professions, including formal education, practical training, ethical accountability, regulation, and continuous professional development. A comparative analysis of major project management certifications and registrations applicable in South Africa is presented, focusing on academic requirements, experience, assessment methods, and statutory recognition. The paper further evaluates the role of local and international professional bodies, including SACPCMP, PMI, IPMA, and PMSA, within the South African regulatory framework. Findings indicate significant variation in academic rigour, professional pathways, and statutory recognition among certifications, creating uncertainty for employers and practitioners regarding the credibility, applicability, and professional standing of project management qualifications in South Africa.

Keywords: legislation, project profession, statutory requirements

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1 INTRODUCTION

The reason for reviewing project management as a profession in South Africa stems from industry concerns about the contextual uncertainty, applicability, and value of various certifications in the country.

Since the early 1990s, various project management-related certifications and registrations have emerged from various global associations. Based on different philosophies, bodies of knowledge, methodologies and industry requirements, a plethora of professional certifications have been developed and marketed to the industry. The availability of different certifications created a conundrum for countries and their regulatory bodies, who had to decide which institutional route to follow and how to localise it without limiting global professional deployment [1], [2]. The development of ISO 21502 – *Project, programme and portfolio management – Guidance on project management* [3] was an effort to consolidate various perspectives and practices into a generally applicable, global approach towards project management across industries and countries. However, it seems that the extended guidelines within the ISO 21500 family of standards have not been incorporated into the quest for a unified, generally accepted criterion for project professionalisation.

In South Africa, certifications are primarily based on the requirements of associations such as the Project Management Institute (PMI), the South African Council for the Project and Construction Management Professions (SACPCMP), and Project Management South Africa (PMSA). Associations that are also becoming more active in South Africa include the International Project Management Association (IPMA) through its local chapter and, to a lesser extent, the Association for Project Management (APM). Other certifications are methodology-related, such as PRINCE2 and Agile, as well as project delivery requirements provided in the Engineering Council of South Africa (ECSA) guidelines.

Given this assortment of certifications, public and private institutions face the difficult task of deciding which certifications to support or prescribe when recruiting or developing project management practitioners. Evidently, organisations want to improve their ability to deliver projects and need some assurance in project professionals' ability to do so.

To address this corporate conundrum in project certification selection, this paper first reviews the requirements for a discipline to be considered a profession. Secondly, it compiles a comparative table of available certifications and their requirements. Lastly, it provides a critical review of the available certifications in South Africa, their suitability for application and value to industry. The research methodology followed a three-step process. Firstly, a literature review was done on the historical developments of the concept of a “profession” and the requirements for an occupation to achieve professional status. Secondly, the available project management certifications in South Africa were retrieved from the websites and/or offices of various organisations and reviewed against the requirements for professional status. Lastly, the status of each certification and potential shortcomings in their professional standing were outlined, along with recommendations for further research.

2 PROFESSION – DEFINITION AND PURPOSE

The Oxford English Dictionary [4] characterises a profession as involving occupation (career or vocation), knowledge, application, training, and formal qualification. The Collins Dictionary [5] defines a profession as a type of job that requires advanced education or training. While dictionary definitions focus on knowledge and training, legal requirements translate these concepts into statutory obligations, protected titles, and regulatory oversight. Flexner, in Tapper and Millet [6], argues that professions involve 'essentially intellectual operations with large individual responsibility; they derive their raw material from science and learning; this material they work up to a practical and definite end; they possess an educationally communicable technique; they tend to self-organisation;[and] they are becoming increasingly altruistic in motivation'.

Legally, a "profession" is often defined by the restriction of its name. In many jurisdictions, including South Africa and the United Kingdom, you cannot legally allocate certain titles to yourself unless you are registered with a statutory body.

According to Algeo [7], the characteristics that define a profession should reflect a substantial history, a body of knowledge, practical application and a high level of education. She also argues that a profession should be able to self-regulate through organised associations.

3 ESTABLISHED PROFESSIONS

Four of the most well-established professions, governed by statutory and legal bodies, are lawyers, medical doctors, chartered accountants and engineers. These professions have a long history of development, with continuous refinements made to enhance each profession. From a South African perspective, most principles applied have been adopted from European, especially British, development.

3.1 Legal practice

Legal practice has a long, evolutionary history. Solicitors were first organised on a professional basis with a grant of a Royal Charter to the Law Society in 1845, and barristers self-regulated from 1501 through admission to The Bar by invitation to be a member of the four Inns of Court [7].

To qualify and practice as a legal practitioner in South Africa, whether as an attorney or advocate, the candidate must satisfy the strict requirements set out by the Legal Practice Council (LPC) under the Legal Practice Act 28 of 2014 [8]. This includes a Bachelor of Laws (LLB) degree from an accredited South African University, which is a minimum of 4 years. This is followed by Practical Vocational Training (PVT), which, for an attorney, includes two years of articles of clerkship at a registered law firm alongside 150 hours of compulsory structured work. Alternatively, a graduate can serve one year of articles of clerkship and a comprehensive 400-hour PVT program. Candidates must also pass the four national professional competency examinations (PCE) administered by the LPC. Advocates must serve a one-year pupillage under the supervision of a practising advocate mentor and must complete the structured training programs required by the Bar. Before final application for admission, candidates must also

pass the national Bar examinations. Over and above the academic and practical requirements, the High Court also requires solid proof of moral integrity and character reference testimonials confirming that the individual is ethical and trustworthy. The further development and refinement of the legal profession is continuous to ensure justice in an ever-changing society [6], [7], [9].

3.2 Medical practice

The Provincial Medical and Surgical Association, founded in 1832, successfully lobbied for the establishment of the General Medical Council in 1858 in the United Kingdom. Prior to this, the Company of Surgeons was granted a Royal Charter to become the Royal College of Surgeons in 1800. The principles contained in the General Medical Council formed the basis of the regulations for health care practitioners and continue to be developed and refined.

In South Africa, the qualification and professional registration of Medical Doctors (MD) is regulated by the Health Professions Council of South Africa (HPCSA) under the Health Professions Act 56 of 1974 [10] and can take eight to nine years of continuous and practical training. The first step is to meet the stringent admission requirements to study for a Bachelor of Medicine and Bachelor of Surgery (MBChB) degree at an accredited university. This is followed by two years of supervised practical training (SPT) and one year of mandatory community service (MCS), after which the HPCSA will grant registration to practice as a general practitioner (GP).

3.3 Accounting

The rich history of the accounting profession dates back literally thousands of years to ancient Mesopotamia and is closely related to developments in writing, counting and auditing systems by the Egyptians and Babylonians [11]. Around 1300, accountants were first mentioned in historical records in the Statute of Westminster. In 1494, Luca Pacioli developed double-entry bookkeeping and published it in his work Summa di Arithmetica, printed in Venice [11]. Over the centuries, accounting practices evolved until 1870 to 1877, when bodies of accountants formed in different British cities and eventually merged to form the Institute of Accountants in London. Today, the International Accounting Standards Board (IASB) has developed numerous standard accounting practices published under the International Financial Reporting Standards (IFRS), which govern the accounting profession in specific countries under their respective legislation [12].

In South Africa, the qualification and professional registration requirements for a Chartered Accountant (CA(SA)) are regulated by the South African Institute of Chartered Accountants (SAICA). This takes seven to eight years, including a BCom degree in Accounting, a Certificate in the Theory of Accounting (CTA) to be completed in one year, and three years of formal traineeship (Articles) at a SAICA-accredited company. At the end, two professional exams must be completed: the Initial Test of Competence (ITC) and the Assessment of Professional Competence (APC).

3.4 Engineering

Engineering, in its purist form, dates to ancient Egypt. From building with stone, wood, metal and advanced composite materials, engineering continues to evolve, and societies modernise.

Different countries embarked on their own journey to formalise and regulate the profession, with the French, for example, forming professional engineering associations in the mid-19th century [13].

The Engineering Council of South Africa (ECSA) regulates the engineering profession in South Africa. Registering as a Professional Engineer (Pr Eng) is a seven to eight-year process. It requires a four-year BEng degree from an academic university, after which registration as a Candidate Engineer can be obtained. A minimum of three years post-graduate training and exposure to the full cycle of an engineering project is required, including formal logs detailing the work and the submission of a comprehensive report for appraisal and peer review by an ECSA panel.

The requirements for registration of these four professions are summarised in Table 1 below.

Table 1: Professional registration requirements

Profession	Title	Academic Requirements	Practical Requirements	Number of years to professional registration
Lawyer/Advocate	Adv	LLB, PCE of Bar Exams	PVT, PCE,	6 years
Medical Doctor	GP	MBChB	PCT, CMS	9 years
Chartered Accountant	CA	BComm, CTA, ITC, APC,	3 years	8 years
Professional Engineer	PrEng	B Eng, BSc Eng	Practical report	8 years

On investigation of these historical factors, to be considered a profession, a vocation must be held accountable and, over time, must be perceived as having a fiduciary responsibility to the community in which they practice. It must adhere to strict ethical standards and apply its body of knowledge [14] to the greater community and public benefit [15].

A profession requires regulation [16] and therefore must have a Governing Body that oversees the practices and conduct of professionals. It should include mandatory continuous professional development requirements and a public service approach.

4 SOUTH AFRICAN PROFESSIONAL LEGAL FRAMEWORK

In South Africa, the primary legal framework that distinguishes between "regulated professions" and general occupations based on their oversight bodies is the National Qualifications Framework (NQF) Act, 67 of 2008 [17]. The NQF Act provides the structural mechanism for this regulation and distinguishes between two regulated professional bodies recognised by the South African Qualifications Authority (SAQA), namely:

- Statutory Bodies: Established by specific Acts of Parliament to legally govern the right to practice. Examples include the mentioned legal, medical, accounting and engineering professions in South Africa. Registration under these bodies is

comprehensive and requires, upon academic graduation, the completion of a mandatory internship or articles, as well as a relevant entrance exam.

- Non-Statutory (Voluntary) Bodies: Recognised by SAQA to promote professional standards and register professional designations, though registration may not always be a legal requirement to work. Examples include the Marketing Association of South Africa (MASA) and the South African Board for People Practices (SABPP). Registration with these bodies varies substantially in terms of academic, practical experience, and examinations.

In South Africa, two laws affecting project management apply. Firstly, the Project and Construction Management Professions Act 48 of 2000 [18] which governs certifications by SACPCMP; and secondly, the Engineering Profession Act 46 of 2000 [19], which governs certifications by ECSA. As per the NQF requirements, SACPCMP is considered a statutory body for project management and ECSA for engineering; however, the latter contains substantial elements of project management.

A distinction between statutory and voluntary certifications lies in compliance versus adherence. In the pursuit of improved project management capability, the content and requirements of certifications are important, but compliance does not necessarily guarantee performance in any respect, including safety. It therefore remains important to be aware of the requirements for the various certifications and of the extent to which the different associations can contribute to and support the profession and continuous project performance improvement.

5 PROJECT MANAGEMENT ASSOCIATIONS AND THEIR CERTIFICATIONS

Globally, there are numerous project management associations and federations. Compared to the other professions discussed in this paper, the formation of these first associations and federations is fairly new, with the IPMA established in 1965 and PMI in 1969. Some operate internationally with local, regional, or country affiliations or chapters, while others are mostly country-specific. For this study, only international associations with South African chapters or representation, as well as local associations, are considered. Each association's project manager certification offerings are reviewed with respect to academic, experience, and assessment requirements (Table 2).

The table excludes project administration or methodology-specific certifications, such as Certified Associate in Project Management (CAPM), PMI Project Management Office Certified Professional (PMI-PMOCP), Agile, PRINCE 2 and many more.

Apart from the statutory/voluntary distinctions, the certifications differ in levels of progression, academic and assessment requirements.

6 PROFESSIONAL CONSTRUCTION PROJECT MANAGERS (PR. CPM) VERSUS OTHER PROFESSIONS

Given the requirements associated with regulated professions, the review of project management as a similarly regulated profession should be based on the academic (body of knowledge) requirements and the final registration criteria.

6.1 Academic requirements

Professions such as those discussed (lawyers, doctors, accountants, and engineers) require strict admission requirements to accredited universities. The mandatory, degree-oriented academic input, also referred to as the body of knowledge, is evaluated and audited against the requirements of the various Professional Governing Bodies.

For a Pr. CPM, there are various academic routes starting from an accredited Honours Degree to merely Recognition of Prior Learning (RPL) with no formal, post-matric academic requirements. This raises questions about the academic rigour of the professional registration process and adherence to national and international professionalisation practices.

A second, significant academic criterion for Pr.CPM is a qualification within the built environment field of study. In the technical environment, this excludes all engineering disciplines except civil engineering.

6.2 Vocational training

As with other professions, registration for Pr. CPM requires, depending on academic qualification, a minimum of four years of experience, culminating in an Evidence Report and an examination on the specific Six-Phase Project Life-Cycle contained in the SACPCMP Services Guidelines (17-page document). Candidates must also demonstrate competence in the Project Management Body of Knowledge (PMBoK).

With the SACPCMP's discipline-specific approach to registration requirements, other disciplines must revert to non-statutory bodies for recognition.

7 CONCLUSION

Project management in South Africa has made significant progress toward professionalisation through the establishment of professional associations, competency frameworks, certifications, and statutory registration pathways. However, when compared to long-established professions such as law, medicine, accounting, and engineering, substantial differences remain regarding academic standardisation, vocational training, statutory regulation, and professional exclusivity.

The study found that project management certifications in South Africa vary considerably in academic entry requirements, expectations for practical experience, and assessment methods. PMSA is the only association that requires a bachelor’s degree (NQF level 8) for progression to Professional Project Manager (Pr.PM) status. All the other associations provide alternative routes that recognise lower-level NQF qualifications with complementary RPL and experience. While international associations such as PMI and IPMA focus primarily on competency and experience-based certification, local statutory registration through SACPCMP attempts to align project management with recognised professional practice. The availability

of alternative routes, including RPL, and the restriction of statutory registration largely to the built environment sector, create inconsistencies in the perceived academic and professional rigour of the profession.

The absence of a single, universally accepted body of knowledge, a mandatory educational pathway, and a unified regulatory framework contributes to industry-wide uncertainty about the value and applicability of different certifications. Despite these challenges, project management continues to evolve as an increasingly important discipline that supports economic development, infrastructure delivery, and organisational performance.

For project management to achieve broader recognition as a mature profession in South Africa, greater alignment between academic institutions, industry, and professional bodies will be required. This includes clearer professional pathways, stronger integration of formal education and practical training, enhanced ethical and regulatory oversight, and broader recognition across industries beyond the built environment.

Further research on the topic continues to examine the scale of the profession in South Africa and the views of employers and professionals.

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Table 2: Project management certifications in South Africa

Association	Local Chapter	Certification	Academic	Experience	Assessment
PMI*	PMI- SA Chapter	Project Management Professional (PMP)	Set A: • Matric • 35 hrs of project management education.	Minimum 5 years of leading and managing projects in the past 8 years.	Exam: • 180 questions • 230 minutes
			Set B: • Bachelor's degree or higher. • 35 hrs of project management education.	Minimum 3 years of leading and managing projects in the past 8 years	
			Set C: • Bachelor's degree or higher from GAC accredited. program • 35 hrs of project management education.	Minimum 2 years of leading and managing projects in the past 8 years	
IPMA**	IPMA-SA	Level A - Project Director	• Matric • IPMA ICB	Minimum 5 years of responsible leadership of complex projects over the last 12 years with strategic impact.	Exam: • Oral, 90 - 120 minutes Evidence Report
		Level B - Senior Project Manager	• Matric • IPMA ICB	Minimum 5 years of leading complex projects over the last 8 years.	Exam: • Oral, 90 minutes • Written - 180 minutes

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Association	Local Chapter	Certification	Academic	Experience	Assessment
					Evidence report
		Level C - Project Manager	• Matric • IPMA ICB	Minimum 3 years of leading moderately complex projects over the last 6 years.	Exam: • Open questions • 180 minutes Evidence report
		Level D - Project Management Associate	• Matric • IPMA Individual Competence Baseline (IPMA ICB)	Broad project management knowledge and exposure.	Exam: • Multiple choice & open 180 minutes
PMSA***	SA based	Professional Project Manager (Pr.PM)	National Qualifications Framework (NQF) Level 8 (Honours/Postgraduate Diploma) in any industry to a field in which the candidate is working as a PM, in addition to the NQF Level 7 (Bachelor's Degree) in the original area of work or technical qualification.	Ten years of working experience managing projects, at least three of which were spent on projects of high complexity according to CIFTER. (CIFTER primarily refers to the Crawford-Ishikura Factor Table for Evaluating Roles [20], a project management tool used to measure project complexity across seven factors, including team size, experience, and technology. It is used to determine the required competence level of project managers.)	Evidence report

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Association	Local Chapter	Certification	Academic	Experience	Assessment
		Senior Project Manager (Sr.PM)	NQF 7 related to a field in which you are currently working as a PM and a formal short learning programme in project management or Industry Credentials (Various): such as a recognised certification or accreditation.	Six years of working experience managing projects, at least three of which were spent on projects of moderate complexity according to CIFTER.	Evidence report
		Project Manager (PM)	NQF 7 is related to a field in which you are currently working as a PM Industry Credentials (Various): Optional at this level.	Three years of working experience managing projects of low complexity according to CIFTER.	Evidence report
SACPCMP****	SA Based	Professional Construction Project Manager (PrCPM)	• Honours Degree / Post Grad Diploma NQF Level 8 *(Only qualifications in the Built Environment are applicable (e.g. construction management, quantity surveying, architecture. Civil engineering will also be eligible through recognised pathways and appropriate experience)*	• 4 years • Evidence report • Personal interview • Exam on Six-Phase Project Life-Cycle	• Exam • Interview
			• Bachelor's Degree / Advanced Diploma NQF Level 7	• 5 years • Evidence report • Personal interview • Exam on Six-Phase Project Life-Cycle	
			• National Higher Diploma NQF Level 6	• 6 years • Evidence report • Personal interview • Exam on Six-Phase Project Life-Cycle	

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Association	Local Chapter	Certification	Academic	Experience	Assessment
			• National Diploma NQF Level 5	• 7 years • Evidence report • Personal interview • Exam on Six-Phase Project Life-Cycle	
			• Recognition of Prior Learning (RPL) certificate	• 10 years • Evidence report • Personal interview • Exam on Six-Phase Project Life-Cycle	

- *Project Management Institute – established in 1969 [21]
- **International Project Management Association – established in 1965 [22]
- ***Project Management South Africa [23]
- ****South African Council for the Project and Construction Management Professions [24]

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Project Management Competence As A Critical Success Factor In Lowest-Bid Infrastructure Projects: Evidence From Rwanda's Electricity Grid Interconnections

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PROJECT MANAGEMENT COMPETENCE AS A CRITICAL SUCCESS FACTOR IN LOWEST-BID INFRASTRUCTURE PROJECTS: EVIDENCE FROM RWANDA'S ELECTRICITY GRID INTERCONNECTIONS

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ABSTRACT

Donor-financed electricity interconnections create public value when projects are delivered reliably, on time and at justifiable whole-life cost. This qualitative multiple-case study examines how project-management competence conditioned risks associated with the Lowest Bidder Method (LBM) in Rwanda's components of the Rwanda–Democratic Republic of Congo (DRIP) and Rwanda–Burundi (BRIP) grid interconnections. Evidence comprised 15 semi-structured interviews and project records; the sample included ten utility, four consultant and one contractor representative, while the researcher's prior involvement required explicit separation of participant, documentary and contextual evidence. Both cases experienced substantial delays, but BRIP reached completion with reported quality burdens, whereas DRIP's original substation contract failed and required prolonged recovery. The comparison refines Principal–Agent Theory: bid-induced financial pressure produced different failure trajectories depending on contractor capability and the principal's organisational capacity to screen, monitor, enforce and recover. Price-realism review, past-performance verification and risk-proportionate supervision are recommended to protect public value

Keywords: Electricity infrastructure, Lowest Bidder Method, Principal-Agent theory, Project management competence, Public value.

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1 INTRODUCTION

Energy infrastructure plays a critical role in supporting economic growth, necessitating reliable and efficient affiliated infrastructure projects. Developing countries increasingly depend on large-scale infrastructure investments to strengthen energy security and improve access to reliable electricity services. The successful delivery of these projects requires effective planning, coordination, stakeholder management, technical expertise, and robust governance mechanisms [1].

In many internationally financed works contracts, award follows a lowest evaluated responsive bid after specified qualification requirements are met, seeking to promote transparency, competition, and value for money [2]. In this paper, this arrangement is termed the Lowest Bidder Method (LBM). LBM can promote competition and procedural transparency, but a formally compliant low bid may conceal unrealistic pricing, weak liquidity, thin staffing or limited contract-management capacity [3], [4]. Contemporary procurement frameworks increasingly address this problem through fit-for-purpose strategies, rated criteria, life-cycle value-for-money analysis and explicit treatment of abnormally low bids [5], [6].

In East Africa, regional electricity grid interconnection projects have become strategic instruments for facilitating cross-border power trade, improving system reliability, and enhancing energy security. These initiatives are implemented through the Nile Equatorial Lakes Subsidiary Action Program Coordination Unit (NELSAP-CU), which was launched in 1999 as a Coordination Unit for the implementation of power development and trade projects among the ten Nile Basin member countries, including Rwanda [7], [8]. Rwanda has actively participated in this initiative through several regional interconnection projects, including the Rwanda–Burundi Interconnection Project (BRIP) and the Rwanda–Democratic Republic of Congo Interconnection Project (DRIP).

Despite the strategic importance of these projects, they have been beset by multi-year delays, cost overruns, and quality concerns. This raises an important question: is the problem rooted in procurement, or in the capacity to manage procured contracts effectively? While the Lowest Bidder procurement approach is extensively used to enhance fairness and transparency, it has its challenges, as it tends to emphasise price over capability, leading to unrealistic pricing and inadequate delivery, impacting project outcomes. Several studies have linked these challenges to procurement approaches that prioritise the lowest contract price over technical capability and organisational competence [9], [10].

Existing research already associates contractor capability and project-management competence with infrastructure performance. The theoretical contribution claimed here is therefore deliberately modest. Rather than proposing a new construct, the paper provides a comparative, context-specific refinement of Principal–Agent Theory: in lowest-bid public works, the principal's project-management competence constitutes governance capacity for screening, monitoring and corrective action, while an unsustainably low bid can intensify the agent's incentive to delay, claim or economise. The interaction—not LBM or competence in isolation—helps explain differing failure trajectories. Existing literature suggests that project management competence may act as a critical mitigating factor capable of reducing procurement-related risks and improving project performance [11], [12].

Rwanda is not treated as statistically representative of all developing countries. It is an analytically useful case because its electricity expansion has depended on coordinated public institutions, international finance and cross-border infrastructure, features shared by many low-income and lower-capacity infrastructure settings [13], [5], [9]. Transferability is therefore bounded to projects with comparable characteristics: donor financing, public-utility implementation, complex imported plant, cross-border coordination and constrained implementation capacity.

The study compares DRIP and BRIP because both were strategically important electricity interconnections, implemented by the same national utility and procured through lowest-evaluated-bid arrangements, yet they produced different implementation trajectories. DRIP included a transmission-line package and a substation package; the latter experienced contractor failure and prolonged recovery. BRIP's Rwandan transmission and substation works were eventually completed but approximately two years late and were followed by reported defects requiring continued oversight.

Table 1: Paired research objectives and research questions

Research objective	Linked research question
RO1: Assess how project-management competence influenced project outcomes	RQ1: How did project-management competence influence scope, time, cost, quality and stakeholder management in the two projects?
RO2: Examine the perceived effects of the Lowest Bidder Method (LBM) on project cost, schedule and quality	RQ2: What were the perceived effects of LBM on the cost, schedule and quality outcomes of the two projects?
RO3: Compare the effectiveness of project-management practices in DRIP and BRIP	RQ3: How did project-management practices and their effectiveness differ between DRIP and BRIP?
RO4: Identify project-management competence and procurement improvements that could mitigate adverse project outcomes	RQ4: What project-management competence and procurement improvements should inform future donor-financed electricity infrastructure projects?

The paper contributes (i) a systematic cross-case account of two under-researched East/Central African electricity projects; (ii) a qualified Principal-Agent Theory refinement centred on monitoring capacity; and (iii) procurement and capability levers that connect project performance to public-value delivery.

The planned regional power transfers across East Africa underscore the significance of successful project delivery, as delays in any component directly affect regional energy trade, grid reliability, and anticipated socio-economic benefits. The Rwanda–Burundi and Rwanda–DRC interconnection projects therefore provide an appropriate context for examining how project management competence influences project success under the Lowest Bidder Method.

2 LITERATURE REVIEW

Large-scale energy projects, such as electricity grid interconnection initiatives, in developing nations in Africa, are frequently characterised by their reliance on international financing institutions, such as the African Development Bank, the World Bank, and Germany Development Bank, among others, for funding and policy. A cohesive line of analysis is thus crucial: (a) define project management competency; (b) explain procurement selection and LBM; and (c) integrate theory that connects incentives, restrictions, and supervision to outcomes.

2.1 Project Management Competence

Project management competence refers to the effective application of knowledge, skills, experience, behaviours, and personal attributes required to achieve project objectives within established scope, time, cost, and quality constraints [14]. In major infrastructure, competence operates at both individual and organisational levels. Planning, scheduling, risk analysis, technical assurance and contract administration are complemented by leadership, communication, stakeholder engagement and the organisational ability to deploy enough skilled personnel when risks intensify [14], [11].

This distinction is important because a competent project manager cannot make up for an understaffed implementation unit, poor delegation, delayed decisions, or insufficient consultant input indefinitely. As a result, competence can be seen in both credentials and routines, such as early risk identification, credible schedules, timely approvals, change control, evidence-based enforcement, and learning across projects.

2.2 Lowest-bid procurement and value for money

Lowest-price award is intended to preserve competition and economy after responsiveness and qualification have been established. Its vulnerability is not low price per se, but the possibility that pass/fail technical thresholds and incomplete due diligence permit an unrealistically priced or weakly resourced bid to remain eligible [15], [16]. Under financial pressure, an agent may delay mobilisation, reduce staffing, pursue claims, defer suppliers or substitute lower-cost inputs. These behaviours can increase supervision, transaction and remedial costs.

The policy environment is not structurally immutable. The World Bank's current framework provides for rated criteria and guidance on abnormally low bids, contract management and procurement strategy [17]. The African Development Bank's procurement framework likewise permits fit-for-purpose methods and quality–cost approaches [15]. These mechanisms do not prove that they were available under the historical contracts studied, but they demonstrate institutional levers through which future donors and borrowers can act.

2.3 Principal-Agent Theory and public value

The Principal-Agent Theory explains problems arising when a principal delegates work to an agent whose information and incentives differ from its own [18]. In public infrastructure, the utility and financier seek compliant, durable assets, while a contractor must protect its commercial position. Monitoring, incentives and enforceable information reduce, but do not eliminate agency loss.

The paper refines this application through a competence-conditioned agency proposition: where bid pressure increases the probability of opportunistic or survival-oriented behaviour, the severity of performance loss depends partly on the principal's capacity to conduct due diligence, detect deviations and intervene promptly. This is a bounded refinement, not a new theory and not a statistical mediation claim.

The impact lens is provided by public value. When resources result in dependable services, prompt regional connectivity and institutional capacity, procurement generates public value [10], [4], [3]. If a delay defers power-trade benefits, flaws lower dependability, or re-procurement requires more public and donor resources, a contract that appears to be inexpensive can erode public value.

These projects are selected as case studies for this research because they are nationally strategic, donor-financed, implemented by the same utility, comparable in scope and purpose, and critically procured under the Lowest Bidder Method, but had different outcomes in terms of project success, thereby offering a distinctive opportunity for comparison research.

3 RESEARCH METHODOLOGY

3.1 Research design and case selection

A qualitative multiple-case study was used to investigate procurement–competence interactions in their implementation context [11], [19]. DRIP and BRIP were selected purposively: both were donor-financed, cross-border, high-voltage projects delivered through the same utility and lowest-evaluated-bid arrangements, but they exhibited contrasting failure severity. The unit of comparison was the Rwandan project component and its principal work packages. The overall research process followed three principal phases as shown in Figure 1.

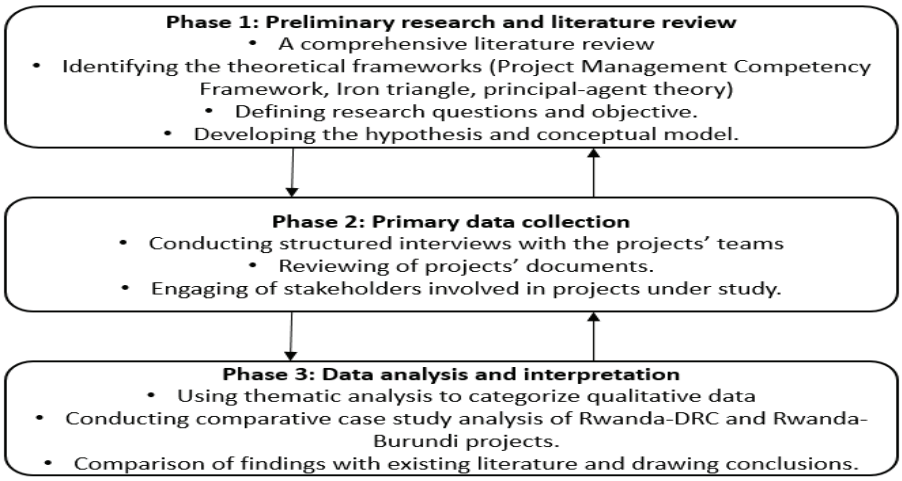


Figure 1: Principal research phases

3.2 Data collection

Primary data were collected through fifteen semi-structured interviews involving key stakeholders from the government utility, supervisory consultants, and contractors. Participants represented various technical and managerial roles, including project managers, project engineers, directors, resident engineers, and contractor representatives.

The interview approach provided sufficient flexibility to explore emerging issues while maintaining consistency across participant responses. The participants possessed considerable expertise, with 13 out of 15 exceeding 10 years in the field, providing informed perspectives regarding project implementation challenges and success factors. Table 2 provides a detailed demographic overview of the participant profile.

Table 2: Interview participants' profile

Interviewee code	Project	Organization type	Role during project implementation	Years of experience
DRIP-RG1	Rwanda-DRC grids interconnection	Government utility	Project engineer & as a coordinator	>10
DRIP-RG2	Rwanda-DRC grids interconnection	Government utility	Project Engineer & as a substation manager	>10
DRIP-RG3	Rwanda-DRC grids interconnection	Government utility	Project engineer - Substations	>10
DRIP-RG4	Rwanda-DRC grids interconnection	Government utility	Project engineer & as a Director	>10

Interviewee code	Project	Organization type	Role during project implementation	Years of experience
DRIP-RG5	Rwanda-DRC grids interconnection	Government utility	Project Engineer - Transmission Line	7-10
DRIP-RG6	Rwanda-DRC grids interconnection	Government utility	Project engineer - Substations	>10
DRIP-CS1	Rwanda-DRC grids interconnection	Consultant	Supervisor - Transmission Line &Substations	>10
DRIP-CS2	Rwanda-DRC grids interconnection	Consultant	Supervisor - Transmission Line &Substations	>10
BRIP-RG1	Rwanda-Burundi grids interconnection	Government utility	Project Manager	>10
BRIP-RG2	Rwanda-Burundi grids interconnection	Government utility	Project Engineer & Project Manager	4-6
BRIP-RG3	Rwanda-Burundi grids interconnection	Government utility	Project Engineer & Project Manager	4-6
BRIP-RG4	Rwanda-Burundi grids interconnection	Government utility	Director Transmission & Generation Development	>10
BRIP-CS1	Rwanda-Burundi grids interconnection	Consultant	Resident Project Manager	>10
BRIP-CS2	Rwanda-Burundi grids interconnection	Consultant	Supervisor - Transmission Line	>10
BRIP-CT1	Rwanda-Burundi grids interconnection	Contractor	Project Manager	>10

Secondary data were obtained through reviews of project reports, contractual documents, procurement records, progress reports, and other relevant project documentation, which enhanced the interviews.

Representatives of financing institutions were invited, but one institution declined on data-protection grounds, and another did not respond. Access to former contractor staff was difficult. BRIP-CT1 was the only contractor representative who agreed to participate; no DRIP contractor representative was interviewed. BRIP-CT1 therefore supplies a valuable but singular counter-perspective. Contractor-side conclusions are based principally on convergent utility/consultant accounts and project records and are labelled as such; the study does not claim saturation of the contractor perspective.

Documentary sources included contract and procurement records, progress reports, appraisal material and project schedules. They were used to confirm scope and planned dates, check recorded delays and contractor events, and distinguish documented facts from participants' causal interpretations. Schedule records support Table 5; attributing the delays to LBM remains a perception-based analytic inference.

3.3 Data analysis

Interview transcripts were analysed using thematic analysis supported by ATLAS.ti software. The analysis combined deductive coding based on the research objectives with inductive coding that emerged from participant narratives. Four principal themes that emerged from the analysis are outlined in Table 3.

Table 3: Themes description and codes

Main theme	Theme Prefix	Sub-theme	Key considerations
Project management competence	PMC	Client/ consultant side competence	Planning, Risk management, Leadership, Supervision, Stakeholder engagement,
		Contractor-side competence	Execution, Quality control, Resource management, Subcontractor management
Procurement approach	PA	Lowest bidder method (LBM)	Selection process, Advantages, Disadvantages, Impact on quality,
		Alternative procurement	Any other procurement approach
Project outcomes & challenges	POC	Project performance	Cost overrun, Schedule delay, Quality issues, Rework
		Challenges encountered	Land acquisition, Payment delays, Client changes, Contractor failure
Lessons & recommendations	LR	Improving PM competence	Skills development, Organisation capacity, Leadership
		Improving procurement	Suitable procurement approaches for developing countries

These themes provided the analytical structure used to examine the relationship between project management competence, procurement practices, and project outcomes.

3.4 Researcher positionality and ethics

The principal researcher was not independent of the cases. In DRIP, the researcher served within the utility as a substation engineer and periodically acted as Projects Coordinator, entering regional transmission work with approximately three years of distribution experience. In BRIP, the researcher later worked for the supervisory consultant on substation construction and commissioning. These roles provided access to context and documents but created risks of confirmation bias, selective recall, social-desirability responses and inhibited criticism by former colleagues.

The researcher's professional identity was not concealed; given prior working relationships, some participants would have known it. The paper records a consistent semi-structured instrument, audio recording and notes, transcript familiarisation, a deductive–inductive coding framework, separation of participant quotations from contextual observation, and

comparison with documentary records and divergent accounts. The analysis also retained a negative case: DRIP-RG1 argued that the method itself was defensible and that deficiencies lay in due diligence. These measures improve traceability but cannot neutralise the conflict of interest. Accordingly, first-person experience is used only as contextual evidence and is not counted as independent corroboration. Otherwise, interview protocols were structured around verifiable project milestones and objective contract management events, whereas ATLAS.ti was utilised to enforce systematic, evidence-based coding, ensuring that findings were grounded strictly in participant narratives rather than personal recollection.

Participants gave informed consent; participation was voluntary; organisational roles were coded; and data were handled under professional ethics requirements. Retrospective recall, role-based identifiability and unequal power relations remain relevant ethical and interpretive constraints.

4 FINDINGS AND DISCUSSION

Table 4 presents the comparison that structures the findings. It separates shared patterns from differences and identifies the evidentiary basis for each inference.

Table 4: Cross-case comparison of mechanisms, outcomes and evidence

Dimension	DRIP	BRIP	Cross-case inference	Evidence
Procurement pressure	Low award price was associated in interviews with thin resources, delayed supply and intensive oversight. One senior utility participant defended LBM but criticised due diligence.	BRIP-CT1 described material-price pressure and protracted negotiations; other participants associated low price with weak staffing and slow design.	Common risk mechanism; the counter-case indicates that implementation of qualification and due diligence matters, not price alone.	Interviews; procurement/contract records.
Contractor capability	Substation package: reported mobilisation, supply-chain and management failures culminated in contractor collapse and re-procurement.	Contractor completed works but reported engineering/procurement gaps; utility/consultant accounts reported schedule and contract-management weaknesses.	DRIP shows organisational failure; BRIP shows delayed delivery with continuing quality/oversight concerns.	Multi-party interviews; progress and schedule records.

Dimension	DRIP	BRIP	Cross-case inference	Evidence
Client/consultant competence	Supervision described as under-resourced and reactive; delayed enforcement and crisis-management limits were reported	Client leadership and supervision were generally rated more positively, though approvals, land matters and contractor follow-through caused delays	Competent oversight mitigated some defects in BRIP but did not restore schedule; limited capacity magnified DRIP's collapse	Utility and consultant interviews; project records
External/contextual factors	Land acquisition, weather, cross-border coordination and delayed decisions contributed	Compensation/land access, design changes and material-price changes contributed	Outcomes were multi-causal; LBM should not be presented as a sole cause	Interviews; project records
Outcome pattern	Transmission line completed 21 months late; substation package entered prolonged recovery after original-contractor failure	Transmission line completed 23 months late; substations completed 22 months late; defects were reported after completion	Both missed schedule; severity and form of failure differed.	Schedule/contract records; interviews
Public-value consequence	Deferred interconnection benefits, re-procurement and prolonged institutional attention	Deferred benefits, intensive supervision and reliability/defect-management burden	Initial price economy did not guarantee timely or whole-life public value	Documented timing plus analytic inference

4.1 Competence as monitoring and recovery capacity

Across both cases, participants distinguished commitment from capacity. Utility and consultant teams were often described as knowledgeable and committed, yet supervision resources were insufficient for the intensity of underperforming contracts. DRIP-CS1 explained that multiple work fronts were sometimes covered by only one supervision engineer. DRIP-RG2 characterised the resulting practice as documenting problems rather than preventing them.

This is evidence of an organisational-capacity deficit, not simply an individual competency deficit.

Reported contractor weaknesses were also managerial rather than uniformly technical. DRIP-CS1 questioned the substation project manager's suitability and linked repeated errors to cost and rework. In BRIP-CT1, acknowledged gaps in engineering and procurement that delayed design review, manufacture and delivery. Site engineer DRIP-RG2 noted, *"Supervision was so demanding since we were understaffed. We were documenting problems rather than preventing them"*. BRIP-RG3 offered an important qualification: materials could be acceptable while contract management remained weak. The evidence therefore supports claims about planning, resource and contract-management deficiencies more strongly than a blanket claim of technical incompetence.

The cases diverged in recovery. BRIP's client and consultant oversight identified defects and maintained contractual pressure until completion, although it did not prevent a roughly two-year delay. In DRIP, limited monitoring resources combined with the original contractor's failure created a problem beyond routine supervision and required lengthy recovery. Competence mitigated risk, but could not fully compensate for a financially or organisationally failing agent.

4.2 Procurement pressure and due diligence

Most participants perceived lowest-price pressure as an important upstream risk. BRIP-CT1 stated that the contractor had entered low prices and later faced increased material prices, leading to prolonged supplier negotiations. This account provides direct but single-source contractor evidence of bid-induced pressure. Utility and consultant participants connected similar pressure to delayed mobilisation, inadequate staffing, claims and quality-control burdens. Consultant DRIP-CS2 noted that the method "*selects for the best bid writer and the most optimistic (or reckless) pricing, not necessarily the best builder*". This structural approach bred adversarial dynamics where the client's energy was spent policing thin-margin operations rather than collaborating.

A deterministic claim that LBM always fails is not supported by the data. DRIP-RG1 stated that the strategy was defensible and contended that technical compliance is evaluated prior to price; in that participant's opinion, due diligence was the bigger failing. This negative example sharpens the interpretation: when qualification is taken as a minimal threshold, financial resilience or prior performance is not thoroughly verified, and the owner lacks the capacity for intensive monitoring, the lowest evaluated price becomes risky. Incentive divergence may be amplified by bid pressure, and monitoring capacity influences the detection and correction of deviations.

4.3 Projects outcomes

Project outcomes were marred with delays of several months and are illustrated in Table 5.

Table 5: Recorded schedule performance of the principal DRIP and BRIP work packages

Case	component	Start	Contract end	Recorded status/date	Delay
DRIP	Kibuye–Rubavu-Shango 220 kV line	13 Jan 2014	13 Nov 2015	20 Sep 2017	21 months

Case	component	Start	Contract end	Recorded status/date	Delay
DRIP	Substations/extensions package	14 Feb 2014	May/Dec 2015	Original package not completed within study period	Over 10 years
BRIP	Kigoma-Gisagara-Gitega 220 kV line	5 May 2018	5 May 2020	16 Jun 2022	23 months
BRIP	Kigoma and Gisagara substations	5 May 2018	5 May 2020	8 Aug 2022	22 months

As shown in Table 5, both cases missed their contractual schedules, but the outcome profiles were not equivalent. BRIP delivered completed assets after delays, whereas DRIP's original substation contract failed and required an extended recovery process. Documentary evidence is strongest for dates and contract events; reported quality effects and causal attributions are interpreted more cautiously.

Participants also identified land acquisition, compensation, weather, scope/design changes, delayed approvals and cross-border coordination. The reasonable conclusion is configurational: negative consequences resulted from the interplay of contractor capability, monitoring resources, contextual disturbance, and procurement pressure.

4.4 Public value and institutional measures

The DRIP and BRIP findings show that procurement and project-management weaknesses reduced public value by delaying electricity exchange, system-reliability and regional-integration benefits. BRIP's components were completed approximately two years late and subsequently required corrective interventions for reported equipment defects. In contrast, the failure and abandonment of DRIP's original substation contract led to re-procurement, additional financing and prolonged recovery. Thus, a low initial contract price did not necessarily produce timely, reliable or lower-cost infrastructure.

Procurement transparency alone was insufficient to prevent these outcomes. DRIP-RG1 maintained that the Lowest Bidder Method was not inherently inappropriate because technical compliance preceded price evaluation, but identified weaknesses in bidder due diligence. BRIP-CS2 recommended stronger verification of bidders' financial and technical capacity and greater weighting of past performance, while BRIP-CT1 explained that rising material prices after bidding caused prolonged supplier negotiations and procurement delays. Together with reactive, understaffed supervision in DRIP, these findings indicate that protecting public value requires rigorous contractor evaluation and permanent, adequately resourced project-management and supervision capacity.

Table 6 synthesises the evidence-to-implication chain: it distinguishes what participants and records showed from the institutional measures inferred from those findings.

Table 6: Case-derived public-value findings and proposed institutional measures.

Empirical finding	Evidence from DRIP and BRIP	Public-value implication	Institutional measure proposed by participants
Bid evaluation did not sufficiently test actual delivery capacity or pricing realism.	DRIP-RG1 identified due-diligence gaps; BRIP-CS2 recommended stronger capacity and past-performance verification; BRIP-CT1 described material-price and supplier-negotiation pressure.	A compliant low bid can still generate delay, contract failure and recovery costs.	Test financial resilience, comparable performance, proposed personnel, supplier plans and price realism before award.
Contractor capability affected the form and severity of project failure	DRIP's original substation contractor failed and abandoned the works, necessitating re-procurement and prolonged recovery. BRIP's contractor completed the works but experienced engineering, procurement and contract-management difficulties, followed by reported defects	Weak contractor capability can produce either project abandonment or delayed completion accompanied by continuing quality and reliability burdens	Evaluate contractor management systems, proposed personnel, supply-chain arrangements and comparable-project experience, rather than relying primarily on minimum technical compliance
Supervision capacity conditioned detection and correction but could not fully offset weak contractor capacity.	DRIP-CS1 and DRIP-RG2 described reactive, understaffed supervision; BRIP oversight identified defects and maintained corrective pressure but did not restore the schedule.	Under-resourced monitoring allows problems to escalate; stronger monitoring protects quality but cannot recover all lost time or value.	Resource supervision in proportion to package complexity and contractor risk, with timely enforcement and escalation.
Temporary and insufficiently resourced project teams constrained institutional learning and continuity	Participants recommended establishing a permanent, highly skilled Project Implementation Unit and strengthening training in procurement, contract management and project-management competencies	Reliance on temporary arrangements weakens knowledge retention and the utility's capacity to apply lessons from one project to subsequent projects	Establish a permanent Project Implementation Unit staffed with experienced project managers, engineers and contract-management specialists
Project delays and defects affected	Both projects missed contractual completion dates; DRIP required	Delays postponed regional electricity exchange and	Include schedule recovery, defect resolution, asset

Empirical finding	Evidence from DRIP and BRIP	Public-value implication	Institutional measure proposed by participants
benefits beyond the individual contracts	prolonged recovery, while BRIP experienced reported post-completion defects and continuing corrective oversight	reliability benefits, while defects and recovery activities absorbed scarce financial and managerial resources	reliability and benefit realisation in assessments of project success and value for money

The findings consequently define public value more broadly than obtaining the lowest contract award price. In these cases, public value depended on whether procurement and project-management arrangements produced timely, reliable and sustainable electricity infrastructure while preserving scarce financial resources and institutional capacity.

5 DISCUSSION

The cross-case comparison adds knowledge by identifying a competence-conditioned agency mechanism rather than merely reconfirming that low bids and weak contractors are associated with poor performance. Across DRIP and BRIP, bid-induced financial pressure increased delivery risk, but the form and severity of loss depended on two capabilities: the contractor's capacity to mobilise and manage the work, and the principal's capacity to screen, monitor, enforce and recover. This mechanism explains why broadly similar procurement arrangements produced completion-with-defects in BRIP but original-contract collapse and prolonged recovery in DRIP.

The findings confirm studies linking project-management competence with project success [1], [12], [16], but refine the unit of analysis. Competence was not only an attribute of an individual project manager; it was an organisational governance capacity expressed through staffing, timely decisions, due diligence, supervision and escalation. DRIP's reactive supervision demonstrates that knowledgeable individuals cannot compensate indefinitely for an under-resourced implementation system. BRIP, conversely, shows that stronger oversight can contain some quality and contractual risks without restoring the original schedule. The study therefore extends competence literature from "who is competent" to "whether the principal can deploy competence at the intensity required by the contract risk."

The results also qualify the lowest-bid literature [20], [19], [21], [22]. Most participants associated low prices with thin resources, delayed supply and claims, yet DRIP-RG1's view located the problem in due diligence rather than least-cost bidding itself. The comparison therefore rejects a deterministic proposition that the lowest evaluated bid necessarily causes failure. A more defensible proposition is that LBM becomes particularly hazardous when pass/fail qualification fails to reveal financial or managerial fragility and when the owner lacks monitoring capacity. This refinement matters for donor-funded projects because it directs reform toward both ex ante selection and ex post governance, rather than treating procurement method and project management as competing explanations.

For Principal–Agent Theory [18], the evidence distinguishes deliberate opportunism from survival-oriented responses to an unsustainably priced contract. Claims, delayed mobilisation, supplier renegotiation or resource reductions may protect the agent's commercial survival whether or not they were intended at bidding. Agency loss is consequently shaped by bid pressure, information quality at selection and the principal's monitoring capacity.

Finally, the public-value analysis connects contract performance to delayed electricity exchange, reliability, additional recovery expenditure and institutional attention. The

practical implication is not simply to "avoid LBM," but to use transparent mechanisms that test price realism, financial resilience, key personnel and past performance, while funding supervision according to package risk and retaining permanent Project Implementation Unit capability. These conclusions are analytically transferable to donor-financed, technically complex public works with thin contractor markets and constrained implementation capacity; they are not statistically generalisable to all African infrastructure.

6 LIMITATIONS

The participant pool is organisationally imbalanced: ten utility representatives, four consultants and one contractor. No financier or DRIP contractor was interviewed. BRIP-CT1 was the only contractor representative who agreed to participate, so the study cannot claim a saturated contractor perspective. While contractor access was constrained by post-project availability, BRIP-CT1's contribution offers direct first-hand evidence on low-bid pricing dynamics. The contractor perspective is further supplemented with data from supervisory consultants.

The principal researcher's employment in both projects creates a material conflict of interest and may have shaped recruitment, answers, coding and interpretation. Structured interviewing, recordings, documentary comparison and negative-case retention improve transparency but do not remove this risk. The lack of member-checking, external coding audit and inter-coder assessment limits confirmability.

Interviews were retrospective and vulnerable to recall bias. Document access was incomplete, and precise cost and whole-life quality impacts could not be independently quantified. Two cases in one utility and one country support contextual explanation, not statistical generalisation.

7 CONCLUSION

This study asked whether the difficulties of lowest-bid electricity interconnections arose primarily from procurement or from the capacity to manage procured contracts. The DRIP–BRIP comparison shows that the explanations are interdependent. Bid-induced financial pressure created an adverse risk environment, while contractor capability, due diligence, supervision resources and contextual disruptions determined how that risk developed. BRIP reached completion after a substantial delay and reported quality-related burdens; DRIP's original substation contract failed and required a prolonged recovery.

The study's principal contribution is to clarify how project-management competence influences the outcomes of lowest-bid infrastructure projects. From a Principal–Agent perspective, competence represents the client's organisational capacity to evaluate contractors effectively, monitor implementation, enforce contractual obligations and respond to emerging failures. This capacity can reduce the risks created by low-bid procurement, but it cannot entirely eliminate them. The DRIP and BRIP cases demonstrate that effective supervision can identify defects, require corrective action and protect contractual rights; however, supervision alone cannot overcome an unrealistically priced contract or a contractor lacking the financial, technical or managerial capacity to deliver. Successful project outcomes therefore depend on the combined strength of contractor selection and implementation management: sound procurement identifies a capable contractor, while competent project management ensures that the awarded contract is effectively executed.

For policy and practice, donor institutions and borrowers should combine transparent competition with verified comparable performance, financial resilience and price realism checks, enforceable key-personnel commitments, risk-proportionate supervision, and permanent utility implementation capacity. These measures protect public value by shifting attention from the initial award price to timely service availability, reliability, whole-life cost and institutional learning. Because the evidence comes from two projects in one Rwandan

utility and an organisationally imbalanced interview sample, the conclusions support analytical transfer to comparable donor-financed infrastructure, not statistical generalisation. Future multi-country and longitudinal studies should test the proposed competence-conditioned agency mechanism against independently verified cost, schedule and quality data.

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Project Management of Academic Research Collaborations: A mixed methods study in the Biological Sciences

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PROJECT MANAGEMENT OF ACADEMIC RESEARCH COLLABORATIONS: A MIXED METHODS STUDY IN THE BIOLOGICAL SCIENCES

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ABSTRACT

Academic research projects have evolved into international, multidisciplinary projects. However, within academia, formal project management appears to be lacking, with most principal investigators having no formal project management training. This study reviews the literature on project management in academic collaborations, focusing on the biological sciences, and how these project management strategies contribute to successful project outcomes. Moreover, the study explores current project management practices through interviews with academic principal investigators involved in collaborative research projects in the biological sciences. Results from this study show that the application of project management practices is sparse and highlights the need for formal project management training of principal investigators within academia. The study continues to showcase, as shown in the literature, the benefits that could come from empowering researchers with this skill set.

Keywords: Academic, Biological science, Collaboration, Project management, Research, University-industry.

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1 INTRODUCTION

In the rapidly evolving landscape of the biological sciences, collaborative academic research projects have become a cornerstone of innovation and breakthrough discovery. These projects, whether between academic institutions or involving industry partnerships, are driven by significant financial, technological, and human resource demands. As a result, such collaborations are inherently complex and require systematic, well-coordinated management to achieve the research objectives of all involved parties.

The increasing trend toward academic–industry collaboration is driven by several factors: rapid technological advancement, heightened global competition, shorter product life cycles, rising research costs, and reduced funding [1]–[3]. While the potential benefits of successful collaboration include access to advanced technology at lower cost, reduced risk, a broader knowledge base, additional funding, and opportunities for licensing or patent income [4], these benefits are often not fully realised in practice.

A key contributor to this shortfall is the limited and fragmented application of project management (PM) in academic research contexts. The existing literature on project management (PM) in academic research, particularly within scientific research environments, remains relatively limited and fragmented, with studies calling for greater integration of project management principles and more holistic frameworks for managing research projects [5], [6]. Where PM practices are applied, they vary widely both across and within research groups. Notably, Ankrah and Al-Tabbaa [7] identify project management as a critical factor influencing the success or failure of university–industry collaborations.

Barnes [4] offers early guidance for managing such collaborations, highlighting elements such as partner commitment, clearly defined objectives, realistic aims, effective planning and monitoring, strong leadership, and communication. Expanding on this, Barnes [8] categorises success factors into six themes: selecting appropriate collaborators; appointing a skilled project manager; applying effective PM practices; ensuring partner equality; monitoring environmental influences; and fostering universal factors such as trust, commitment, and positive relationships.

Despite these insights, collaborative research projects remain difficult to manage. They require integrating diverse perspectives, which is essential for comprehensive problem-solving but introduces challenges related to interdisciplinary coordination, organisational differences, and communication. These complexities are compounded by the limited authority of project managers in academic settings. Recognising these challenges underscores the need for more context-specific PM approaches for collaborative research in the biological sciences.

This need is further emphasised by Chin et al. [9], who critique existing PM approaches in academic–industry collaborations as poorly adapted to their inherent uncertainty and complexity. Fernandes et al. [10] build on this by proposing a stakeholder-centred value framework to better capture the role of PM in such environments.

Collaborative biological science projects are typically long-term, resource-intensive, and highly complex. Yet, there remains a limited understanding and application of project

management practices that could improve their outcomes. This reflects a broader knowledge gap: the lack of comprehensive literature on PM within this specific research context.

Building on the identified inadequacies of current PM approaches in academic–industry collaborations and aligned with the aim of developing a stakeholder-centred value framework, this study addresses this critical gap. Specifically, it examines project management practices in academic research partnerships to identify the factors that enable success and the challenges that hinder progress. The objectives are as follows:

1 To identify and analyse key project management (PM) practices in collaborative academic research in the biological sciences and examine factors associated with successful collaborative research outcomes in South Africa.
2 To provide practical recommendations to improve PM practices in academia and enhance the success of collaborative research projects in the biological sciences.

By identifying key PM practices that contribute to successful academic collaborations, this research aims to support project managers and academic stakeholders in improving project planning, execution, and completion. In doing so, it contributes to enhanced research outcomes and innovation in the biological sciences.

The study further contributes to the literature by providing empirical insights into PM practices within a niche and under-researched context. It advances understanding of how project management can be applied to academic research collaboration and may inform the development of context-specific PM frameworks. More broadly, it highlights how effective management can accelerate scientific discovery, optimise resource use, and strengthen collaborative environments, laying a foundation for future research.

Against this backdrop, the study addresses the following research questions, informed by a systematic literature review and expert interviews:

RQ1: What, if any, project management practices are reported in the literature on collaborative academic research projects in the biological sciences?

RQ2: What project management and relational factors are associated with successful collaborative academic research projects?

RQ3: Which project management practices are lacking and could improve outcomes in collaborative academic research projects

In order to address the identified knowledge gap and answer the research questions, this study adopts a mixed-methods approach. A systematic literature review (SLR) is used to establish a comprehensive understanding of project management practices as reported in literature, followed by interviews where practitioners provide empirical insights into their application and effectiveness in real-world academic–industry collaborations. The data-collection procedures are detailed below.

1.1 Data-collection procedure

The Systematic Literature Review (SLR) follows the PICOC format [11] of specifying population, intervention, comparison, outcomes and context. A breakdown of PICOC-associated keywords

can be found in Table A1. Briefly, the process for conducting the SLR constituted a web-based search using PICOC-derived keywords and filtering of all identified papers through selected inclusion or exclusion criteria based on the research questions to obtain the final selection of papers most relevant to this study (for a full list of all parameters employed, see Table A2).

1.1.1 Interviews

To complement the SLR with empirical insights, seven semi-structured interviews were conducted with individuals from the author's academic research network. Participants were purposively selected to represent a range of project management roles in academic–industry collaborations, from senior oversight to specialised technical management. To mitigate potential sampling bias, the study:

- defined clear selection criteria focused on project management involvement;
- ensured diversity across disciplines, institutions, industry and academia;
- included participants with varied backgrounds (e.g., gender, ethnicity, and experience levels).

Table 1 presents the demographic characteristics of the interviewees.

Table 1: Interviewee demographic information

Interviewee	Years in PM role	Current PM role	Field
Interviewee 1	20 years	International project lead, local project lead, collaborator	Human and Biological Sciences
Interviewee 2	5 to 8 years	Principal Investigator or co-investigator	Human and Biological Sciences
Interviewee 3	30 years	Project leader, collaborator.	Animal Sciences
Interviewee 4	30 years	Principal Investigator	AgriScience
Interviewee 5	15 years	Liaison between international funding agency and research teams	Biological Sciences
Interviewee 6	20 years	Liaison between international funding agency and research teams	Biological Sciences
Interviewee 7	25 years	Program lead for R&D	Sciences

1.1.2 SLR quality assessment and data extraction

To address RQ1 and provide literature-based foundational knowledge as to project management (PM) practices in academic collaborations, the systematic literature review (SLR) dataset was analysed and quality-assessed. Descriptive statistics were generated using the R package *bibliometrix* [12] in R (v4.4.0). Studies were assessed for methodological relevance based on the inclusion criteria as outlined in Table A2.

Literature identified using the PICOC-guided keywords (Table A1) underwent a two-stage screening process. First, non-relevant material (e.g. conference proceedings, bibliometric studies, opinion pieces, reviews, and duplicates) was removed. Second, studies not related to academia or the biological sciences were excluded (see exclusion criteria, Table A2).

The final set of articles was analysed to extract information relevant to the research questions, including:

- PM processes, knowledge areas, and principles applied
- Practices contributing to project success or failure
- Definitions of project success
- Study sample sizes

Extracted data were coded into keywords or concepts, then aggregated and tabulated to identify recurring patterns and themes.

1.1.3 Data extraction from interviews

To complement the SLR and address RQ2 and RQ3 through empirical insights, semi-structured interviews were conducted. The research instrument (Appendix: Research Instrument) included seven questions on PM success and failure factors, and two on participant background.

Responses were recorded in writing and analysed by extracting keywords and PM-related concepts. These were then coded, aggregated, and tabulated across interviews to identify common themes and practitioner perspectives. These findings are contextualised in the literature reviewed below.

2 LITERATURE REVIEW

Academic research typically emphasises theoretical exploration and long-term knowledge development, whereas industry focuses on tangible outcomes, deadlines, and practical application. This misalignment can result in poorly managed projects, mismatched expectations, and suboptimal outcomes.

Existing literature proposes various approaches to address this divide, often incorporating project management (PM) practices tailored to the unique demands of academic–industry collaborations. However, these approaches remain fragmented, reinforcing the need for a more coherent understanding of PM practices in this context.

2.1 Integration of academic research into industry outcomes

The literature highlights the importance of effective knowledge transfer between academia and industry. Arnold et al. [13] propose structured approaches that emphasise clearly defined goals, planned outcomes, and early agreement on research roadmaps and responsibilities. These elements align closely with established PM principles [14].

Universities act as catalysts for innovation by bridging academic knowledge and industry needs [15]. Initiatives such as those described by Goldsby and Zinn [16] promote dialogue between

academia and industry to enhance research relevance. Similarly, human resource development can support the translation of research into practice [17], while programmes like Stanford SPARK demonstrate how mentorship and funding enable successful application of research outputs [18].

Together, these studies highlight the role of structured coordination and management—core aspects of PM—in translating research into practical outcomes.

2.2 Research collaborations: interdisciplinary approaches

As research becomes increasingly interdisciplinary, collaboration requires integrating diverse perspectives to address complex problems. While such approaches have driven advancements (e.g. in oncology [19]), they also introduce challenges related to communication and methodological differences.

Frameworks aimed at improving collaboration include fostering cross-disciplinary dialogue [20] and emphasising key principles such as communication, coordination, and cooperation [21]. These approaches implicitly reflect PM practices, although they are not always explicitly framed as such.

2.3 Project management in research collaborations

Effective PM is central to managing the complexity of academic–industry research collaborations. Literature distinguishes between “soft” and “hard” systems. Soft systems focus on human factors such as leadership, motivation, and team dynamics [22]–[24]. Organisational support and motivation are critical to project success [25], as are executive backing and learning from past projects [26], [27].

Hard systems involve structured PM methods, though their universal application is often questioned. Besner and Hobbs [28], [29] highlight both commonalities and variations across projects, suggesting the need for context-specific approaches. Similarly, Lotz et al. [30] advocate tailoring PM strategies, for example through stage-gate models adapted to specific project environments.

Time management, often challenging in biological research due to uncertainty, illustrates this need for adaptation. While traditional methods such as the Critical Path Method are widely used, more flexible approaches like Critical Chain Scheduling may better accommodate uncertainty and resource constraints [31], [32].

Overall, the literature underscores the importance of adapting PM practices to the specific context of collaborative research—yet provides no unified framework for doing so.

2.4 Evaluating research collaboration success

Understanding the factors that drive successful collaboration is critical for improving outcomes. Key success factors include effective leadership, trust, and mutual respect [33], as well as strategic alignment and shared goals [34]. The role of principal investigators is also significant in guiding and integrating research efforts.

Institutional support further influences success, with policies, infrastructure, and human resource practices shaping research productivity [35]. These findings align with PM principles but are rarely synthesised within a PM framework specific to academic research.

2.5 Project management challenges in research collaborations

PM in research collaborations is characterised by tension between flexibility and control. Morris [23] argues against universal PM approaches and advocates context-specific adaptation. Similarly, Odusanya et al. [36] emphasise adaptability in addressing uncertainty and evolving project goals.

Academic–industry collaborations also face inherent paradoxes, such as balancing innovation with risk management [37]. Addressing these requires flexible planning and skilled project leadership.

Traditional PM approaches are often insufficient in dynamic research environments. Scholars advocate for more adaptive and agile methods that accommodate uncertainty and evolving requirements [38], [39].

3 CONCEPTUAL FRAMEWORK

In the fast-evolving landscape of the biological sciences, the pressure to innovate and produce impactful research is high. This competitive environment necessitates a shift toward more collaborative approaches. However, collaboration is inherently complex and requires structured project management (PM) to realise its full potential. This section therefore introduces a theoretical framework, drawing on Pelaez et al. and vom Brocke and Lippe [21], [37], to guide the current study.

The U.S. National Science Foundation's Directorate for Biological Sciences promotes collaboration to enhance biology education through improved participation, learning, and assessment. Pelaez et al. [21] propose the "Five C's" of collaboration—Commitment, Collegiality, Communication, Consensus, and Continuity—as a framework for strengthening interdisciplinary collaboration. Grounded in empirical evidence from the ACE-Bio Network, this framework highlights participation and communication as critical to successful collaboration, aligning with the project management focus of this study.

Collaborative research projects present unique challenges, requiring adaptation of traditional PM approaches. vom Brocke and Lippe [37] identify four key strategies that inform this study's framework: emphasising a clear project vision; ensuring partner compatibility; enabling flexible planning and monitoring; and appointing a skilled project manager.

Figure 1 presents the integrated conceptual framework combining the "Five C's" with these collaborative management strategies. The framework links relational practices (e.g., communication and trust) with process-oriented practices (e.g., planning, monitoring, and project vision), reflecting the PM's dual role in enabling both collaboration and project success.

Guided by this framework, the research instrument was designed to assess the extent to which these practices are applied in academic research collaborations, while also allowing

participants to identify additional PM practices. This supports the study's aim of systematically identifying existing practices, success factors, and gaps in the current literature and practice.

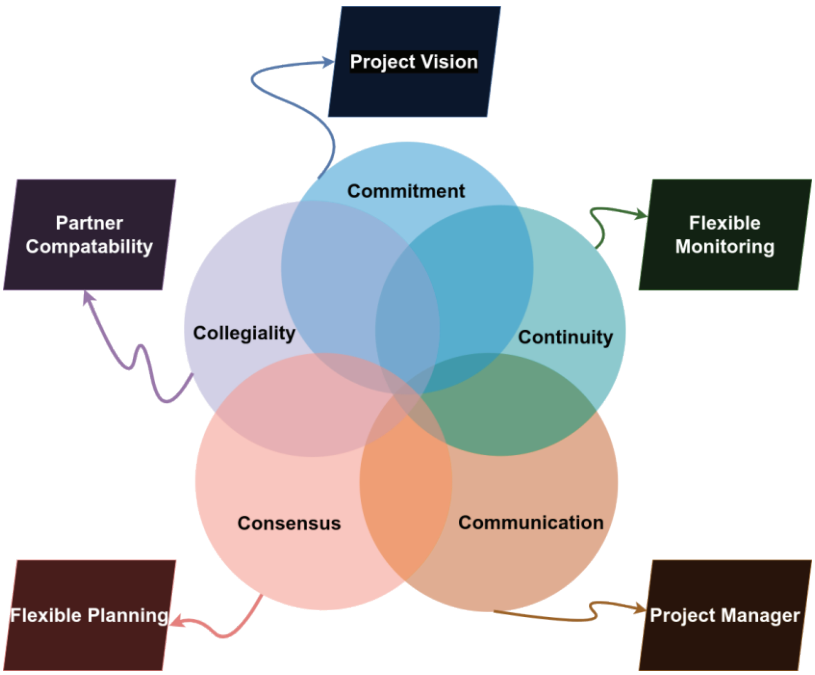


Figure 1: Conceptual framework combining the "Five C's" of collaboration [21] with the general project management strategies [37].

Framed by this integrated conceptual framework, the study examines both relational principles (e.g., Pelaez's Five C's) [21] and process-oriented strategies (e.g., stage-gate approaches and the integration of hard and soft systems) to understand project management in collaborative research. Consistent with the study's aim, this perspective emphasises a holistic and adaptive approach to PM that addresses both technical and human dimensions of collaboration. By aligning these dimensions with the goal of identifying effective practices, success factors, and gaps, the study seeks to generate insights that support more effective and impactful academic research collaborations.

4 RESULTS

4.1 Quality assessment of the SLR: bibliometric analysis

The Web of Science search for the SLR yielded 532 records across all PICOC components. After removing 20 review papers, 8 conference proceedings, 4 bibliometric studies, 9 duplicates, and 425 papers that did not meet PICOC criteria (Table A1), 66 papers remained.

A further relevance screening excluded studies not related to the biological sciences or academic collaborations, resulting in a final dataset of 33 research papers. The combined sample included 1852 R&D projects, 1643 interviews, 716 case-study papers, and 18 case-study interviews.

Descriptive statistics were generated using the R package bibliometrix v4.2.3 [12] in R v4.4.0. Citation peaks occurred in 2009, 2013–2014, and 2016, indicating periods of increased interest

in project management and academic collaboration. These peaks coincide with post-2009 funding pressures, where industry collaboration may have become more prominent [40].

Core journal sources included Research Policy (9%), International Journal of Project Management (6%), and Project Management Journal (6%). Notably, most studies were published outside core PM journals, highlighting the fragmented nature of PM literature in this context.

Keyword co-occurrence analysis (Figure 2) shows "innovation" as the most connected term, reflecting a strong industry and technology focus. Three clusters emerge: (1) innovation–technology–industry; (2) academic research–knowledge–challenges; and (3) performance–strategies–firms. While interconnected, these clusters are relatively distinct, reinforcing the lack of an integrated PM perspective across the literature.

Keywords such as "science", "scientific collaboration", and "impact" cluster around innovation, while "knowledge" and "challenges" reflect academic concerns, and "conflict" and "strategy" reflect managerial dimensions. This fragmentation aligns with the study's identified gap in integrated PM understanding.

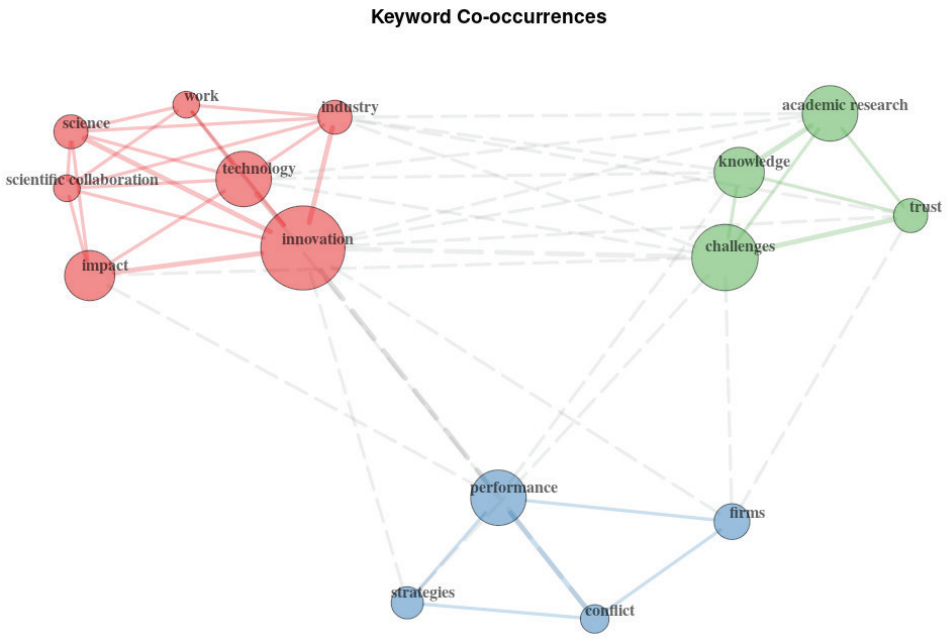


Figure 2: Keyword co-occurrence network of keywords from the final list of 33 research papers obtained from the SLR.

4.2 Literature-prescribed project management practices

To address RQ1, the 33 studies were analysed by extracting keywords across PM processes, knowledge areas, principles, and success/failure factors (Tables 2 and 3).

All six PM processes are represented, with initiating and planning most prominent (Table 2), aligning with planning as a key success factor (Table 3). Risk and time management are the most frequently cited knowledge areas, reflecting their importance in addressing uncertainty and timelines.

Communication and planning emerge as the strongest contributors to project success (Table 3), supporting the central role of relational and process-oriented practices [41]. Resource constraints are the main contributors to failure. Project success is most commonly defined by cost, objectives, and financial outcomes.

Overall, while key PM practices are evident, they are applied unevenly and lack integration—supporting the identified gap and motivating further empirical investigation.

Table 2: PM processes, knowledge areas, and principles from the 33 SLR studies.

PM process	Percent	PM knowledge area	Percent	PM principle	Percent
Initiating	12.1%	Risk Management	12.1%	Team	6.1%
Planning	9.1%	Time Management	9.1%	Systems Thinking	6.1%
Executing	3%	Scope Management	6.1%	Change	3%
Monitoring	3%	Cost Management	6.1%	Stewardship	0%
Controlling	3%	Quality Management	6.1%	Stakeholders	0%
Closing	3%	Human Resource Management	6.1%	Value	0%
		Stakeholder Management	6.1%	Leadership	0%
		Communication Management	3%	Tailoring	0%
		Integration Management	0%	Quality	0%
		Procurement Management	0%	Complexity	0%
				Risk	0%
				Adaptability	0%

Table 3: Success factors, failure factors, and success measures identified from the 33 SLR studies. Percentages represent the share of papers reporting each theme.

Contributes to success	Percent	Contributes to failure	Percent	What is success?	Percent
Communication	15.2%	Resources	12.1%	Completing within cost	6.1%
Planning	15.2%	Change	9.1%	Meeting project objectives	6.1%
Knowledge management	12.1%	Communication	6.1%	Financial success	6.1%
Leadership	9.1%	Competition	6.1%	Project continuation	3%

HOPE Summit

https://www.hopesummit.co.za/

Contributes to success	Percent	Contributes to failure	Percent	What is success?	Percent
Trust	9.1%	Conflict	6.1%	Customer satisfaction	3%
Collaboration	6.1%	Discipline	6.1%	Completing within time	3%
Commitment	6.1%	Management and control issues	6.1%	Meeting project scope	3%
Flexibility	6.1%	Tools and technology	6.1%	Meeting quality expectations	3%
Go/no-go decisions	6.1%	Activity bottlenecks	3%	Senior management expectations	3%
Open Innovation	6.1%	Activity neglect	3%	Commercial success	3%
Partnership	6.1%	Autonomy	3%	Programmatic success	3%
Activity duration estimation methods	3%	Bureaucracy	3%	Relational success	3%
Agreement	3%	Commitment	3%	Knowledge co-production	3%
Alternate controls	3%	Goal orientation asymmetry	3%	Stimulating innovation	3%
Canvas	3%	Inadequate policies	3%	Scientific publication	3%
Capacity building	3%	Knowledge management	3%		
Clear goal	3%	Legal issues	3%		
Clear stakeholder requirements	3%	Non-quantitative view of project success	3%		
Clear statement of work	3%	Planning	3%		
Competence	3%	Quality issues	3%		
Competing experiments	3%	Skills and experience	3%		

Contributes to success	Percent	Contributes to failure	Percent	What is success?	Percent
Contingency theory	3%	Socio-cultural issues	3%		
Embed PM practice	3%	Structural differences between partners	3%		
Emergent planning	3%	The market	3%		
Flexible budget	3%	Timescales	3%		
Flowcharts	3%	Trust	3%		
Hybrid project management	3%	Unknown end-products	3%		
Implementing project management	3%	Volatility	3%		
Lasting partnerships	3%	Weak industry link	3%		
Make-static	3%				
Manuals	3%				
Opportunity	3%				
Organizational learning	3%				
Process	3%				
Product	3%				
Project portfolio management	3%				
Project priority assignment	3%				
Research coordination	3%				
Resources	3%				
Roles based coordination	3%				
Routines for milestone declaration	3%				
Scheduling methods	3%				
Scope reduction	3%				

Contributes to success	Percent	Contributes to failure	Percent	What is success?	Percent
Staged releases	3%				
Teamwork	3%				
Technical expertise	3%				
Termination decision	3%				
Timelines	3%				
Top management support	3%				

4.3 Real-world project management practices

To address RQ2 and RQ3, seven interviews were conducted with individuals involved in academic collaboration projects (Table 1). Participants varied in experience, roles, and duration of involvement.

Consistent with the SLR, communication was the most frequently cited success factor (71%) (Table 4). Interviewees also emphasised interpersonal relationships, inclusivity, and clearly defined roles. For example, Interviewee 2 highlighted “open and honest communication” as key to success.

Key contributors to failure included differences between partners (57%), followed by shortcomings in planning, leadership, management, and integration (29%). Notably, lack of integration—particularly exclusion from planning—reinforces the importance of relational PM principles and aligns with the prominence of teamwork identified in the SLR (Table 2).

As in the SLR, project success was primarily defined as meeting objectives (Table 4). However, interviewees placed equal or greater emphasis on relational success, such as sustained partnerships, highlighting the importance of the relational dimension reflected in the conceptual framework.

A key finding is the limited use of formal PM tools. None of the interviewees referred to established methodologies such as PMBOK [14]. Instead, gaps were identified in practices such as risk management, teamwork, leadership, and the presence of trained project managers. One interviewee (Interviewee 1) noted that international collaborations with dedicated project managers were more effective.

Table 4: Summarised results of the success factors and factors associated with failure from the interviewees' responses.

Contributes to success	Percent	Contributes to failure	Percent	What is success?	Percent	What is failure?	Percent
Communication	71%	Differences Between Partners	57%	Meeting Project Objectives	71%	Not Achieving Research Objectives	57%
Interpersonal Relationships	43%	Planning	29%	Relational Success	57%	When Results Carry No Contribution	29%
Inclusivity	43%	Leadership	29%	Knowledge Co-Production	29%	Underutilization of Expertise	14%
Defined Roles and Responsibilities	43%	Management	29%	Publication	29%	Not Completing in Time	14%
Planning	43%	Lack of Integration	29%	Meaningful Answers to Research Questions	29%	Failed Experiments	14%
Competence	29%	Communication	29%	Continuity	29%	Useless Research Material	14%
Goodwill	29%	Exploitation	14%	Completion Within Time	29%	Communication Breakdown	14%
Knowledge Management	14%	Incompetence	14%	Promised performance	14%	Poor relationships	14%
Trust	14%	Incorrect hypothesis	14%				
Closing Strategy	14%						
Big-Picture Thinking	14%						
Funding	14%						
Interesting Research Question	14%						

Contributes to success	Percent	Contributes to failure	Percent	What is success?	Percent	What is failure?	Percent
Maintained momentum	14%						
Risk Management	14%						

Table 5: Summarised results of the PM practices, tools and techniques from the interviewees' responses.

Lacking PM practices	Percent	Tools and Techniques	Percent
Risk Management	43%	Online Knowledge Management Tools	71%
Dedicated PM Partners	29%	Online Communication Tools	57%
Proper Management	29%	Scheduling Software	29%
Teamwork	14%	Contingency Plans	14%
Fostering Inclusive Environments	14%	Defined Roles and Responsibilities	14%
Collaboration is Not Independent	14%	Transparency	14%
Organizational Structure	14%	Leadership	14%
Motivating People	14%	Continuous Assessment of the Plan	14%
Accountability	14%	Capacity Building	14%
Knowledge management	14%	Communication	14%
Resource allocation	14%	Documentation	14%
Financial management	14%	Flexibility	14%

Overall, the findings from both the SLR and interviews converge to highlight a fragmented but consistent set of project management (PM) practices underpinning collaborative academic research. The SLR results (RQ1; Tables 2 and 3) identify key practices such as planning, communication, and risk management, which align with established PM literature [4], [8], [14]. However, the interview findings (RQ2 and RQ3; Tables 4 and 5) reveal that these practices are often applied informally and inconsistently in practice.

Notably, relational factors—such as communication, trust, and integration—emerge as equally, if not more, important than formal processes, reinforcing the relevance of the integrated conceptual framework combining Pelaez et al.'s [21] "Five C's" and the collaborative management strategies of vom Brocke and Lippe [37]. At the same time, the limited use of structured PM methodologies (e.g. PMBOK [14]) and the absence of dedicated project management roles highlight a disconnect between prescribed best practices and their application in academic contexts.

These findings collectively support the central premise of this study: that a more holistic, context-specific approach to PM—integrating both relational and process-oriented practices—is needed to enhance the success of collaborative research in the biological sciences.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 RQ1: What, if any, project management practices are reported in the literature on collaborative academic research projects in the biological sciences?

5.1.1 PM knowledge areas

The absence of integration and procurement management in the literature suggests these areas are either overlooked or considered less relevant in academic research collaborations (Table 2). Integration management may be assumed to occur organically through shared goals and communication; however, interview findings contradict this, identifying lack of integration as a contributor to project failure (Table 4). Procurement management was also not mentioned by interviewees, reinforcing its low perceived importance (Tables 4 and 5).

In contrast, risk and time management are frequently emphasised, highlighting their importance in managing uncertainty and timelines. Despite this, risk management was also identified as a lacking practice in interviews (Table 5). As noted by Interviewee 6:

> *"You can't always base (your actions or decisions) on prior experience - except for knowing something will go wrong! Risk management is therefore really important."*

Time management was similarly highlighted as critical, with timely project completion used as a key measure of success (Table 4). However, its application requires flexibility:

> *"Flexibility is really important. In science there's an understanding that time and cost are not so easily compartmentalised." - Interviewee 6*

Together, these findings indicate that while key knowledge areas are recognised, they are not consistently applied in practice.

5.1.2 PM processes

The prominence of initiating and planning processes in the literature suggests that academic collaborations prioritise defining objectives and planning early in the project lifecycle, particularly to secure funding and establish agreements. This is supported by interview findings, where planning, role definition, and coordination were identified as critical to success (Table 4).

Interviewee 6 noted the use of formal agreements at project initiation:

> *"Collaboration research agreements… ensure everyone in the collaboration is on the same page."*

Although all six PM processes are represented (Table 2), the emphasis on early stages suggests a relative underfocus on monitoring, controlling, and closing. This is reflected in the interview data, where few practices relate to project maintenance and completion (Table 4).

Interviewees also highlighted a broader lack of formal PM knowledge and training:

> *"I have never seen a work breakdown structure applied." - Interviewee 6*

> *"I am not a professionally qualified project manager… in academia… investigators are expected… to take over project managing aspects." - Interviewee 2*

> *"I'm not a formal project manager." - Interviewee 6*

These findings reinforce the gap between recognised PM processes and their structured application in practice, indicating a clear need for PM training in academic environments.

5.1.3 PM principles

The PMBOK 7th edition [14] introduced a shift toward principle-based PM. However, only three principles—team, systems thinking, and change—were identified in the SLR (Table 2). While these principles are relatively recent, their limited presence suggests gaps in their adoption within academic research collaborations.

At the same time, the emphasis on relational factors in both the SLR and interviews (e.g. communication, trust, teamwork) aligns with a principles-based approach. This suggests that while PM principles are not explicitly applied, they are implicitly present in practice.

5.2 *RQ2: What project management and relational factors are associated with successful collaborative academic research projects?*

5.2.1 Communication

The SLR identified communication, planning, knowledge management, leadership, and trust as the most frequent contributors to success in collaborative biological science research (Table 3). This is strongly reinforced by the interview findings, where communication was the most cited success factor (Table 4). As noted, project management is often described as being largely communication-driven [41], a view supported consistently across both literature and practice.

5.2.2 Relationships

The relationship between trust, collaboration, and project success is complex but well established. Research suggests a cascading effect in which trust enhances collaboration, which in turn improves project outcomes [42]. In this study, relational factors—particularly trust and collaboration—emerge as central to success, both as contributing factors and as measures of success (Table 4).

All interviewees emphasised the importance of building and maintaining strong relationships, often linked to inclusivity and team cohesion. Notably, relational success was in some cases valued as highly as, or more highly than, achieving project objectives:

> *"There's obviously the results themselves, but measuring how well the collaboration did as a cohesive unit is a win." - Interviewee 6*

These findings align closely with the relational dimension of the conceptual framework [21].

5.2.3 Planning

Planning is consistently identified in the literature as a key contributor to project success (Table 3). Interview findings refine this further, emphasising the importance of clearly defining roles and responsibilities at project initiation (Table 4).

Although formal tools such as work breakdown structures were not mentioned, and flexibility in planning (e.g. time and budget) is necessary in scientific contexts, the need for structured role allocation remains evident. In practice, this element of planning is closely linked to communication, particularly in complex or international collaborations.

5.2.4 Knowledge management

Knowledge management is a prominent success factor in both the SLR and interviews. Collaborative research projects generate large volumes of data, protocols, publications, and intellectual property, requiring effective systems for documentation and sharing.

Managing this information—while ensuring compliance with funding, governmental, and institutional requirements—necessitates clear processes established at the outset of the project. This supports alignment among partners throughout the project lifecycle and contributes to both process efficiency and successful outcomes.

5.3 *RQ3: Which project management practices are lacking and could improve outcomes in collaborative academic research projects?*

Building on RQ1, both the SLR and interview findings indicate a lack of project management processes related to the later stages of the project lifecycle, particularly those associated with monitoring, maintaining, and concluding projects. These phases are largely absent from both the literature and practitioner responses, suggesting an underdeveloped focus on project continuity and closure.

The interview findings further highlight a broader absence of formal project management practices in academic research collaborations. In response to the question on lacking PM practices, none of the interviewees referred to established PM processes, knowledge areas, principles, or widely recognised tools and techniques (e.g. work breakdown structures, critical path method, project charters, or lessons learned documentation).

Instead, identified gaps centred on general management capabilities, such as risk management, teamwork, and leadership (Table 5), reinforcing the earlier observation that PM practices in this context are applied informally rather than systematically.

Taken together, these findings indicate that while elements of project management are present, project management as a formalised discipline remains largely absent in collaborative academic research. This gap highlights a key opportunity to improve project outcomes through the structured adoption of context-appropriate PM practices.

5.4 Limitations and directions for future research

This study highlights the need for project management approaches in academic–industry collaborations within the biological sciences that emphasise flexibility and strong

relationships. This presents an avenue for future research in developing context-specific frameworks. Fernandes and O'Sullivan [43] take initial steps in this direction by proposing a University–Industry Collaborative framework (PM.UIC), consisting of transversal (must-have) and contingent (optional) PM practices. While their framework acknowledges the need for flexibility, it primarily introduces adaptability through Agile principles. Further research is needed to assess whether Agile approaches are sufficiently adaptable for academic research collaborations, or whether alternative models are required.

This study is subject to limitations inherent to systematic literature reviews, including potential selection bias, geographical and cultural constraints, and gaps in the existing literature. Additionally, the number of interviews was limited, and participants were selected from within the author's research network, which may introduce bias. However, purposive sampling was employed to ensure relevance, and the sample included diverse roles and experience levels within the available timeframe.

The findings indicate that project management practices in collaborative academic research are both limited and informally applied. Where applied, they require greater flexibility and adaptability than conventional approaches provide. Furthermore, strong relationships between collaborators emerged as both a key success factor and an important measure of success.

5.4.1 A people-centric approach to project management

Jensen et al. [22] propose a human-centric approach to project management that extends beyond organisational structures, emphasising the interplay between activities, time, spaces, and relationships. Unlike conventional PM approaches, which rely on fixed hierarchies, this perspective prioritises relational dynamics and connectivity. This aligns with the findings of the present study, which highlight the importance of relationships in collaborative projects. It is also consistent with the study's conceptual framework based on the "Five C's" of Pelaez et al. [21]—Commitment, Collegiality, Communication, Consensus, and Continuity—which emphasises team cohesion and collaboration.

5.4.2 The need for greater flexibility in project management frameworks

The need for adaptable PM approaches is widely recognised. Lotz et al. [30] advocate tailoring PM practices to project-specific requirements, for example through stage-gate models. Similarly, Morris [23] and Gustavsson [24] critique rigid approaches and emphasise flexibility.

The findings of this study reinforce these perspectives, showing both a lack of formal PM practices and the limited applicability of traditional tools in highly uncertain research environments. This suggests that the absence of formal PM is not only due to limited training but also to the difficulty of applying rigid methods in practice. The volatile nature of academic research collaborations therefore calls for more flexible, context-specific approaches.

This need is further supported by Ciric et al. [44], who emphasise aligning PM approaches with project context, and Collyer et al. [38], who highlight the limitations of traditional PM in dynamic environments. Similarly, vom Brocke and Lippe [37] emphasise both flexibility and a strong focus on participants, highlighting project vision, partner compatibility, and adaptable planning and monitoring as key strategies.

The shift toward flexible and principle-based PM is also reflected in the PMBOK 7th edition [14], which encourages more adaptive, innovative, and responsive approaches to managing modern projects.

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7 APPENDIX

Table A1: PICOC components with clarification within the context of the study and associated keywords as used for the systematic literature review.

PICOC component	Component clarification	Component keywords
Population	Academic researchers in the field of biological sciences engaged in collaborative	◦ "biological sciences" and "collaborative research"

PICOC component	Component clarification	Component keywords
	projects with other academics or industry.	◦ "academia-industry collaboration" and "biotechnology" / "biology" ◦ "interdisciplinary teams" and "biology"
Intervention	Project management strategies and practices implemented in these collaborations.	◦ "project management strategy" and "research" ◦ "project management strategy" and "academia" ◦ "project management practice" and "academia" ◦ "project management practice" and "research" ◦ "research collaboration" and "management approach" ◦ "project management implementation" and "scientific research"
Comparison	Project management practices in the literature associated with academic research collaborations (with a focus on the biological sciences), and an ultimate comparison to practitioners in real time.	◦ "project management approach" and "research" ◦ "structured or unstructured project management" ◦ "project management practices" and "effectiveness"
Outcomes	Success factors identified as contributing to the effectiveness, efficiency, and overall success of research collaborations, as well as challenges encountered.	◦ "successful research collaboration" ◦ "academic research" and :challenge" ◦ "project management" and "research success" ◦ "project management" and "pitfalls"
Context	The specific environment of academic research in the biological sciences, which may include multidisciplinary teams, funding conditions, institutional policies, or geographical considerations.	◦ "multidisciplinary team" and "research" and "biology" ◦ "funding" and "biology" and "research collaboration" ◦ "institutional policy" and "research"

PICOC component	Component clarification	Component keywords
		◦ "Academic collaboration" and "geography"

Table A2: Detailed components of the systematic literature review (SLR).

Component	What should be stated
Database	*Clarivate Analytics Web of Science (WoS)* (https://www.webofknowledge.com)
Search date	14 June 2024
Search framework	PICOC
Inclusion criteria	Papers that could address the following: • PM processes discussed in the study (initiating, planning, executing, monitoring, controlling, closing) • PM knowledge areas involved in the study (integration, scope, time, cost, quality, human resources, communication, risk, procurement and stakeholder - management) • PM principles involved in the study (stewardship, team, stakeholders, value, systems thinking, leadership, tailoring, quality, complexity, risk, adaptability, change) • Tools or practices that contributed to project success in the study • Tools or practices that contributed to project failure in the study • What is project success as defined in this study? • The sample size utilised in the study
Exclusion criteria	• non-relevant material such as conference proceedings, bibliometric studies, opinion pieces, reviews and duplicate papers • papers dealing with topics or organizations or industries not related to academia and the biological sciences
Screening	Bash-coded keyword searches using 'grep'
Duplicate handling	Duplicate papers detected through alphabetical ordering of citations had one of each duplicate removed
Data extraction	Excerpts for each question addressed in the list of inclusion criteria was summarised to single keywords or concepts, counted and tabulated.

7.1 Research Instrument

To reiterate, the objectives of this research project are as follows:

1. To identify and analyse the key project management practices employed in collaborative academic research projects in the biological sciences through a comprehensive literature review and examine the factors associated with success or failure of these research projects.
2. To provide practical insights and recommendations for improving project management practices in order to enhance the success of collaborative academic research projects in the biological sciences.

In this study, and the following interview questions, several terms are used which might have different interpretations depending on the individual's background and field of expertise. To that end, I provide the following definitions as clarification:

Project management practices: Here we define project management practices as those practices, tools and techniques specific to the project management field. Though these practices can be different between different types of projects, they are all aimed at project management (see the Project Management Body of Knowledge (PMBOK) [45]. Briefly, project management practices relate to the ten project management knowledge areas as set out by the PMBOK guide:

- Integration Management: Ensuring all aspects of the project are properly coordinated.
- Scope Management: Defining and controlling what is included and excluded from the project.
- Schedule Management: Sequencing and scheduling project activities.
- Cost Management: Estimating, budgeting, and controlling costs.
- Quality Management: Ensuring the project meets the quality requirements.
- Resource Management: Identifying, acquiring, and managing resources needed for the project.
- Communications Management: Planning, managing, and distributing project information.
- Risk Management: Identifying, analyzing, and responding to project risks.
- Procurement Management: Acquiring goods and services from outside the organization.
- Stakeholder Management: Identifying stakeholders, managing their expectations, and engaging them in the project.

*Project success:*Here we define project success as the meeting of project objectives as outlined in the project scope, staying within constraints (whether time, budget or both) and adhering to quality standards if any.

Project failure: Project failure would be the opposite of project success in that either project objectives were not met (whether one objective or many), constraints were exceeded or quality standards not maintained.

*Collaboration:*Collaborative projects are those endeavours with:

- shared goals between parties
- requiring teamwork between different groups
- shared responsibility between and among different groups
- requiring feedback and communication between different groups

In this study I refer to '*collaborative academic project*'. This term can imply any collaborative project undertaken by the individual either with other academics or with an industry partner(s).

7.1.1 General Information

- What is your role in the project/projects you are currently involved in?
- How many years of experience do you have in project management or in your current role within projects?

7.1.2 Questions relating to project management practices

- Thinking of a collaborative project you were involved in that completed with **success**, what factors contributed to that success?
- Thinking of a collaborative project you were involved in that completed with **failure**, what factors contributed to its failure?
- Based on your experience, what project management practices do you think are lacking in collaborative academic research projects and could potentially improve outcomes?
- How do you assess the success of a collaborative academic research project?
- What would constitute a failed collaborative academic project?
- Are there any specific tools or techniques that you find useful for managing collaborative academic research projects?
- Do you have any additional comments or insights you would like to share?

Project Phase Requirements Across Epcm Projects Aligned With Personality Characteristics

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HOPE Summit

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PROJECT PHASE REQUIREMENTS ACROSS EPCM PROJECTS ALIGNED WITH PERSONALITY CHARACTERISTICS

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ABSTRACT

Engineering projects progress through distinct phases that differ significantly in terms of uncertainty, complexity, and execution requirements. While traditional project management approaches emphasise technical processes and governance structures, less attention has been given to how human behavioural characteristics influence performance across the phases making up the project life cycle (PLC). This study explores the relationship between project phase requirements and Dominant, Influence, Steadiness and Conscientiousness (DISC) personality characteristics in an Engineering, Procurement, and Construction Management (EPCM) environment. Semi-structured interviews with ten experienced managers were conducted. Thematic analysis of the interview data revealed that different project phases favour different behavioural tendencies. The qualitative findings were corroborated through a quantitative questionnaire, requesting the same expert cohort to rate individual, randomised behavioural traits in terms of suitability across project phases. The findings suggest that aligning behavioural characteristics with project phase requirements may support team effectiveness and overall project performance.

Keywords: DISC profiles, EPCM projects, Project life cycle, Project management

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1. INTRODUCTION

This research is based on managerial perceptions of how project requirements changed as the engineering project matured through its various phases. The researcher became interested in exploring opportunities to improve project performance by identifying specific requirements for each project phase and addressing them by aligning the delivery team's DISC personality profiles.

The project life cycle is well understood in project management and is broken down into phases, with stage-gate review processes between each phase [1]. These stage-gate reviews determine whether the project should proceed to the next phase. The DISC personality profiling tool categorises personalities into four behavioural groups, assigning a percentage score to each. The rationale is that if an alignment between project phase requirements and DISC personality characteristics can be identified, it could add value to the project planning phase by enabling the selection of team members based on their DISC profiles. This is in addition to existing selection criteria (not considered in this paper), including team diversity, technical ability and project or resource-specific experience.

Problem statement:

Current project management and people management literature emphasises leadership and team dynamics as key performance indicators for project success, but these sources do not sufficiently address how individual behavioural profiles align with project phases. This omission limits managers' ability to allocate staff optimally.

Research question:

Can project phases across the PLC be aligned with DISC personality profiles to improve their delivery?

Semi-structured qualitative interviews, followed by semi-blind quantitative questionnaires, were used to guide the researcher in determining whether certain DISC profiles might benefit certain project phases more than others, thereby enabling better resource planning. Results were largely exploratory and require further research.

2. BACKGROUND LITERATURE

2.1 Project phases

The project life cycle is the logical sequence of phases and their associated activities that a project follows from early start to a conclusion. Decisions made during the FEL (Front-End Loading) phases of a project are considered crucial to project success, and early adoption of the FEL process during project definition is key to supporting this success [2].

The four project phases that can be expected in an EPCM environment are shown in Figure 1 below:



Figure 1: EPCM Project Life Cycle

2.1.1 Conceptual engineering requirements

In determining a project's initial feasibility, George [4] emphasises the importance of defining the project's business objectives as a starting point for concept development. Romero [3] discusses the importance of conducting a business feasibility analysis by evaluating business viability indicators. Early stakeholder engagement is key to a successful conceptual phase, as it helps achieve alignment with stakeholder objectives, including organisational goals, costs, quality, timelines, and risk appetite [6].

2.1.2 Front-end engineering design requirements

The FEED phase refines the engineering solution designed at a conceptual level and allows design modifications if the project remains financially feasible [7]. These design modifications and changes are still possible with minimal financial impact on engineering rework and form part of the design engineering development activities completed during this phase of the project. Project execution planning is a key method to define the future execution of the project, while addressing potential risks and responses to risks should they surface [4]

2.1.3 Detailed design requirements

Lowe [5] highlights the importance of producing a detailed description of the designed solution as a crucial deliverable in the final design phases of a project. This means that all engineering design is finalised and integrated for alignment with the objectives and functionality of the overarching project. Lowe [5] also notes that the detailed design phase includes a final approval process, requiring formal approval and sign-off of engineering and procurement deliverables, so the project can progress to procurement and construction activities.

2.1.4 Construction requirements

As a starting point for construction activities and in alignment with the requirement for stage-gate reviews, Jergeas [8] notes the need to adhere to the 80 % – 100 % rule, which requires that at least 80 % of the engineering design work be complete before establishing contractors on site for construction. The 80 % can be measured by the number of signed-off IFC (Issued for Construction) drawings. Jergeas [8] further states that, once site teams are established, the requirements on site are site supervision, effective labour management, and resource scheduling. Aghimien [2] notes the importance of effective monitoring and control of site activities during the project's construction phase.

2.2 Personality profiling tools

Modern organisations utilise a wide range of psychological and behavioural assessment tools to evaluate talent, configure teams, and predict job performance. Hough [9] lists some widely used personality tests as follows:

- Big Five Personality Test
- Myers-Briggs Type Indicator (MBTI)
- Minnesota Multiphasic Personality Inventory (MMPI)
- Hogan Personality Inventory
- 16 Personality Factors (16PF)
- DISC (Dominance-Influence-Steadiness-Conscientiousness) Personality Assessment
- Caliper Profile

The DISC personality tool has gained traction in the workplace and is being utilised in 75 % of Fortune 500 companies [10]. It is also simple to implement, as it reduces human behaviour down to four numbers. This makes explaining the profile to the subject easier and also makes the practical application of the DISC assessment in an organisational performance context easier.

2.2.1 Diversity in Teams

Pinto [11] notes that selecting the right team members is key to team effectiveness. Yeh [12] builds on this notion, where team member selection should be done to enable a well-balanced, diverse team. This diversity enables more innovative solutions as teams become more diverse [13]. When speed of delivery is a key performance metric, Kim [14] found that teams with similar personality types communicate more concisely, leading to faster delivery times, albeit at the expense of quality.

Several studies [13, 15, 16, 17] have suggested that the key factor distinguishing high-performing from lower-performing teams is diversity. Diverse yet complementary personality characteristics are key to project success.

2.2.2 DISC

The DISC personality categorisation was developed from an initial theory by William Marston, which categorised people into four behavioural types [14]. Marston's work initially focused on the four groupings called DISA, where the A (Analytical) is used instead of the C (Conscientiousness) [14]. This naming is still used by Erikson [18], who explains the DISC personality types, categorises them into colours, and describes them using the following behaviours:

Table 1: Behaviours per DISC category [18]

D **Dominant** (Red)	**I** **Influence** (Yellow)	**S** **Steadiness** (Green)	**C Conscientiousness / Analytical** (Blue)
Aggressive	Talkative	Patient	Conscientious
Ambitious	Enthusiastic	Relaxed	Systematic

D **Dominant** (Red)	**I** **Influence** (Yellow)	**S** **Steadiness** (Green)	**C Conscientiousness / Analytical** (Blue)
Strong-willed	Persuasive	Self-controlled	Distant
Goal-oriented	Creative	Reliable	Correct
Pushing	Optimistic	Composed	Conventional
Problem-solver	Social	Loyal	Seems insecure
Pioneer	Spontaneous	Modest	Objective
Decisive	Expressive	Understanding	Structured
Innovator	Charming	Lengthy	Analytical
Impatient	Full of vitality	Stable	Perfectionist
Controlling	Self-centered	Prudent	Needs time
Convincing	Sensitive	Discreet	Reflecting
Performance-oriented	Adaptable	Supportive	Methodical
Powerful	Inspiring	Good listener	Seeks facts
Results-oriented	Needs attention	Helpful	Quality-oriented
Initiator	Encouraging	Producer	Scrutinizes
Speed	Communicative	Persistent	Follows rules
Timekeeper	Flexible	Reluctant	Logical
Intense	Open	Thoughtful	Questioning
Opinionated	Sociable	Conceals feelings	Meticulous
Straightforward	Imaginative	Considerate	Reflecting
Independent	Easy-going	Kind	Reserved

No literature was found linking DISC profile characteristics to project phase requirements. This gap is intended to be addressed by the conceptual model and methodology that follows. Caution must be exercised when linking DISC profiles to project phase requirements, as Erikson [18] notes that every individual is a unique blend of profiles and that oversimplifying the model to a single most dominant DISC profile can lead to limited productivity in a project environment. Everyone should be considered in the context of their overall DISC profile and its alignment with the individual project's lifecycles.

Due to its simplicity and availability within the international engineering organisation in which the participants were interviewed, only the DISC personality test was considered for this explorative research.

The conceptual model describing the expected linkage between project phase requirements and DISC personality types is described in Chapter 3.

3. CONCEPTUAL MODEL

As no correlation between project phase characteristics and DISC personality profiles was found in the reviewed literature, the conceptual model aims to predict this correlation based on the above literature.

The proposed conceptual model is based on the synthesis of the project requirements identified in section 2.1 and the behavioural characteristics of the DISC framework described in section 2.2. The rationale is as follows:

- The creative or exploratory requirements in early project phases, especially conceptual engineering, are characterised by high levels of ambiguity, uncertainty and the need for diverse thinking to explore alternative options potentially suitable for a business case. This type of thinking is typical for I-types.
- As the phase shifts into FEED and Detailed Design, the requirement shifts from creating value to capturing that value through engineering designs and proving the project's financial and technical business case. This type of detailed thinking is typical of C-type personalities.
- During construction and commissioning, managing schedules and meeting project milestones becomes increasingly important. The decisive D-types are likely most suitable to meet these requirements due to their results-oriented nature.
- The stable S-type personalities assist in improving team cohesion due to their patient and reliable nature, making them beneficial to all project phases.

4. METHODOLOGY

4.1 Mixed methods approach

Semi-structured interviews were conducted and analysed using Braun and Clarke's Thematic Analysis as a qualitative approach to investigate the relationship between project phase requirements and DISC personality characteristics.

Project Managers, Engineering Managers and Engineering Team Leads were interviewed. These team members were specifically selected for their holistic view of the delivery team and their experience managing teams with diverse personalities. They were asked the following four semi-structured questions:

- How many years have they worked as managers on engineering projects, and why did they choose that specific career path? This is to gain an understanding of the interviewees' background and experience in the context of their later responses.
- The interviewees were asked to define the various project phase requirements and to highlight differences and similarities in terms of complexity, team size, pace of delivery and procedural rigour required. This was done to determine whether a correlation could be drawn from the similarities described by all interviewees in their definitions of the specific project phase requirements. An emphasis was placed on the requirements for certain personality types to deliver specific project phases.
- Which project phases are the interviewee most comfortable and most uncomfortable working in as a manager, and why? This is to gauge whether the interviewee prefers a specific project phase and to investigate potential reasons for the preference.
- What specific leadership attributes would be most suitable for which phases and why?

The same cohort of interviewees were then asked to complete an online quantitative questionnaire, from which the data was used to corroborate the thematic analysis results

specific to alignment between project phase requirements and DISC personality characteristics.

The questionnaire asked participants to rank the 88 randomised behavioural characteristics established in Erikson's [18] framework according to alignment with project phases. The questionnaire was considered semi-blinded, as the participants had no knowledge of how the 88 behavioural characteristics correlated with the 4 DISC profiles.

Participants ranked the alignment of each behavioural characteristic with each project phase on a Likert scale.

4.2 Participant selection

A purposive sampling strategy was used to select interview participants with relevant professional experience. 10 participants were selected from the international engineering organisation due to their seniority and experience. The participants held roles including:

- Project Manager
- Engineering Manager
- Engineering Discipline Lead

The participants had between 4 and more than 25 years of experience in managing engineering project environments and collectively had experience across the full project life cycle. This range of experience enabled the study to capture perspectives from professionals involved in different phases of project delivery, as well as perspectives gained while working for the same client on the same project as the project progressed through those phases. The same participants were sent the quantitative questionnaire to corroborate the interview findings and assess potential framing biases in the qualitative interviews.

4.3 Limitations

A limitation of the methodology is that 5 interviewees had no prior knowledge of the DISC personality assessment, which was explained to them at the outset of the semi-structured interviews. This explanation of the DISC assessment tool could, in the context of the discussion, lead to framing bias. To mitigate this potential bias, the quantitative questionnaire was administered to the same cohort of interviewees as a semi-blinded instrument.

Additionally, only 7 interviewees responded to the quantitative corroboration questionnaire due to time constraints. This small dataset makes statistical correlation difficult. Triangulating qualitative data with quantitative data gathered from team members who delivered the Engineering Projects (a separate cohort) can address this limitation and is suggested for future research. This data could be collected by administering DISC assessments to individuals and then asking them to rank their project-phase preferences.

Finally, the data was gathered from only one organisation, which may have introduced organisational bias. Future research should therefore also consider qualitative and quantitative data from additional organisations and larger pools of participants.

4.4 Data collection and analysis

The interview data was analysed using Braun and Clarke's thematic analysis with the aid of the ATLAS.ti software tool. The six steps followed to conduct the thematic analysis are described by Braun [19] and were implemented as follows:

1. Data familiarisation through transcription and in-depth understanding of the interview content by actively reading and listening to the interview content repeatedly. The transcripts removed any potentially confidential information, such as names of participants, colleagues, employers, competitors and clients.
2. Code generation – this was done in ATLAS.ti for data which was found to be related or at least applicable to the research question. During this process, 468 codes were generated.
3. Searching for themes by clustering codes into groups. This was done on paper using mind maps and then brought back into ATLAS.ti manually, by adding groups and then grouping the codes per theme. While grouping codes, the total number of codes was reduced to 315 unique codes.
4. Review of the themes. Only themes useful to the research question and objective were kept and unrelated themes and codes were removed from the ATLAS.ti database. During this process, 124 codes were removed. Braun [19] highlights that codes should fit logically within a theme and that the themes should be clearly distinct from each other.
5. Defining and naming the final selected themes. Theme names were made broader as groups of codes were integrated into fewer themes. A total of four themes were identified, comprising 191 codes.
6. Analysing the themes and writing the summaries provided in Chapter 5.

5. DISCUSSION OF QUALITATIVE RESULTS

The interview data was grouped into four recurring and distinct themes. Across the interviews, participants consistently highlighted that project phases require fundamentally different problem-solving approaches, decision-making styles, and leadership behaviours.

The data suggests that many project challenges arise not necessarily from technical deficiencies but from misalignment between engineers' personality characteristics and the requirements of specific project phases that those characteristics must meet. Participants repeatedly suggested that engineers are frequently expected to perform optimally across all phases of a project lifecycle, even though these phases demand significantly different thinking styles and can benefit from differing behavioural traits.

Four key themes emerged from the analysis:

- T1: Project phase requirements and aligned personality types
- T2: Specialist expertise contrasted with holistic understanding
- T3: Management roles required across project phases
- T4: Organisational and environmental influences

The most frequently recurring codes throughout the 10 interviews, along with their themes, are highlighted in Table 2. Only codes with 10 or more recurrences are shown. Higher levels of code recurrence suggest that the interviewees placed greater focus on these codes and themes than on the others within the semi-structured nature of the interviews.

Table 2: Most frequently recurring codes from thematic analysis

Theme	Code	Recurrence
T1	Team dynamics	38
T1	Project phase dynamics	31
T3	Leadership	26
T4	Work adaptability	24
T1	Project phase requirements	19
T3	Leadership dynamics	18
T3	Leadership assessment	17
T2	Problem-solving approach	16
T4	Adaptation challenges	16
T3	Management issues	15
T1	Phase preference	14
T1	Project execution	14
T4	Collaboration challenges	14
T3	Decision-making	13
T1	Project phases	10
T2	Training and development	10

5.1 Project phase requirements and aligned personality types

The most relevant theme to the research question, emerging from the interviews, is that different phases of engineering projects require distinct personality characteristics and behavioural tendencies. In this context, the data reveals a common industry misconception: Engineers who can conceptualise a process engineering solution should also be able to define every technical detail required to construct that system. Several interviewees argued that conceptualisation and detailed execution require fundamentally different personality characteristics. Interviewees suggested that early project phases, such as conceptual and prefeasibility studies (PFS), require individuals comfortable working with uncertainty and incomplete information.

One participant explained:

> *"In the study phases, we determine how it should work and we identify what all of the options are. Then we slowly but surely trim those options down to a few."*

This quote highlights the exploratory nature of early project phases. Engineers operating in these phases must evaluate multiple potential process configurations, technologies, and plant layouts without becoming overwhelmed by the excessive technical detail of each.

Managers described the early phases as benefiting from individuals being particularly effective at managing ambiguity and facilitating discussions that help narrow down design options. The presence of highly detail-oriented personalities during the early study phases can slow decision-making.

Participants from interviews 3 and 6 described situations in which engineers attempted to develop conceptual designs in excessive detail. While technically sound designs were achieved, this work often consumed significant engineering hours and project budget, without meaningfully contributing to early-stage decision-making, ultimately resulting in sunken costs.

5.2 Specialist expertise contrasted with holistic understanding

Although interviewees emphasised the importance of aligning personality characteristics with project phases, they also cautioned against overly rigid role separation. Participants highlighted that engineers must develop a holistic understanding of how early design decisions influence later project outcomes. Limiting engineers to specific project phases based solely on their personality traits may prevent them from understanding the real-world implications of their design choices.

One interviewee described the profound learning experience that occurs when engineers are confronted by the operational consequences of their design decisions. When confronted with adversity due to a design not operating as expected, their client stated:

> *"This is your design; you must make it work."*

This quote highlights the importance of exposing engineers to later project phases, even if their natural strengths lie in conceptual design. Its significance lies in demonstrating how practical experience can deepen engineers' understanding of operational realities and improve future design decisions made during earlier phases.

Another participant warned that isolating conceptual thinkers within early project phases (in an organisational context) can lead to designs that appear viable on paper but prove difficult to operate in practice.

5.3 Management roles required across project phases

Another theme emerging from the coded interviews concerns the evolution of management styles as projects progress through different phases. Participants consistently suggested that management approaches must adapt to the changing nature of project work. Early project phases were described as requiring more collaborative and flexible management approaches, while later phases often require stricter management and procedural discipline to be enforced by leaders.

5.4 Organisational and environmental influences

Beyond personality and leadership/management dynamics, participants also emphasised the influence of external organisational factors. Interviewees highlighted that client type can significantly influence project dynamics. Large, well-established companies typically operate under strict corporate governance frameworks that enforce formal project development processes. In contrast, smaller or emerging companies may prioritise short-term objectives such as investor confidence or share price performance, which can create conflicting incentives for the engineering team delivering the project. One participant highlighted the importance of achieving the right balance between quality management and schedule management, which can differ depending on the client's requirements.

5.5 Summary of identified themes

The four main themes identified are relevant to the research question. The first theme, however, project phase requirements and aligned personality types, best draws the required correlation between project phase requirements and DISC profile characteristics across those project phases. A questionnaire was sent to the interviewees to corroborate this finding within the same cohort of interviewees and to provide more specific reference to the DISC personality profile and Theme 1. This is discussed in 6.

6. DISCUSSION OF QUANTITATIVE RESULTS

A quantitative questionnaire was sent to the interviewees, and seven responses were received. Due to the small number of responses, the findings discussed below must be considered exploratory only and statistically inconclusive. The findings are only beneficial in corroborating the qualitative findings.

The questionnaire asked participants to evaluate 88 behavioural characteristics that make up the four DISC profiles as defined by Erikson [18] and presented in Table 1, where the alignment to each DISC profile was blinded, and these were presented in a random order. This evaluation compared the management team’s perceived alignment of each behavioural characteristic with the four project phases on a Likert scale. This method also ensures that participants were not tested on their understanding of the DISC tool, but rather on their perception of the alignment between the behaviours that make up the four profiles and the requirements of the four project phases.

Results were interpreted by calculating the mean and variance for each individual behavioural characteristic and then grouping these behavioural scores back into their respective DISC profiles (unblinding).

The results can be seen in Figures 2 – 3.

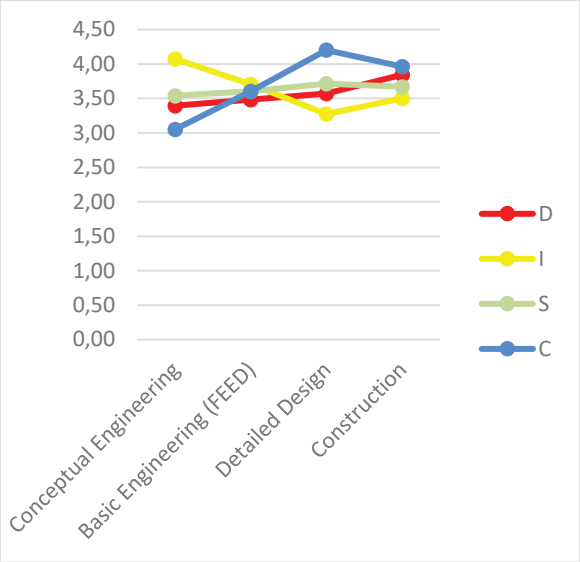


Figure 2: Mean of Likert Results

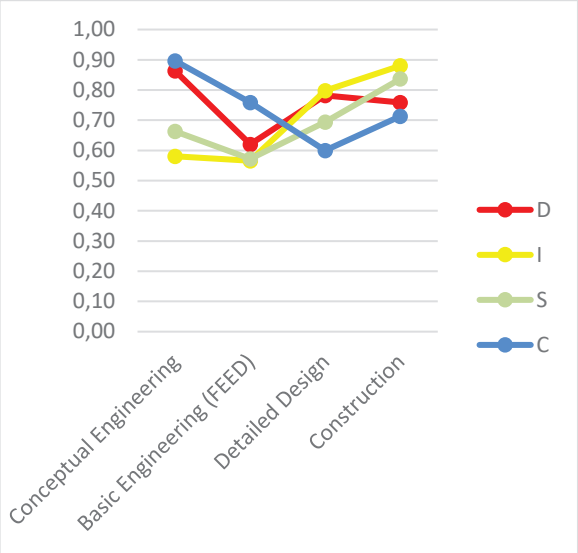


Figure 3: Variance of Likert Results

The figures representing the quantitative findings are colour-coded according to the DISC colours. The relative alignment of the various DISC profiles is shown on the Y-axis, with the PLC on the X-axis.

Considering the D-type:

The mean increases as the project progresses from conceptual engineering through FEED to detailed design, and then to construction. The variance is highest at the conceptual engineering phase, suggesting that some participants might have ranked the D-type high for concept studies, contradicting the expected lower alignment here. Subjects rated D-types as being even more aligned with the construction phase than with the detailed design phase.

Considering the I-type:

The I-type scores highest in the conceptual phase alignment and then reduces as the level of detail increases. The I-type also scores slightly higher again in the construction phase. This aligns with the quantitatively defined need to develop ad hoc solutions when working on site. The I-type also shows the highest variance during the construction phase, indicating disagreement among managers regarding its alignment with this phase.

Considering the S-type:

The S-type shows the most horizontal mean across phases and the lowest variance, except for the construction phase, which has a higher variance. This suggests that S-types are aligned regardless of the project phase.

Considering the C-type:

The conceptual model is only partly supported by the questionnaire data. The detailed design phase scored the highest mean here, but the next highest was not the FEED phase but rather the construction phase. C-types have the lowest mean score in the conceptual phase, supporting the qualitative data presented in Chapter 5. The discrepancy between the expectation that blue would not be suited to construction phases and the questionnaire

feedback that participants deemed C-types to be aligned with the construction phase is suspected to stem from C-types' deep technical understanding of the equipment installed on site, which is especially beneficial when the engineers who designed the equipment and the flowsheet are required to commission it, as per the qualitative observations in section 5.2.

7. CONCLUSIONS AND RECOMMENDATIONS

This study explored managerial perceptions on how project phase requirements can be addressed by various DISC personality types throughout the lifecycle of engineering projects. The data reveals that engineering projects are not only technical undertakings, but also complex socio-technical systems shaped by human personality profiles and behaviours.

The most prominent finding is that different project phases might require fundamentally different personality characteristics for efficient project delivery. When personality characteristics are misaligned with the requirements of a particular project phase, decision-making processes may become either excessively cautious or insufficiently rigorous. This finding is based solely on the perceptions of managers who delivered the various project phases within a single engineering organisation.

This finding must also be contrasted with literature suggesting that a diverse team is required for effective project delivery. Further research might consider the extent to which diversity in DISC profiles across project phases can benefit a project before reduced diversity becomes a limitation.

Additional research is recommended:

- Conduct DISC assessments on the team members delivering the project (new cohort) to triangulate the alignment between project phase requirements and DISC personality profiles.
- Determine project phase preference of the team members delivering the project to align this with their DISC personality profiles.
- Conduct the research at multiple organisations to remove potential organisational bias.

This exploratory research suggests that successful engineering project delivery requires not only technical competence but that this can also benefit from a deliberate alignment between the requirements of the different project phases and the DISC profiles of the team members delivering them. Implementing DISC personality tests across teams and specifically selecting profiles based on project phase requirements may enable managers to allocate team members more effectively to project phases across the PLC, which may improve project performance.

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Structuring Fragmented Applied Research: A Framework-Based Architecture For Cumulative Knowledge Development

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STRUCTURING FRAGMENTED APPLIED RESEARCH: A FRAMEWORK-BASED ARCHITECTURE FOR CUMULATIVE KNOWLEDGE DEVELOPMENT

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ABSTRACT

Applied research in project and management environments often produces rigorous but disconnected studies, with inconsistent constructs and limited mechanisms for accumulating evidence across contexts.

This paper develops Framework-Based Research Architecture (FBRA) as a higher-order architecture for coordinating cumulative applied research. Using a conceptual research-architecture development approach, FBRA is defined around governed constructs and relationships, context-specific framework instances, evidence provenance, and controlled evolution. Its incremental novelty lies not in any component individually, but in integrating these functions within one research-system architecture.

A developing Metropolitan Cape Town framework instance demonstrates how related research pathways can remain methodologically independent while contributing to a shared structure. The demonstration establishes operational plausibility rather than empirical validation of effectiveness. The paper contributes a foundational architecture for prospectively coordinating applied research and supporting construct consistency, traceability, evidence reuse, cross-context comparison, and cumulative knowledge development.

Keywords: Applied Research, Cumulative Knowledge, FBRA, Framework Instances

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1 INTRODUCTION

Applied research increasingly addresses problems that span multiple domains rather than residing within a single disciplinary boundary. In project, program, and portfolio management, for example, outcomes are shaped not only by technical execution but by interactions between governance, leadership, organizational structures, culture, and value realization [1] – [3]. Similar patterns are observed across organizational research, where performance and change emerge from the interaction of multiple conditions rather than isolated variables [4], [5].

Despite this multi-domain reality, research remains largely structured around disciplines and, institutionally, around university faculties. These structures provide depth and methodological rigor, but they also influence how knowledge is organized, how constructs are defined, and how research questions are framed. When the phenomena under investigation are inherently cross-domain, disciplinary structuring can contribute to fragmentation rather than coherence [6], [7].

This fragmentation manifests in several ways. Studies are often conducted in isolation, with limited cumulative linkage across related research streams. Constructs are defined inconsistently across the literature, reducing comparability and inhibiting synthesis. Moreover, interdisciplinary research frequently operates at the level of individual studies rather than contributing to a systematically integrated body of knowledge [8], [9]. As a result, research produces valid but disconnected insights, while practice operates within complex systems that require their integration [10] – [12].

In project management research, this challenge is particularly visible. The field has expanded from a focus on planning and control to encompass governance, leadership, strategy, culture, and projects-as-practice perspectives [13] – [15]. While this expansion has enriched the field, it has also increased its plurality and reduced coherence [16]. The issue is not the diversity of perspectives, but the absence of mechanisms for systematically connecting and accumulating them.

This raises the question of how applied research can be structured to support the development of cumulative knowledge across disciplinary and contextual boundaries.

To address this question, the paper proposes a Framework-Based Research Architecture (FBRA). FBRA is not intended to replace existing methodologies or disciplinary expertise. Rather, it introduces a complementary structuring layer through which research can be organized around domains, constructs, relationships, evidence, and context. Within this architecture, research is coordinated through framework instances, defined here as governed, context-specific research models that evolve over time as studies contribute to the refinement of constructs, relationships, and evidence.

FBRA does not claim novelty for frameworks, research programs, evidence synthesis, or governance considered separately. Its incremental contribution lies in combining the prospective coordination of related studies with governed construct and relationship definitions, context-specific framework instances, evidence provenance, and controlled evolution within one research architecture. This distinguishes the proposal from approaches that primarily synthesize completed studies or integrate disciplines within a single study. A detailed comparison with established approaches is presented later in the paper.

The paper makes three contributions. First, it conceptualizes fragmentation in applied research as a structural problem linked to the organization of research rather than solely to disciplinary specialization. Second, it defines the components and characteristics of FBRA and clarifies its incremental contribution as a mechanism for coordinating and accumulating research across studies. Third, it provides a worked demonstration through the developing Metropolitan Cape Town framework instance, showing how related research pathways can be

positioned within a shared architecture. This demonstration supports operational plausibility; it does not constitute empirical validation of FBRA's effectiveness.

2 LITERATURE REVIEW

2.1 Fragmentation in applied research

Applied research increasingly addresses problems that span multiple domains, involving interactions between technical, organizational, social, and strategic elements. In such contexts, knowledge is not generated within isolated variables but through the interaction of multiple constructs operating across different levels of analysis [4], [5]. Despite this, the production of research knowledge remains largely organized around discrete studies, each focusing on a limited set of constructs within a bounded conceptual frame [17] – [20].

This structural arrangement contributes to fragmentation in applied research. Fragmentation is not simply the result of disciplinary diversity or methodological variation; rather, it reflects the absence of mechanisms through which findings can be systematically connected and accumulated across studies [17], [18]. Individual research efforts may be internally coherent and methodologically rigorous yet remain externally disconnected from related work addressing adjacent constructs or contexts [19].

The effects of this fragmentation are visible in several ways. First, studies are frequently conducted in isolation, with limited cumulative linkage across related streams of inquiry [13], [16]. While literature reviews attempt to synthesize findings, they often operate at the level of narrative aggregation rather than structural integration [18], [21]. Second, similar constructs are defined and operationalized differently across studies, reducing comparability and inhibiting the development of shared conceptual foundations [22], [23]. Third, relationships between constructs are typically examined within the scope of individual studies, without mechanisms to extend or refine those relationships across a broader body of research [5], [17], [24].

This problem is particularly pronounced in applied domains such as project, program, and portfolio management, where outcomes are shaped by interacting factors including governance structures, leadership practices, team competencies, organizational culture, delivery mechanisms, and value realization. Although each of these dimensions has been studied extensively, research remains distributed across multiple streams that are rarely connected in a cumulative or systematic manner [13], [16], [18]. As a result, the field has expanded in scope but not necessarily in coherence.

Existing approaches to addressing fragmentation, such as meta-analysis, systematic literature reviews, and interdisciplinary research designs, provide important but partial solutions. These approaches primarily operate retrospectively, focusing on the synthesis and aggregation of existing findings rather than shaping how research is produced and accumulated prospectively [18], [21], [25]. Consequently, fragmentation persists not due to a lack of research activity, but because of the limited mechanisms and shared frameworks for coordinating research efforts across studies and contexts.

2.2 Disciplinary structures and knowledge silos

The organization of research into disciplines and, institutionally, into university faculties has historically provided the foundation for depth, methodological rigor, and cumulative expertise. Disciplines offer shared paradigms, common vocabularies, and established methodological standards that enable focused inquiry and theoretical development [6], [7]. In this sense, disciplinary structures are not only necessary but central to the advancement of knowledge.

However, these same structures also shape the boundaries within which research problems are defined and investigated. Disciplinary paradigms influence what constitutes a legitimate research question, which constructs are considered relevant, and how relationships between variables are conceptualized [7], [26]. As a result, when research problems extend across multiple domains, as is typical in applied contexts, disciplinary boundaries can also constrain the integration of knowledge across related areas [27].

This constraint does not manifest as an absence of interdisciplinary work, but rather as a limitation in how such work is structured. Interdisciplinary research often combines perspectives within individual studies, drawing on multiple bodies of knowledge to address complex problems [8], [9]. However, these integrations are typically localized to a single research effort. They do not, in themselves, establish mechanisms for the systematic accumulation, extension, and coordination of knowledge across multiple studies over time [18], [25].

Consequently, knowledge silos persist not only because disciplines exist, but because the structures that organize research do not provide a shared architecture for connecting insights across those disciplines [28]. Constructs that are conceptually related, such as strategy, leadership, culture, governance, and performance, are often examined within separate research traditions, using different definitions, measures, and theoretical lenses [22], [23], [29]. While each stream contributes depth, the absence of structural linkage across them limits the ability to develop a coherent, cumulative understanding [18], [25].

2.3 Complex and dynamic systems in applied research

Applied research frequently addresses systems rather than isolated entities. Complex systems are characterized by interdependence, non-linearity, adaptation, and sensitivity to context [30], [31]. In organizational settings, these characteristics are evident in the interaction between structures, behaviors, processes, and external pressures [32].

This has important implications for research design. Approaches that isolate variables too aggressively may overlook the structural conditions within which those variables operate. As noted by Checkland [33] and Meadows [34], system behavior cannot be understood solely by examining components in isolation; it emerges from relationships and feedback mechanisms.

In project, program, and portfolio environments, complexity is further intensified by multi-level interactions. Decisions at the portfolio level shape project-level behavior, while project outcomes feed back into organizational strategy [35]. Governance structures influence how methods are selected and applied, creating interdependencies across levels of analysis [1], [2].

This is not an argument against focused empirical studies. Rather, it highlights a structural limitation: while individual studies can examine relationships within bounded contexts, there is no inherent mechanism for connecting those insights across studies in a way that reflects the broader system [17], [36]. As a result, research captures elements of complex systems without providing a structured basis for integrating them into cumulative understanding [18], [37].

2.4 Systems thinking and systemic research

Systems thinking provides a conceptual basis for addressing complexity by shifting attention from isolated components to relationships, patterns, and feedback loops [33], [34], [38]. It has been widely adopted in management and organizational research to understand the broader consequences of decisions and interventions [39].

However, systems thinking primarily operates at the level of interpretation rather than research structure. A researcher may adopt a systemic perspective and still produce a study

that remains isolated from adjacent work. In this sense, systems thinking supports how problems are conceptualized, but not how research is coordinated or accumulated [25], [29], [40], [41].

The distinction, therefore, lies between thinking systemically and structuring research systemically. While the former is increasingly present in the literature, the latter remains underdeveloped. Systems thinking explains why integration is necessary, but it does not specify how studies should be related, how constructs should be aligned across contexts, or how knowledge should evolve cumulatively over time [18], [25], [29], [36].

This gap reinforces the need for a research architecture that operates beyond individual studies, enabling relationships identified within one context to be systematically connected, compared, and refined across a broader body of research [24], [37], [42], [43].

2.5 Knowledge integration and interdisciplinarity

Interdisciplinarity is often proposed as a response to fragmentation in research arising from increasing specialization across disciplines [27], [28]. Repko and Szostak [9] define interdisciplinary research as the process of integrating insights from multiple disciplines to address a problem too broad for a single field. Klein [44] similarly emphasized that interdisciplinarity is not merely juxtaposition but integration.

This is clearly valuable. Yet, in practice, interdisciplinary work often remains project-specific. A study may successfully integrate two or three bodies of literature, but the integration usually stops there. There is no guarantee that the next study addressing a related problem will use the same structure, constructs, or terminology. As a result, integration is achieved within a study but not necessarily across studies [25].

The consequence is that interdisciplinarity reduces fragmentation locally but does not solve the problem of cumulative development at the field level. The issue is not only whether disciplines are brought together. It is whether the knowledge produced can be coordinated, compared, and accumulated over time [18], [25], [43].

2.6 Cognitive structuring and frameworks

Frameworks play a central role in structuring complex applied problems. They help define scope, identify constructs, make relationships visible, and guide data organization and analysis [45], [46]. In applied research, they support movement from conceptual ambiguity to analytical structure by clarifying relationships and enabling sensemaking in complex environments [47].

As cognitive devices, frameworks therefore help researchers organize inquiry and make complex phenomena researchable. Their value lies in providing structure without necessarily prescribing a single method or theoretical position.

However, when frameworks are treated as standalone study artifacts, they do not necessarily resolve the challenge of cumulative knowledge development across multiple research efforts [18], [25], [36].

Five limitations may arise in such circumstances. First, frameworks may not specify who maintains construct definitions, what validation standards apply, how relationships are approved, or how versions are controlled over time [22], [24], [25]. Second, they may not be designed for cumulative extension across multiple studies [18], [21], [25]. Third, they may not provide a shared structure across research efforts, limiting comparability and coordination [25], [36], [43]. Fourth, inconsistencies in construct definition and terminology may hinder conceptual clarity and synthesis [22], [23]. Fifth, context-specific frameworks may lack mechanisms for systematic comparison across contexts [24], [43].

Taken together, these limitations indicate that the problem is not the absence of frameworks, or an inherent deficiency in frameworks themselves, but their isolation from a broader architecture that enables governance, coordination, comparison, and evolution across studies.

2.7 Positioning FBRA relative to established approaches

FBRA draws on functions that are already present in established research and knowledge-structuring approaches. Its contribution does not depend on portraying these approaches as deficient or claiming that their individual elements are new. The distinction concerns their primary purpose, timing, and unit of coordination.

A particularly important distinction concerns systematic reviews and meta-analyses. These approaches primarily operate retrospectively: individual studies are completed, relevant studies are subsequently identified and assembled, and their findings are synthesized or, where appropriate, statistically aggregated [17], [18], [21], [25]. FBRA addresses a different point in the research process. It is intended to operate prospectively by establishing a research architecture within which constructs, relationships, contextual boundaries, and research pathways can be coordinated before and across studies. Evidence generated by those studies can then be linked back to the relevant constructs and relationships, allowing the framework instance to evolve cumulatively.

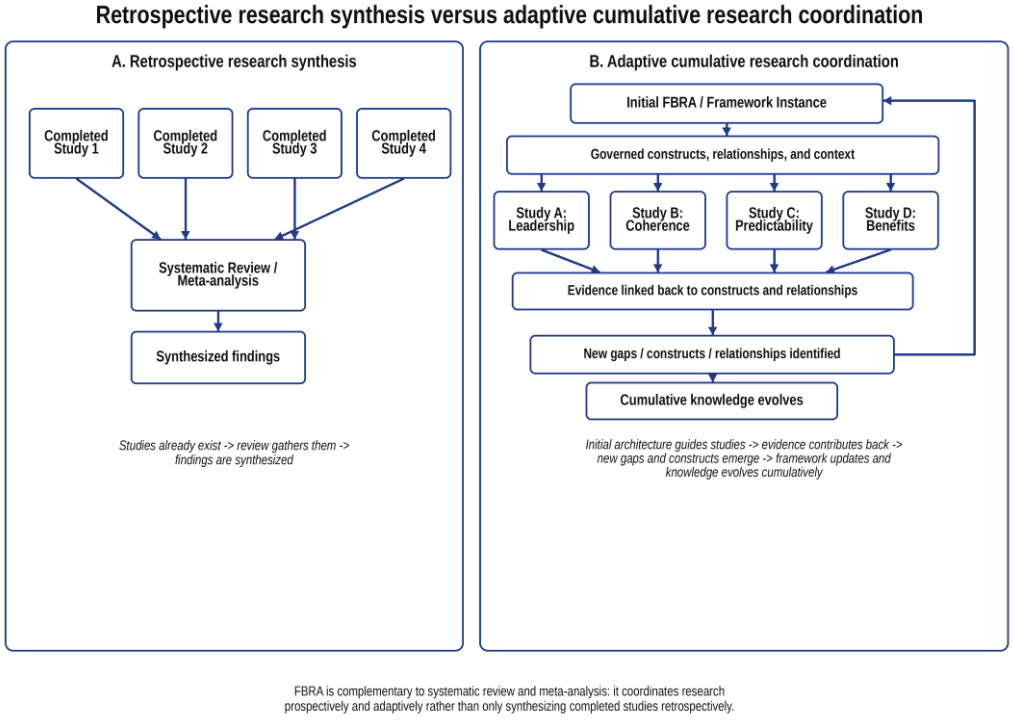


Figure 1: Retrospective synthesis versus adaptive cumulative research coordination

Figure 1 illustrates that the two approaches are complementary rather than competing.

Systematic reviews and meta-analyses provide mechanisms for consolidating evidence from studies that already exist. FBRA is intended to provide a structure through which ongoing and future studies can remain independently designed while contributing to a shared and evolving research architecture. Systematic synthesis may subsequently form part of the evidence contributed to a framework instance.

The same distinction applies, in different ways, to other established approaches. Table 1 summarizes their primary strengths and identifies the boundary relative to the proposed role of FBRA.

Table 1: Positioning FBRA relative to established research approaches

Approach	Primary purpose and strength	Typical scope boundary relative to FBRA
Systematic review and meta-analysis [17], [18], [21], [25]	Retrospectively synthesizes completed research and, where appropriate, aggregates effects.	Does not normally govern how future studies define constructs, specify relationships, record context, or contribute to an evolving research architecture.
Interdisciplinary research [8], [9], [44]	Integrates perspectives from several disciplines to address complex problems.	Integration is commonly achieved within a study; cross-study stewardship, evidence provenance, and cumulative evolution are not automatic consequences.
Research program [48]	Provides continuity around a related problem, theoretical core, or sequence of inquiries.	Can coordinate related research strategically, but does not necessarily formalize construct definitions, evidence linkage, contextual instances, or version governance.
Ontology [49]	Formally specifies shared concepts and relationships to support consistent and reusable knowledge representation.	Does not by itself specify research pathways, evidence requirements, study coordination, or the evolution of context-specific research instances.
Design science [50], [51]	Designs, demonstrates, and evaluates artifacts intended to address identified problems.	Can be used within FBRA research, but primarily concerns artifact development and evaluation rather than cumulative coordination across multiple independent studies.
FBRA	Prospectively and adaptively coordinates cumulative applied research through governed, context-specific framework instances.	Integrates constructs, relationships, studies, contextual boundaries, evidence provenance, and controlled evolution; its effectiveness remains to be evaluated empirically.

The comparison indicates that FBRA's proposed contribution is architectural and configurational rather than elemental. Systematic reviews and meta-analyses may contribute synthesized evidence; interdisciplinary studies may investigate cross-domain relationships; ontologies may support formal knowledge representation; design-science studies may develop and evaluate artifacts; and research programs may organize related inquiries. FBRA is intended to provide a higher-order coordination structure through which these contributions can remain traceable and cumulatively connected across studies and contexts.

2.8 Knowledge gap

The preceding review indicates that the problem is structural rather than conceptual. Existing approaches can organize, integrate, represent, or synthesize research, but they do not normally provide a common architecture for coordinating constructs, relationships, contextual boundaries, evidence, and their evolution across multiple studies. Consequently, applied research can remain rigorous at the study level while producing weak cumulative linkage across related research efforts.

The identified gap is therefore the absence of a research architecture that provides: (1) governance of definitions, standards, and evolution; (2) shared construct organization and terminology alignment; (3) relationship linkage across studies; (4) explicit contextual boundaries and transferability conditions; (5) evidence provenance and status; (6) controlled cumulative evolution as new evidence, contradictions, constructs, relationships, and research

needs emerge; and (7) explicit linkage between research outputs, their intended users and decision contexts, and the potential benefits and wider value that the research may enable.

The latter is particularly relevant in applied research, where the contribution of research ultimately depends not only on knowledge production but on whether that knowledge can inform decisions, practices, benefits, and wider value within the context in which it is applied.

This gap motivates the FBRA proposed in this paper.

3 RESEARCH METHODOLOGY

3.1 Research approach and design

This study adopts a **conceptual research-architecture development approach** to address fragmentation in applied research.

The research follows a three-stage process. First, fragmentation in applied research is examined through a conceptual synthesis of literature on disciplinary structures, interdisciplinary research, systems thinking, frameworks, construct clarity, and cumulative knowledge. This stage identifies the structural gap addressed by FBRA and informs the comparison with existing research approaches presented in Section 2.7.

Second, FBRA is developed as a research architecture for coordinating domains, constructs, relationships, evidence, framework instances, and governance mechanisms across studies.

Third, FBRA is examined through a problem-led operational demonstration using the developing Metropolitan Cape Town framework instance. Research pathways addressing leadership, structural coherence, portfolio volatility and predictability, adaptive coherence, project–operations balance, benefits and public value, and sustainability are positioned within the shared instance. The demonstration considers whether these studies can remain methodologically independent while using or extending related constructs and relationships.

The study is conceptual and qualitative. It does not seek to empirically test the substantive relationships represented within these research pathways, but to establish and examine the structural architecture through which such research can be coordinated. The unit of analysis is therefore the proposed research architecture and the framework instance as its operating unit, rather than the substantive causal relationships investigated by the associated studies.

3.2 Validity and rigor

Rigor is addressed in five ways. First, the architecture is grounded in the literature and structural research gap developed in Section 2. Second, internal consistency is supported by explicitly defining and distinguishing FBRA, framework instances, domains, constructs, relationships, evidence, and governance. Third, conceptual transparency is supported by stating the architecture's purpose, boundaries, assumptions, and limitations and by distinguishing proposed relationships from empirically supported findings.

Fourth, the Metropolitan Cape Town operational demonstration is examined against explicit criteria: whether a framework instance can define a context and boundary; position multiple studies; link studies to shared or related constructs and relationships; preserve study-level methodological independence; and allow evidence or newly identified research needs to feed back into the evolving instance.

Fifth, claims are bounded by distinguishing **operational plausibility from empirical validation**. The comparison with established research approaches in Section 2.7 also reduces the risk of novelty being asserted solely through terminology.

3.3 Limitations of the methodological approach

This was a conceptual study and did not provide empirical validation of FBRA. The Metropolitan Cape Town early operational demonstration showed that the architecture could be instantiated and could position multiple research pathways within a shared structure; it did not establish that FBRA improves research quality, efficiency, completion, coordination, practitioner uptake, or practical outcomes.

Several associated studies remained under development, and the evidence-accumulation and framework-revision cycles had not yet been observed longitudinally. Governance was specified here only at the level required to explain the foundational architecture. A companion paper submitted to the XIV SINGEP-CIK-SPARK 2026 International Conference develops this aspect further by proposing an operational lifecycle for designing, governing, versioning, integrating evidence within, and evolving framework instances [52].

Detailed governance roles, evidence thresholds, versioning procedures, and decision workflows nevertheless require further application and empirical evaluation. Transferability across other geographic, institutional, sectoral, and topic-based contexts also remains to be tested.

4 RESULTS: FBRA AND EARLY OPERATIONALIZATION

4.1 Overview of results

The primary result of this study is the development of a Framework-Based Research Architecture (FBRA) for the structured coordination and cumulative development of knowledge across multiple studies in applied research contexts.

Unlike conventional Results sections that present statistical outcomes, the results here consist of three interrelated outputs:

1. a defined research architecture;

2. a structured set of representational and operating components, including domains, constructs, relationships, framework instances, studies and evidence, and governance;

3. early operationalization through the developing Metropolitan Cape Town framework instance.

The third output establishes operational plausibility rather than empirical effectiveness.

4.2 Core structure of FBRA

Within each framework instance, research is organized around three core representational elements: domains, constructs, and relationships.

1. **Domains** represent high-level problem-relevant conceptual areas that define the research system. In applied contexts, these may include leadership, governance, structure, culture, delivery systems, and value realization.
2. **Constructs** are researchable concepts positioned within domains. Examples include structural coherence, portfolio volatility, delivery predictability, adaptive coherence, and benefits realization.
3. **Relationships** link constructs within or across domains and may be direct, mediated, moderated, associative, or exploratory. Together, these elements enable research to move beyond isolated variable analysis toward the structured examination of system interactions.

These elements operate within context-specific framework instances and are coordinated by governance across the architecture and framework-instance levels. Architecture-level governance provides shared principles for construct definitions, relationship classification, evidence traceability, and controlled evolution. Framework-instance governance applies those principles to the specific context while preserving researchers' ability to select appropriate questions, theories, methodologies, and methods.

The elements are also supported by explicit construct definitions, traceable measurement choices, and mechanisms for the framework instance to evolve as evidence accumulates. FBRA is therefore not simply a framework. It is an architecture for creating, coordinating, and evolving multiple framework instances and the research conducted within them.

The proposed governance model operates at two levels. At the architecture level, an FBRA stewardship group maintains shared definitions, relationship classifications, evidence-status rules, and versioning principles. At the framework-instance level, an appointed instance steward and review group assess proposed additions or revisions. Researchers submit changes with their rationale and provenance; decisions are recorded as approved, provisional, superseded, or retired and released through a version log. These controls govern traceability and evolution rather than researchers' choice of questions, theories, or methods.

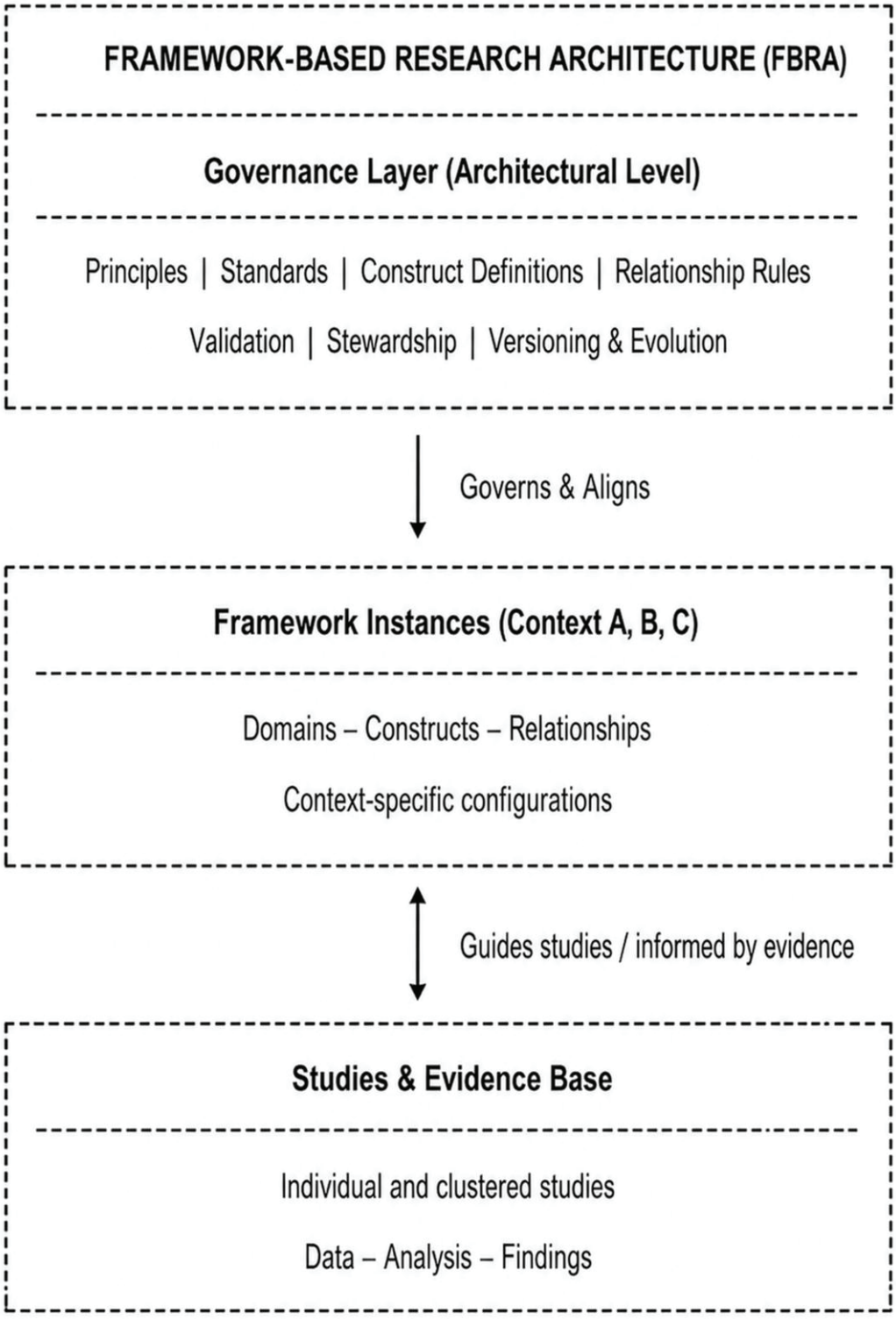


Figure 2: FBRA governance layer coordinating framework instances, studies, and evidence

Figure 2 should be read as a layered research system. The governance layer establishes common principles and controls. Each framework instance then configures domains,

constructs, relationships, boundaries, and assumptions for a defined context. Individual studies investigate selected parts of that model and contribute evidence back to the relevant constructs and relationships. The resulting evidence may support, challenge, refine, or extend the framework instance.

The figure therefore represents coordination and traceability rather than centralized control of individual studies. Studies remain independently designed, but their positioning within the architecture makes their relationships to other studies and to the wider research problem explicit.

4.3 Contextual positioning of FBRA

FBRA is applied through framework instances. In this paper, a framework instance is treated as a governed, context-specific research model that organizes the purpose, boundaries, domains, constructs, relationships, assumptions, studies, and evidence associated with a defined applied problem.

Context informs the selection and configuration of these elements and establishes the conditions under which findings should be interpreted. It does not function as a fixed structural component or universal taxonomy. Context is made explicit through the framework instance's scope, boundaries, assumptions, exclusions, dependencies, levels of analysis, and transferability conditions.

This separation allows framework instances to remain adapted to their settings while retaining sufficient architectural consistency to support comparison and cumulative knowledge development.

4.4 Structural representation

The architecture organizes research into a multi-domain system. Constructs are positioned within domains and linked through defined relationships. This allows research to move beyond isolated variable analysis and instead examine how constructs interact across a broader system.

FBRA supports:

- cross-domain interaction,
- multi-level analysis,
- the identification of missing constructs, relationships, or evidence,
- refinement of relationships over time, and
- coordinated positioning of multiple studies.

4.5 Early operationalization: Metropolitan Cape Town

To examine operational plausibility, FBRA has been applied at an early stage through a developing Metropolitan Cape Town framework instance. The instance is bounded around metropolitan municipal project systems rather than public administration generally and spans project, portfolio, PMO, team, and municipal-system levels.

Operationalization to date includes an initial problem and scope definition, construct and relationship maps, multiple coordinated research pathways, and shared documentation and governance arrangements. The problem-relevant domains include governance and PMO structure, leadership, structural coherence, portfolio stability, adaptive delivery, project-operations balance, benefits realization, public value, and sustainability.

The developing instance has also moved into institutional engagement. Discussions have been held with senior academic representatives responsible for project management and industrial

engineering at the University of Cape Town and Stellenbosch University regarding participation in, and potential governance support for, the Metropolitan Cape Town framework instance. These discussions have generated positive interest in contributing to the further development and use of the instance. Such engagement is treated here as evidence of implementation readiness and stakeholder adoption potential rather than as empirical validation of FBRA.

Beyond Cape Town, the FBRA concept has also been presented to Nove de Julho University (UNINOVE), São Paulo, Brazil, where discussions have agreed on a pilot involving three doctoral researchers. The intention is for these researchers to undertake studies within an FBRA-guided environment and, subject to the results of the pilot, potentially extend the approach to a broader doctoral research program in project management. The pilot is not treated as an operationalized Brazilian framework instance in the present paper; rather, it represents an approved cross-context application of FBRA through which the architecture's transferability, scalability, and applicability to coordinated doctoral research can subsequently be examined.

These developments show that the architecture can be populated, used to position related research, and attract interest from external academic partners. They do not constitute empirical validation of FBRA or of the substantive relationships represented within the framework instance. Several associated studies remain under development, and their proposed relationships should not be interpreted as validated findings.

4.6 Coordinated research pathways

The architecture enables the definition of coordinated research pathways across domains. The Metropolitan Cape Town framework instance currently accommodates several developing research pathways:

- **Leadership → Structural Coherence**, with governance considered as a moderating or boundary condition.
- **Structural Coherence → Portfolio Volatility → Portfolio Predictability**.
- **Adaptive Coherence → Delivery Predictability**, with Structural Coherence considered as a moderating condition.
- **Project → Output → Primary and Secondary Outcomes → Benefits → Public Value**.
- **Enabling Team Conditions → Team Tension Management Capability → Balanced Project and Operations Performance**.
- **PMO Structural Cohesiveness/Coherence → Sustainable Outcomes**.

Each pathway can be studied independently and may use a different theoretical or methodological approach. Within FBRA, however, the pathways are positioned in relation to shared or connected constructs, making dependencies, definitional tensions, and evidence requirements visible. The architectural result is coordinated research without requiring methodological uniformity.

The use of both *structural coherence* and *structural cohesiveness* across the developing pathways also illustrates the need for construct governance. Their respective definitions and conceptual relationship must be made explicit rather than assuming that the terms are interchangeable.

4.7 Illustrative system-level insights

Positioning the pathways together exposes system-level relationships that would be less visible if each study were represented in isolation. For example, leadership may influence portfolio predictability indirectly through structural coherence and portfolio volatility. Structural

coherence may also condition whether adaptive coherence contributes to predictable project delivery.

In the value-realization pathway, project outputs may generate primary and secondary outcomes that contribute to benefits and wider public value. This connects project delivery to cross-directorate and city-wide effects that would be difficult to represent within a narrowly bounded delivery study.

The same pathway also illustrates how a framework instance may provide a basis for tracing the potential value of research itself. Because research questions, constructs, evidence, intended users, and contextual decision problems are positioned within the same instance, it becomes possible to examine how research findings are subsequently used and whether that use contributes to identifiable outcomes, benefits, or wider value. In the Metropolitan Cape Town context, for example, research identifying previously unrecognized secondary or latent benefits from capital investment programs could create practical value if those benefits are subsequently recognized, measured, and realized. Such value is not demonstrated in the present study, but FBRA provides a structure through which it could be investigated and traced.

The project–operations pathway introduces a team-level mechanism through which competing demands may be balanced, while the sustainability pathway extends the instance toward organizational and societal outcomes. Together, these pathways illustrate how FBRA can connect research operating at different levels of analysis.

These relationships are researchable propositions and pathways, not empirical findings of this paper. Their value at this stage is that they expose where studies connect, where constructs require alignment, and where additional evidence or new areas of investigation are needed.

4.8 Framework instances as evolving research models

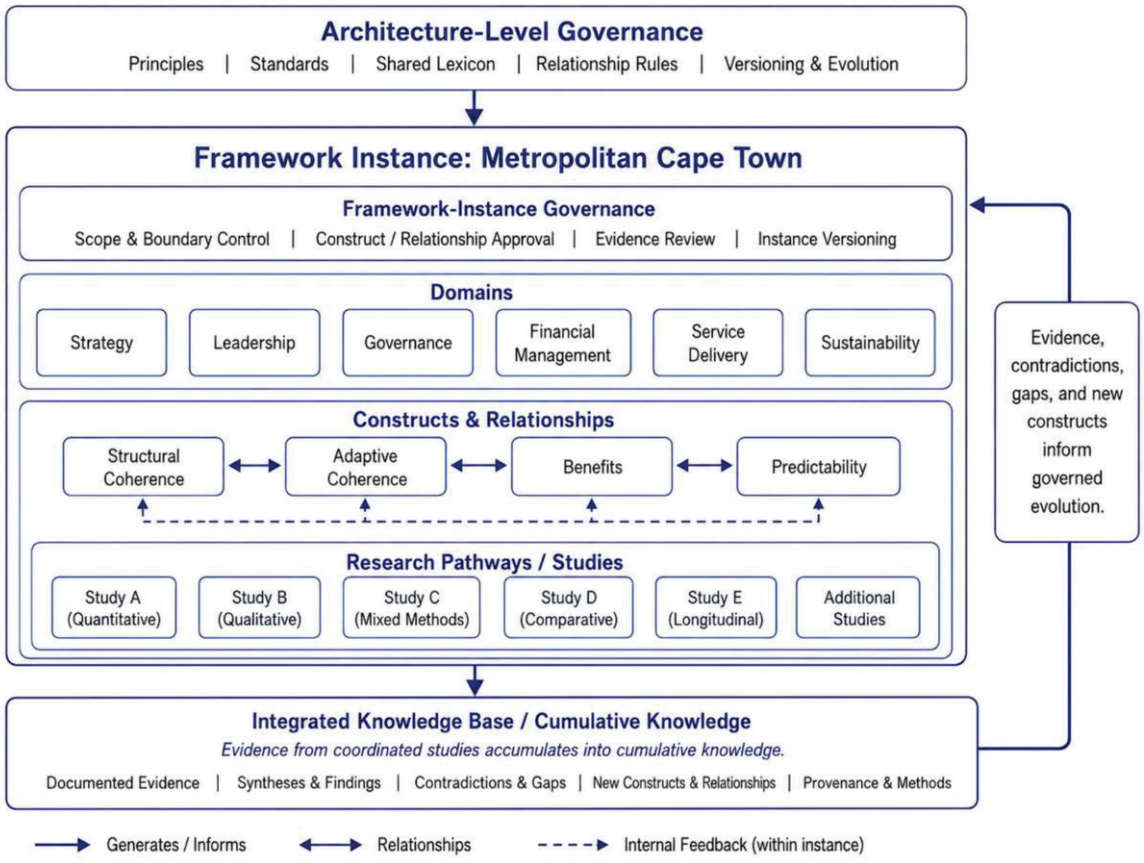


Figure 3: FBRA framework instance as evolving research models

A central result of the study is the concept of the framework instance as an evolving research model rather than a passive knowledge container. Within a framework instance:

- domains define the problem-relevant conceptual areas;
- constructs represent the researchable elements;
- relationships specify how those elements may interact;
- studies investigate selected constructs and relationships; and
- evidence is linked to the relevant parts of the model.

Figure 3 should be read as an adaptive cycle. An initial framework instance provides a governed baseline for research. Studies then generate evidence, identify contradictions, or reveal previously unrecognized constructs, relationships, boundary conditions, or research gaps. These inputs are reviewed and, where justified, incorporated into an updated version of the framework instance. The revised instance then informs subsequent research.

Cumulative development therefore occurs through repeated cycles of inquiry, evidence integration, and controlled evolution rather than through complete advance specification. This adaptive logic allows FBRA to coordinate research prospectively without assuming that every relevant problem, construct, or relationship can be identified at the beginning.

Framework instances remain context-specific, but common architectural principles make it possible to compare how constructs and relationships behave across settings without assuming automatic transferability. The detailed lifecycle for designing, governing, integrating evidence within, versioning, and evolving framework instances is developed in a companion study submitted separately [52].

4.9 Summary of results

The results define the proposed FBRA architecture and demonstrate its early operationalization through the Metropolitan Cape Town framework instance. They establish:

- the structural logic of FBRA for organizing applied research across domains, constructs, relationships, studies, evidence, and governance;
- the role of framework instances as governed, context-specific, and adaptive research models;
- the operational plausibility of positioning multiple developing research pathways within a common framework instance while preserving the methodological independence of individual studies;
- the ability of the architecture to make shared constructs, relationships, dependencies, research gaps, and terminology issues visible across studies;
- a structured mechanism for coordinating multiple studies within a shared research architecture, rather than treating them as isolated research efforts;
- a mechanism through which evidence, contradictions, emerging constructs, and new research needs can be linked back to the framework instance and considered through governance;
- the basis for cumulative knowledge development through repeated cycles of coordinated research, evidence integration, and governed framework evolution;
- a shift in research logic from isolated studies toward structured, connected, and evolving research systems; and

- a basis for tracing how research evidence may connect to practitioner decisions, subsequent outcomes, benefits, and wider value within the context of a framework instance.

These results establish the architectural logic, early operationalization, and operational plausibility of FBRA. They do not establish its empirical effectiveness. Whether FBRA improves research coordination, construct clarity, evidence reuse, practitioner uptake, or cumulative knowledge development remains to be evaluated longitudinally and across multiple framework instances.

5 DISCUSSION

This study reframes fragmentation in applied research as a structural problem: rigorous studies may generate useful local findings while remaining weakly connected to related work across domains and contexts. FBRA responds by adding a coordinating architecture above individual studies. Its proposed novelty is therefore architectural and configurational, rather than a claim that domains, constructs, relationships, frameworks, or governance are individually new.

This distinction clarifies FBRA's relationship with existing approaches. Systematic reviews and meta-analyses synthesize completed research; interdisciplinary studies integrate perspectives within a study; systems thinking helps interpret interdependence; research programs coordinate related inquiries; ontologies represent shared concepts; and design science develops and evaluates artifacts. FBRA is intended to complement these approaches by providing a governed structure through which their contributions can be positioned, traced, compared, and carried forward across studies. The contribution lies in coordinating research prospectively and adaptively while retaining the ability to incorporate completed evidence.

This has particular relevance in complex applied environments. Individual studies must impose boundaries, but the wider problem may involve interactions among governance, leadership, structures, delivery systems, benefits, and public value. A framework instance makes those boundaries and relationships explicit without claiming to represent the whole system or identify every relevant construct in advance. As evidence, contradictions, and new questions emerge, the instance can be revised through governance. This adaptive logic is important because cumulative research cannot be fully predetermined.

Framework instances are also designed to address construct drift and weak evidence traceability. FBRA does not require identical definitions in every context or prevent theoretically justified alternatives. It requires definitions, scope conditions, relationship types, evidence status, provenance, and changes to be explicit. This supports comparison while preserving contextual validity and makes disagreements visible rather than allowing them to remain hidden in inconsistent terminology [22], [23].

The Metropolitan Cape Town instance illustrates the analytical potential of positioning related pathways within one research structure. The value-realization pathway distinguishes project outputs, primary and secondary outcomes, benefits, and public value. Other pathways connect leadership, structural coherence, portfolio volatility, predictability, adaptive coherence, project–operations balance, and sustainability. The significance is not that these relationships have been validated by this paper, but that the architecture reveals dependencies, gaps, competing definitions, and possible system-level mechanisms that isolated studies may overlook.

For research, FBRA offers a way to coordinate studies without imposing methodological uniformity. This may be especially useful in doctoral and practitioner-led research, where studies commonly develop independently and duplicate conceptual and measurement work. For practice, a framework instance may improve visibility of what evidence exists, which relationships remain provisional, and where additional research is needed. Its practical value must, however, be demonstrated through actual use in governance, portfolio, PMO, benefits-

realization, and public-value decisions rather than inferred from the architecture alone [5], [43].

A further implication concerns the value of applied research. Research value is often difficult to establish because research outputs, practitioner use, subsequent decisions, and organizational outcomes are rarely represented within a common structure. A framework instance may make this pathway more explicit by linking research questions and evidence to defined contextual problems, intended users, and decision settings. This creates the possibility of tracing whether research contributes to changes in practice and, subsequently, to identifiable benefits or wider value. The Metropolitan Cape Town benefits-realization pathway provides an illustrative setting in which such value could eventually be examined, including whether research helps identify and realize secondary or previously unrecognized benefits from municipal capital investments. This remains a future empirical question rather than a demonstrated outcome of FBRA.

Practical adoption also depends on institutional conditions. Framework instances require identifiable stewardship, accessible shared records, agreed change procedures, and incentives for researchers and practitioners to contribute. Early Cape Town engagement and the approved Brazilian cross-context pilot indicate adoption potential, but they should be treated as implementation readiness rather than evidence that FBRA has already improved research or practice.

A principal risk is over-governance. If FBRA becomes prescriptive, it could constrain originality and reproduce the fragmentation it seeks to address through rigid classifications. Governance should therefore be enabling: researchers remain free to challenge constructs, propose alternative relationships, use different methods, and introduce new areas of inquiry. Governance concerns stewardship, transparency, evidence review, versioning, and the justification of changes—not centralized control of research conclusions. The operational lifecycle and associated controls are developed further in a separately submitted companion paper [52].

The key theoretical implication is that cumulative knowledge development can be treated as a research-design and governance problem, not only as a later synthesis problem. However, this study establishes the proposed architectural logic and early operational plausibility rather than empirical effectiveness. Future research should evaluate FBRA longitudinally and comparatively against criteria including construct consistency, relationship traceability, evidence reuse, contradiction detection, governance quality, research efficiency, practitioner uptake, transferability, and cumulative integration. Stronger claims about value or impact should depend on that evidence.

6 CONCLUSION

This paper addressed fragmentation in applied research as a structural problem arising not only from disciplinary specialization, but from the limited mechanisms available to connect constructs, relationships, studies, and evidence over time. The analysis showed that existing approaches provide important functions but do not normally supply a common architecture for prospective and adaptive coordination across distributed research efforts.

FBRA was proposed as that coordinating layer. It organized research through governed, context-specific framework instances that can position multiple studies, preserve methodological independence, make conceptual dependencies visible, and evolve as evidence and new research needs emerge. Early operationalization through the Metropolitan Cape Town instance showed that the architecture could be populated with related research pathways and used to expose shared constructs, gaps, and terminology issues.

The study remained conceptual and did not establish that FBRA improves research quality, efficiency, practitioner uptake, or cumulative knowledge development. These outcomes require longitudinal and cross-context evaluation, including assessment of governance, evidence reuse, transferability, and realized research value.

The paper therefore provided a foundation for moving applied research from isolated studies toward connected, governed, and evolving research systems, while defining the empirical questions that subsequent FBRA research must address.

Future evaluation should also examine whether framework instances improve the traceability of research into practitioner use, realized benefits, and wider organizational or public value.

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The Influence Of Organisational Culture On Project Communication Management And Project Success: A Case Study Of Project Success In A Namibian Consulting Construction Organisation

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THE INFLUENCE OF ORGANISATIONAL CULTURE ON PROJECT COMMUNICATION MANAGEMENT AND PROJECT SUCCESS: A CASE STUDY OF PROJECT SUCCESS IN A NAMIBIAN CONSULTING CONSTRUCTION ORGANISATION

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ABSTRACT

This study explores how organisational culture (OC) influences project communication management (PCM) within a Namibian consulting construction firm. Using a qualitative Delphi approach with seven senior engineering professionals, the research identified three core themes: leadership influence, cultural resistance to digital tools, and the interplay between hierarchy and collaboration. The firm's mixed hierarchical-clan culture shaped communication practices by balancing structure, trust, and teamwork. Leadership emerged as crucial for fostering psychological safety, accountability, and proactive engagement. Although digital tools such as Microsoft Teams were available, cultural resistance and limited adoption undermined communication. Unclear roles, ego-driven interactions, slow information flow, and email miscommunication were linked to project delays and cost overruns. Project success was defined by time and budget, client satisfaction, functional designs, and stakeholder collaboration. Team dynamics is proposed as a mediator through which OC and PCM influence project success. This is an expert-informed proposition that requires quantitative validation

Keywords: Organisational culture, project communication management, team dynamics, project success

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1 INTRODUCTION

Project communication management (PCM) coordinates stakeholders, information flow, and team alignment. Organisational culture (OC) shapes these interactions through shared values and norms. Although both are critical, research on their relationship is limited within multidisciplinary consulting construction organisations where civil, structural, mechanical, and electrical professionals must collaborate in fast-moving environments. If a disconnect exists between cultural values and communication practices, it introduces role ambiguity, fragmented communication channels, and cultural misalignment, leading to project delays and conflicts. Conversely, an OC encouraging open communication can enhance stakeholder satisfaction. While prior African studies examine culture–communication links, most focus on large-scale contractors or public infrastructure, leaving a gap in how smaller, private multidisciplinary consulting firms manage these dynamics. This study investigates how OC affects project communication and teamwork within a Namibian consulting engineering company. Misalignments can trigger project failure, yet context-specific empirical research remains sparse in Namibia's sector, which comprises over sixty consulting engineering firms [1].

To examine these dynamics, this study utilises a qualitative Delphi method to gather expert consensus, limit groupthink, and identify structural patterns through iterative rounds of interviews and surveys with senior engineering professionals. The study is guided by four core research questions:

I. What values of organisational culture influence project communication management practices within the Namibian consulting company?
II. How do team dynamics, influenced by organisational culture, impact project communication effectiveness?
III. What challenges do project teams face in aligning organisational culture with project communication practices?
IV. What is the impact of project communication practices and organisational culture on project success in the consulting construction environment?

Theoretically, this study introduces a contextually adaptive framework that integrates OC and PCM and proposes team dynamics as a possible mediator between them and project success. Because the Delphi method builds expert consensus rather than testing statistical relationships, this mediating role, and the other links in the framework, are presented as expert-informed propositions that future quantitative research must validate. Practically, it offers targeted recommendations for consulting firms to align cultural values with communication strategies to improve project performance, contributing directly to the expanding body of engineering management literature in the Southern African context.

2 LITERATURE REVIEW

2.1 Project communication management

Project Communication Management (PCM) involves planning, sharing, storing, and overseeing essential project information to coordinate multidisciplinary teams and support critical governance decisions regarding risk, conflicts, and stakeholder engagement [2]–[4]. By optimising information flows, PCM minimises delays, miscommunication, and project costs, ultimately driving client satisfaction and successful project delivery [5], [6]. A structured communication plan defines stakeholder roles, communication channels (individual, group, organisational), styles (formal, informal), and delivery mechanisms (push, pull) [4]. In contemporary project environments, digital platforms like Microsoft Teams, email, and instant messaging accelerate information exchange. However, these tools face constraints from cultural resistance or inconsistent adoption, which can limit collaboration across distinct locations and areas of technical expertise [7]. Beyond structural transmission, effective

project communication requires interpersonal competencies—such as conflict resolution, negotiation, and team motivation—to help project managers navigate linguistic, cultural, and environmental complexities [2], [5].

Technology acceptance theory helps explain why available tools are not always used. The Technology Acceptance Model holds that perceived usefulness and perceived ease of use shape a person's intention to use a system [8]. The Unified Theory of Acceptance and Use of Technology adds social influence and facilitating conditions and shows that age and experience moderate these effects [9]. These theories suggest that providing a platform such as Microsoft Teams is not enough. Use also depends on team norms and on the behaviour that senior staff model.

2.2 Organisational culture

Organisational culture (OC) encompasses the shared values, norms, beliefs, and behaviours that shape how members navigate internal dynamics and external challenges [6], [10]. OC manifests as both substance (core principles) and form (enacted practices), profoundly influencing individual decision-making and interpersonal interactions [11]. Schein and Schein [12] describe culture at three levels: visible artefacts, espoused values, and basic underlying assumptions. Communication habits are visible artefacts, but they rest on deeper assumptions about authority and trust. This helps explain why they change slowly. In construction and engineering management literature, OC typologies are frequently categorised using the Competing Values Framework into four dimensions: Clan culture (teamwork, trust, and support); Hierarchy culture (stability, procedural rules, and consistency); Market culture (competition and results); and Adhocracy culture (flexibility and innovation) [13], [14]. These deep-seated cultural norms dictate how internal and external communication channels are managed [15]. Aligning cultural orientations with organisational strategy streamlines communication structures, drives employee engagement, and builds intercultural resilience against systemic communication barriers [10], [16].

Organisational culture also sits within national culture. Hofstede [17] defines power distance as the extent to which less powerful members of a society accept that power is distributed unequally. Where power distance is high, information tends to flow vertically, and junior staff are less likely to question seniors. This dimension is relevant to the hierarchical communication patterns examined in this study.

2.3 Team dynamics and psychological safety

Team dynamics are the behavioural and relational patterns through which team members interact, coordinate and resolve differences. Tuckman [18] showed that groups move through developmental stages (forming, storming, norming and performing), so communication quality changes as a team matures. Salas et al. [19] identified five core components of teamwork: team leadership, mutual performance monitoring, backup behaviour, adaptability and team orientation. These are supported by shared mental models, mutual trust and closed-loop communication.

Edmondson [20] defined team psychological safety as a shared belief that the team is safe for interpersonal risk-taking. Her study showed that psychological safety supports team learning behaviour, which in turn relates to team performance. In multicultural construction teams in Kenya and the United Kingdom, Ochieng and Price [21] found that project leaders play a central role in building shared understanding and open communication across cultural groups. Together, these studies show that team-level processes can carry the influence of wider factors, such as culture and leadership, through to project outcomes. This is the theoretical basis for treating team dynamics as a possible mediator in the present framework.

2.4 Defining project success

Project success is no longer judged only by the "iron triangle" of time, cost and quality. Atkinson [22] argued that these criteria are "two best guesses and a phenomenon" and proposed adding benefits to the organisation and to the wider stakeholder community. This multidimensional view frames the success measures used in this study: schedule and budget compliance, design functionality, client satisfaction and stakeholder collaboration.

2.5 Prior studies on organisational culture's effect on communication and project success

Empirical research demonstrates a clear nexus between OC, communication management, and project outcomes. Muneer et al. [23] established that constructive cultures enhance team collaboration, minimise scope ambiguity, and optimise knowledge exchange, with project manager competencies acting as a critical moderator. Similarly, strategic human resource interventions that focus on employee engagement and talent development strengthen cultural norms, which directly improve team performance and organisational communication [24]. Furthermore, positive organisational cultures cultivate high-performing team dynamics characterised by inclusive decision-making, trust-based relationships, and transparent feedback mechanisms [25]. Within the Southern African region, Lukas [26] confirmed that utilising diversified digital communication platforms (e.g., email, intranet, Microsoft Teams) coupled with structured feedback loops yields measurable enhancements in institutional culture and operational effectiveness in Namibia. In Ghana, Abdul-Fatawu et al. [16] assessed project communication management on construction projects, and in South Africa, Zulch [5] proposed a communication model for construction project management. Collectively, these studies confirm that OC establishes the behavioural norms and relational dynamics that dictate communication efficacy and subsequent team performance.

Two gaps follow from this review. First, most studies treat culture and communication as direct predictors of success. Few examine the team-level processes, such as trust, role clarity and psychological safety, through which they act. Second, the African evidence comes mainly from contractors, public bodies and universities rather than private multidisciplinary consultancies. A significant gap therefore remains regarding the direct interaction between OC and PCM within specialised, private consulting engineering firms—particularly in the culturally diverse, multidisciplinary landscape of Namibia. This study addresses that gap by exploring how cultural typologies and communication management practices converge to influence project success.

3 PROPOSED CONCEPTUAL FRAMEWORK

This study builds upon established organisational frameworks to introduce an integrated model exploring how Organisational Culture (OC) shapes Project Communication Management (PCM), and how these constructs interact to influence Team Dynamics and Project Success within multidisciplinary consulting engineering. The framework is exploratory. Its links are stated as propositions to be tested, not as confirmed causal paths.

3.1 Foundational theoretical models

The proposed framework synthesises and extends four core models from existing literature:

Muneer et al. [23]: Established a quantitative baseline proving that constructive organisational cultures and robust communication management directly drive construction project success, with project manager competencies acting as a critical moderator.

Zulch [5]: Positioned communication at the core of project leadership, demonstrating that communication environments dictate team building, role clarity, conflict resolution, and psychological safety.

Febrian and Solihin [24]: Highlighted that targeted human resource and organisational practices actively strengthen cultural norms, directly impacting communication performance and operational adaptability.

Adham and Sukkar [25]: Demonstrated that positive, inclusive organisational cultures strengthen team productivity by fostering trust-based relationships and open feedback mechanisms that directly enhance team cohesion.

As summarised in Table 1, the present study adapts these general paradigms to the specific context of private, multidisciplinary consulting engineering in Namibia. Crucially, it proposes Team Dynamics as a mediating construct to provide a granular view of how culturally driven communication translates into project performance, while framing the relationship as a cyclical, adaptive learning process. This mediating role is an expert-informed proposition (Section 6.5). The Delphi design used here cannot test it statistically.

Table 1: Comparative synthesis of conceptual models

Author	Constructs	Methodology	Key contribution to present framework
Muneer et al. [23]	OC, PCM, Project Scope, Leadership	Quantitative survey	Establishes the direct baseline relationship between OC, PCM, and success.
Zulch [5]	Core Communication Skills, Leadership Styles	Competency Framework	Links leadership behaviours directly to the health of the team communication environment.
Febrian and Solihin [24]	HR Practices, OC, Team Performance	Conceptual model	Identifies organisational mechanisms that intentionally drive culture and teamwork change.
Adham and Sukkar [25]	OC, Team Management, Productivity	Empirical case study	Trust and an inclusive culture enhance team cohesion and feedback.
Present Study	OC, PCM, Team Dynamics, Project Success	Qualitative Delphi Study	Integrates variables to propose that Team Dynamics mediate the OC-PCM path to success, as an expert-informed proposition for later quantitative testing.

The integrated framework consists of five structurally interlinked constructs designed to map the cultural and communicative realities of multidisciplinary engineering teams operating in culturally diverse environments.

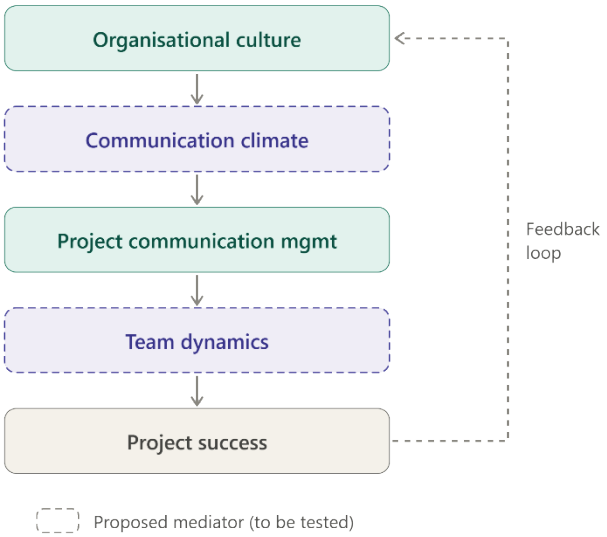


Figure 1: Proposed conceptual flow chart

Organisational Culture (OC): Formulates the foundational layer of the framework. It establishes the shared values, beliefs, and behavioural norms that govern team interactions. Hierarchical cultures default to structured, top-down channels, whereas clan-oriented cultures promote horizontal openness and interpersonal trust.

Communication Environment: Directly informed by OC, this represents the contextual climate of the workplace. It dictates the degree of psychological safety, operational transparency, and mutual accountability present when teams collaborate.

Project Communication Management (PCM): Represents the formalised methods, strategies, and digital tools (e.g., Microsoft Teams, email) used to execute information exchange across stakeholders. The tone, responsiveness, and adoption rate of PCM protocols are directly shaped by the underlying culture and communication environment.

Team Dynamics (Proposed mediator): Captures the behavioural and relational patterns within the project team, including trust, role clarity, autonomy, and collaborative engagement. In this framework, team dynamics are proposed as a mediating variable; even technically sound PCM strategies can be undermined if dysfunctional team dynamics or role friction exist.

Project Success: Measured as a multidimensional outcome encompassing time/budget compliance, design functionality, client satisfaction, and collaborative harmony [22].

As illustrated in Figure 1, a continuous feedback loop runs from project success back to OC and PCM. This acknowledges that project outcomes are not static; successes reinforce positive collaborative behaviours, while failures prompt iterative organisational adjustments and cultural learning.

4 RESEARCH METHOD

4.1 Research design

This study adopted a qualitative Delphi design to explore how organizational culture (OC) shapes project communication management (PCM) and team dynamics. The Delphi method uses iterative data collection and refinement rounds to build expert consensus on complex, context-sensitive organisational phenomena without requiring physical group meetings,

thereby minimising groupthink and promoting independent, reflective contributions [27], [28]. This interpretive, consensus-driven approach is uniquely suited for capturing nuanced perceptions, behavioural norms, and interdisciplinary interactions that are difficult to isolate using purely quantitative metrics.

The design is exploratory. It identifies relationships that experts agree on, but it cannot estimate the size or statistical significance of direct or indirect effects. Testing mediation requires quantitative data and techniques such as regression-based mediation analysis or structural equation modelling (SEM) [29]. The relationships reported in this study, including the mediating role of team dynamics, are therefore expert-informed propositions that require validation through future quantitative research.

4.2 Sampling and study population

Purposive sampling targeted senior engineering professionals within a prominent multidisciplinary consulting engineering firm in Namibia to ensure deep domain expertise. Eleven experts were invited, and seven completed the full three-round Delphi process. Selection criteria required participants to have:

- Current employment in an engineering or project management role within the organisation.
- A minimum of five years of professional experience in consulting engineering construction projects.
- Direct exposure to multidisciplinary project communication and team dynamics.
- Familiarity with organisational cultural impacts during project execution.

The panel spanned civil/structural, mechanical, and electrical engineering disciplines, capturing diverse hierarchical levels and technical perspectives. Participants were anonymised using identifiers R1 through R7.

4.3 Data collection

Data collection occurred across three structured Delphi rounds over a defined timeframe:

Round One (Exploratory Interviews): Semi-structured, 15 to 30-minute interviews were conducted with all seven participants. Aligned with the research questions, the interview protocol captured views on organisational cultural traits, communication channels, cultural barriers to PCM, and recommendations for improvement. Interviews were transcribed verbatim for qualitative analysis.

Round Two (Consensus Survey): A structured questionnaire was developed from the Round One themes. Participants evaluated statements regarding OC, PCM, leadership, team dynamics, and project success using a five-point Likert scale (Strongly Disagree to Strongly Agree).

Round Three (Consensus Refinement): Items failing to reach the predefined 70% consensus threshold in Round Two were refined for clarity and redistributed. This allowed experts to re-evaluate their positions and finalise a consensus on the core constructs.

4.4 Ethical considerations

Ethical approval was granted by the Stellenbosch University Faculty of Engineering Research Ethics Committee (Project ID: 33249; approval date: 28 July 2025).

4.5 Data analysis

Inductive thematic analysis of the interview transcripts was conducted via ATLAS.ti. Open coding identified fundamental concepts, such as communication delays and hierarchical

bottlenecks. Axial coding systematically grouped these codes into themes corresponding directly to the study's framework constructs: organisational culture typologies, communication climate, team dynamics, culture–communication barriers, and project success metrics. Code co-occurrence mapping was applied to uncover underlying relational patterns between cultural traits and communication behaviours. For the survey rounds, quantitative consensus was defined at a ≥70% agreement threshold [30]. Finally, a triangulation matrix integrated the qualitative themes with the statistical consensus ratings to cross-validate findings and isolate structural alignment patterns (Table 2). Code co-occurrence and consensus ratings show where experts agree on a relationship. They do not test whether one construct transmits the effect of another.

Table 2: Triangulation matrix integrating qualitative and quantitative data

Qualitative theme	Representative quote	Consensus rating	Interpretation / framework fit
Hierarchical Bottlenecks	"Everything must go through senior management."	78% Agreement	Hierarchical traits hinder responsiveness and reduce psychological safety.
Clan-Oriented Openness	"In our team, people feel safe to speak up because we trust each other."	85% Agreement	Trust and openness enhance collaboration and proactive engagement.
Digital Tool Resistance	"Some older staff prefer in-person meetings over Teams or email."	62% Agreement	Cultural and generational barriers limit effective use of digital platforms.
Role Clarity & Team Performance	"When roles are clear, we avoid duplication and conflict."	91% Agreement	Lack of role clarity directly undermines team coordination and accountability.
Ego-Driven Friction	"Some people just want to prove they're right, not solve the problem."	70% Agreement	Status-seeking behaviours disrupt team cohesion and problem-solving.
Leadership Support	"Our manager encourages us to speak up and take ownership."	88% Agreement	Leadership behaviours actively shape the communication climate and team engagement.
Culturally Aligned PCM	"When communication is clear and inclusive, the project runs smoothly."	91% Agreement	Structured and culturally aligned PCM improves delivery and stakeholder satisfaction.
Iterative Feedback Loops	"After each project, we adjust how we communicate based on what worked."	74% Agreement	Project outcomes systematically inform future communication and cultural practices.

5 RESULTS

5.1 Panel demographics

The Delphi panel comprised seven senior engineering professionals who fully engaged across all three iterative rounds. Six of the seven panel members had more than 11 years of project experience, with each expert having executed several multidisciplinary consulting engineering projects, ensuring deep experiential grounding (Table 3).

Table 3: Delphi panel profiles

Participant identifier	Engineering department	Years of project experience
R1	Civil/Structural	21+
R2	Mechanical	16 – 20
R3	Electrical	11 – 15
R4	Civil/Structural	21+
R5	Civil/Structural	6 – 10
R6	Mechanical	11 – 15
R7	Civil/Structural	11 – 15

5.2 Consolidated Delphi findings and thematic analysis

Rather than treating the three Delphi iterations as isolated events, this section synthesises the qualitative themes from Round One alongside their statistical tracking and consensus evolution through Rounds Two and Three (Table 4).

Table 4: Consolidated Delphi consensus and thematic matrix

Framework construct	Round 1 qualitative theme, expert insight and grounded quotes	R2 consensus	R3 consensus	Final consensus interpretation
Organisational Culture (OC)	"We're expected to collaborate, but decisions still flow top-down. You can suggest things, but final calls come from above." – R3 / "There's trust within our team, but once you go up the ladder, it's more about protocol than dialogue." – R6	Divided	Divided	Persistent tension between structural hierarchy (governance) and horizontal clan norms (trust) is structural and remains divided.
Team Dynamics (Proposed mediator)	"When the team trusts each other, communication flows. But if roles aren't clear, it becomes chaotic." – R1 / "Our manager makes space for everyone to speak — that's rare and makes a big difference." – R4	Agree (88%)	Agree (91%)	Leadership styles shape the communication climate, which experts see as determining whether team dynamics act as an enabler or barrier.
Project Communication Management (PCM)	"We have Teams, but most people still prefer face-to-face or email — it's what they're used to." – R2 / "Sometimes emails go unanswered for days, or people misinterpret tone. It's frustrating." – R5	Agree (62%)	Agree (74%)	Tech adoption is limited by cultural habits. Ineffective tool usage breeds fragmentation and misaligned scopes.
Project Success	"Success isn't just finishing on time — it's about whether the client is happy and the design works in the real world." – R4 /	Agree (91%)	Agree (91%)	Technical execution alone cannot achieve success; communication

Framework construct	Round 1 qualitative theme, expert insight and grounded quotes	R2 consensus	R3 consensus	Final consensus interpretation
	"We've had projects that ticked all the boxes technically, but the client was unhappy because they felt excluded." – R2			health and client inclusion are critical project success components.

5.3 Framework synthesis

The data suggest that Organisational Culture serves as the initial environmental anchor. While internal team subcultures leverage clan traits to build trust, the broader corporate structure remains firmly hierarchical, establishing rigid boundaries for information flows. This mixed cultural climate shapes the Communication Environment, determining the level of psychological safety and openness present during project execution. These factors directly dictate how Project Communication Management (PCM) tools are deployed. Cultural inertia and preference for legacy channels (e.g., informal face-to-face or isolated emails over centralised Microsoft Teams environments) generate frequent communication gaps, unaligned project scopes, and sequencing errors across engineering departments (Table 5).

Table 5: Individual expert perspectives on communication breakdowns

Respondent	Identified communication challenge & behavioural root cause	Impact on Project Success
R1	Collaboration relies excessively on individual personalities and interpersonal styles rather than standardised processes.	Dilutes process reliability.
R2	Late involvement of critical engineering disciplines causes severe sequencing errors and scope misalignment.	Causes structural re-work.
R3	Fragmented email distribution lists lead to inaccurate information sharing and a lack of unified stakeholder awareness.	Breeds information silos.
R4	Over-reliance on email leads to overly rigid, formal exchanges that obscure the intent of the message and obscure language barriers.	Restricts real-time collaboration.
R5	Written text lacks shared contextual or emotional cues, leading to frequent misinterpretation of communication tone.	Amplifies relational friction.
R6	Inadequate early-stage scope definition forces team members to operate on assumptions, causing misaligned expectations.	Undermines delivery metrics.
R7	Ego-driven and status-seeking interactions block collaborative inputs, directly damaging interdisciplinary performance.	Disrupts collective cohesion.

As these challenges cascade, Team Dynamics appears to act as a mediating link, as proposed in the framework. Where leadership intervenes to define specific project roles, encourage horizontal feedback loops, and foster psychological safety, teams successfully bypass rigid hierarchical barriers to maintain operational agility. Conversely, when roles blur, or leadership fails to manage ego-driven friction, team cohesion degrades, directly translating

communication breakdowns into schedule overruns, budget creep, and compromised client satisfaction. Ultimately, Project Success is achieved when teams balance structural hierarchical accountability with clan-based collaborative flexibility. The iterative feedback loop is supported by the panel: post-project reviews systematically capture these behavioural lessons, allowing past project outcomes to reshape the organisation's evolving cultural norms and future communication strategies.

6 DISCUSSION

This study evaluated the interdependent relationship between Organisational Culture (OC) and Project Communication Management (PCM) practices within a Namibian consulting engineering firm, tracking their combined influence on Team Dynamics and Project Success.

6.1 Organisational culture influence on PCM practices

The empirical results reveal a hybrid cultural configuration combining hierarchical structures with clan-oriented norms. This dual environment is consistent with the conceptualisation by Katzenbach et al. [11] of culture operating simultaneously as substance (shared collaborative beliefs) and form (enacted procedural controls). While hierarchical elements provide the baseline procedural clarity, accountability, and stable role definitions required for highly regulated, compliance-driven engineering environments, clan-oriented traits introduce the relational trust and flexibility necessary to navigate interdisciplinary complexities. This fluid, context-dependent expression of culture mirrors the adaptive construction industry frameworks proposed by Rameezdeen and Gunarathna [13]. However, the findings highlight a persistent systemic friction. The deep-seated dominance of hierarchy within engineering management reinforces vertical command chains and procedural rigidity, which can be interpreted through Hofstede's power distance dimension [17], where high power distance restricts multi-directional dialogue. Respondents confirmed that while decentralised teamwork is encouraged, critical decision-making remains strictly top-down. As argued by Groysberg et al. [10], culture heavily shapes communication style; excessive structural rigidity directly reduces operational responsiveness and creates communication bottlenecks. To optimise the communication environment, leadership must actively mediate between formal procedural boundaries and informal relational trust, demonstrating the practical application of Cameron and Quinn's Competing Values Framework [14], where clan and hierarchy typologies must be balanced to achieve strategic alignment.

6.2 Team dynamics as a proposed mediating construct

The expert consensus suggests that team dynamics may function as a mediating link translating cultural intent into project performance. High-performing interdisciplinary teams require an explicit synthesis of collaborative support and individualised accountability. When project leaders actively delegate authority and secure operational resources, they establish a supportive communication environment characterised by psychological safety, role clarity, and shared responsibility. This relational health enables engineers and technical specialists across civil, mechanical, and electrical fields to engage in proactive, horizontal problem-solving, supporting Zulch’s [5] model that leadership actions directly dictate team communication health. Conversely, when teams encounter ambiguous role boundaries, status-seeking ego friction, or restrictive vertical hierarchies, open information exchange breaks down. As demonstrated by Adham and Sukkar [25], inclusive cultural norms directly determine team cohesion and productivity. Overcoming these behavioural barriers requires leaders to consciously adjust management styles to match team composition [7], reinforcing the Project Management Institute's emphasis on integrating iterative feedback loops and robust stakeholder engagement within the core team dynamic [4].

These observations rest on expert consensus, not on a statistical test of indirect effects. They support the proposition that team dynamics mediate the relationship between OC, PCM and project success (Proposition P2 in Section 6.5), but they do not establish it. Edmondson's [20] work suggests a mechanism: psychological safety enables the learning and speaking-up behaviours that the panel linked to project performance.

6.3 Alignment challenges and digital tool resistance

The panel isolated several recurring barriers that undermine PCM effectiveness: severe email miscommunication, ego-driven isolation, delayed cross-disciplinary sequencing, and ill-defined project scopes. These disruptions frequently lead to project delays, cost overruns, and extensive technical rework, corroborating Zulch's [5] operational risk assessments. The primary structural challenge stems from the operational disconnect between spontaneous, clan-style relational communication and rigid, formal hierarchical documentation requirements. This tension increases information ambiguity and slows team response times. Furthermore, communication lags from project leads stall interdisciplinary coordination, supporting Muneer et al.'s [23] baseline assertion that proactive leadership is the primary driver bridging cultural values with daily PCM execution. A critical operational finding is the widespread underutilization of digital collaboration platforms like Microsoft Teams. Despite full technological availability, deep-seated cultural resistance and a generational preference for legacy channels (isolated emails and face-to-face meetings) impede adoption. This digital-cultural disparity echoes Lukas [26], who documented comparable institutional barriers to technology adoption within the Southern African region. It also fits technology acceptance theory, in which social influence and facilitating conditions shape use alongside perceived usefulness [8], [9]. Technical capability alone cannot optimize PCM; organizations must align their deployment strategies with the underlying behavioural readiness of their staff.

6.4 Pathways to project success

The Delphi panel rejected a purely technical definition of project success (time, cost, and scope metrics), framing it instead as a multidimensional construct that mandates client satisfaction, functional design quality, team harmony, and long-term infrastructure impact, in line with calls to look beyond the iron triangle [22]. The results suggest that project success relies heavily on communication structures rooted in trust, openness, and psychological safety, which directly drive operational coordination [10], [11]. When cultural expectations mismatch PCM practices, or when rigid hierarchies suffocate horizontal information flows, project performance drops. To mitigate this risk, integrating targeted communication training within broader corporate culture initiatives enhances overall project execution capabilities [24]. The high level of panel consensus (≥70%) across most core thematic areas indicates that balancing structural accountability with relational flexibility is essential for improving consulting engineering project outcomes.

6.5 Expert-informed propositions for future testing

In line with the exploratory Delphi design, the framework is summarised as four propositions. They describe relationships the expert panel agreed on. They are not tested effects.

- **P1:** A balanced hierarchy–clan culture is positively associated with PCM effectiveness.
- **P2:** Team dynamics (trust, role clarity and psychological safety) mediate the relationship between OC and PCM, on the one hand, and project success, on the other.
- **P3:** Cultural resistance to digital tools weakens the link between tool availability and PCM effectiveness.
- **P4:** Project outcomes feed back into OC and PCM through post-project reviews.

P1 to P3 can be tested with survey data from several firms. Suitable methods are regression-based mediation and moderation analysis with bootstrapped confidence intervals for indirect effects, or structural equation modelling (SEM) [29]. P4 requires longitudinal data.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Key research conclusions

This study addresses an academic gap by providing qualitative empirical insight into how organisational culture affects PCM in Namibia's private consulting engineering sector. The research supports and extends established paradigms [5], [10], [23] by showing, through expert consensus, that a hybrid cultural model—blending structured hierarchical accountability with collaborative clan values—is essential for optimising team performance and project delivery. Crucially, the study concludes that technical competence alone cannot secure project success; it requires purposeful management of the team communication environment, leadership alignment, and the systematic mitigation of behavioural resistance to digital platforms. The proposed mediating role of team dynamics, and the other relationships in the framework, are expert-informed propositions. They require validation through future quantitative research.

7.2 Actionable recommendations

Based on the Delphi consensus findings, the following actions are recommended for engineering consultancies:

- **Attune Leadership Competencies:** Leadership training programs must prioritise transparent communication, active feedback facilitation, and emotional intelligence to help project managers balance formal corporate authority with horizontal team collaboration.
- **Manage Digital Transformation Culture:** Address digital tool underutilization by combining platform rollouts with behavioural change strategies. Embed digital literacy initiatives in corporate onboarding and tie them directly to collaborative team values.
- **Institutionalise Clan Values:** Formalise trust-building, horizontal feedback loops, and open-door policies within standard project protocols to build psychological safety across distinct engineering disciplines.
- **Standardise PCM Protocols:** Implement mandatory early-stage scope alignment sessions, clear interdisciplinary sequencing schedules, and explicit role responsibility matrices to eliminate ego-driven friction and communication gaps.

8 LIMITATIONS AND FUTURE DIRECTIONS

8.1 Methodological limitations

The study focused on a single private consulting engineering firm and a small, purposively selected expert panel (n = 7), which limits the immediate statistical generalisability to the wider regional construction industry.

The iterative nature of the Delphi method can induce expert bias, oversimplify complex viewpoints during consensus refinement, or inadvertently foster group conformity despite participant anonymity.

The Delphi method identifies expert agreement but does not test causal or mediating relationships. The mediating role of team dynamics is therefore a proposition, not a demonstrated effect.

8.2 Directions for future research

Future studies should implement mixed-method designs across multiple engineering firms in Namibia and Southern Africa, combining Delphi insights with larger quantitative surveys to improve external validity and to test the propositions in Section 6.5 using regression-based mediation analysis or SEM [29].

Research should evaluate how broader national cultural dimensions, such as power distance and uncertainty avoidance, influence corporate PCM execution across different regional sectors [17].

Tracking project teams throughout the complete lifecycle of large-scale infrastructure projects would capture valuable data on how cultural sub-dynamics, leadership transitions, and communication strategies evolve from initiation to closeout.

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Navigating Decision-Making Challenges In Matrix-Structured Projects: The Impact Of Unpredictable Priority Changes By Stakeholders

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NAVIGATING DECISION-MAKING CHALLENGES IN MATRIX-STRUCTURED PROJECTS: THE IMPACT OF UNPREDICTABLE PRIORITY CHANGES BY STAKEHOLDERS

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ABSTRACT

Client-driven changes in project priorities create significant challenges in weak-matrix organisations, resulting in blurred authority, conflicting instructions, strained resources and reduced stakeholder confidence. Few studies address how organisations can systematically respond to externally imposed priority changes in these settings, so coping strategies remain largely ad hoc and reactive. This study explored the effects of client-driven priority changes on project execution and developed a framework to guide decision-making. The elaborated Action Design Research (eADR) methodology was applied, focusing on the diagnosing and design stages. Semi-structured interviews with nine managers and team members in a single defence and engineering organisation were analysed using Applied Thematic Analysis, yielding ten themes. These include lack of leadership alignment, absent change management enablers, fragmented communication and ad hoc coping mechanisms. The design stage produced a Strategic Change Coordination Framework with five layers: governance and decision-making, operational coordination, people and capacity, communication and stakeholder engagement, and monitoring and review. The study concludes that structured, repeatable coordination can replace improvisation when client priorities shift. Testing the framework in practice and across other organisations remains future work.

Keywords: Change management, Decision-making, eADR, External changes, Matrix organizations

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1 INTRODUCTION

Managing projects within a matrix structure has become increasingly common in engineering and technology-driven organisations [1], [2], [3]. In this structure, multiple projects are executed concurrently, often competing for limited resources, while employees report to both project and functional managers [4]. Although matrix arrangements are intended to optimise resource utilisation and enhance flexibility [1], they create significant challenges in authority, decision-making, and coordination. In weak-matrix environments, where functional managers retain primary control over resources, project managers often experience difficulties in aligning priorities and ensuring smooth execution [3].

This challenge is intensified when external stakeholders, particularly clients, impose frequent changes to project priorities. Such changes may be justified from the client's perspective, yet they often occur without prior consultation and disrupt internal planning. The result is blurred authority, conflicting instructions, strained relationships between managers, and delays in project delivery. In environments where resources are already stretched, these shifts compound inefficiencies and reduce stakeholder confidence [5].

The importance of addressing this problem lies in its direct impact on project execution and organisational stability. While project and change management literature provides established models for handling internally initiated change [6]; [7], there is a lack of literature on how organisations in weak-matrix settings can manage externally driven priority changes. This leaves managers reliant on ad hoc and reactive coping mechanisms that undermine effective decision-making [8].

1.1 Industry context

A certain organization operates within a matrix organisational structure that combines elements of traditional functional management with project-based coordination. This hybrid model enables the organization to utilise specialised expertise across departments while aligning project execution with the strategic requirements of its principal client.

A key feature of this operating environment is the client's frequent revision of project priorities, often communicated with no prior consultation. These changes are typically directive in nature, requiring immediate shifts in focus, resource allocation, and scheduling. While such top-down decisions are reflective of the client's broader operational imperatives, they place considerable pressure on the organization to rapidly adjust internal planning processes and execution strategies to remain responsive and compliant.

The challenge is further intensified by the concurrent execution of multiple projects that compete for the same limited pool of resources. The organisation operates within the context of a weak matrix structure, where functional managers retain significant authority over resource allocation, while project managers are primarily responsible for managing project budgets and have only limited influence over schedules. This distribution of authority necessitates continuous coordination and negotiation between project and functional managers to ensure that critical resources are allocated appropriately, even as external changes to project priorities increase internal complexity.

1.2 Research aim and objectives

Against this background, this study focuses on exploring the effects of client-driven priority changes on project execution in a weak-matrix organisation. It examines the challenges these changes introduce, investigates how project and functional managers currently respond, and develops a framework to guide organisations in managing such changes more effectively. The research was guided by these key questions: How do managers currently cope with sudden shifts? And what structured framework can be implemented to strengthen adaptability and decision-making?

By situating the problem within both organisational practice and scholarly debate, this

research establishes the need for a structured, validated framework that responds directly to client-driven disruptions. The introduction of such a framework is not only relevant to the case under study but also holds wider significance for organisations navigating the complexities of weak-matrix environments.

2 LITERATURE REVIEW

2.1 Matrix organisations and their challenges

The matrix structure combines functional expertise with project-based delivery, enabling organisations to use resources more efficiently across multiple initiatives. Employees report to both functional and project managers, which creates flexibility but complicates authority and accountability [3]. In weak-matrix environments, functional managers maintain control over resources while project managers carry responsibility for delivery without corresponding authority. This misalignment often results in blurred decision rights, duplicated instructions, and conflicts between managers [9].

2.2 Stakeholder management

Stakeholder management is central to project success, as effective identification, engagement, and communication align expectations and reduce resistance [10]. Proactive involvement builds trust, whereas exclusion results in dissatisfaction and disruption [11]. However, weak-matrix organisations face particular difficulty when the client dominates as the most powerful stakeholder. In such cases, client-driven directives can override organisational processes, aggravating existing tensions between project and functional managers [5]; [12]. Clients may reprioritise in response to shifting operational demands, funding or budget cycles, and changing strategic imperatives, often without visibility of the internal resource conflicts these changes create [5], [12]. Understanding these drivers is essential for designing responses that are proactive rather than reactive.

2.3 Change management theories

Traditional models, such as Lewin's three-stage process and Kotter's 8-Step model, assume predictable, internally initiated change [6]; [7]. While effective in planned contexts, these frameworks are less useful for sudden, externally imposed disruptions. Emergent change theory, which views change as ongoing, unstructured, and unpredictable, is more applicable in environments shaped by client-driven shifts [13].

2.4 Agile approaches

Agile project management has grown in importance as an adaptive response to volatile conditions. Approaches such as Scrum and Kanban promote iterative cycles, responsiveness to shifting priorities, and strong stakeholder involvement [14]. While these methods align with emergent change theory, their application is mostly at the team level. They do not resolve governance conflicts or decision-rights issues in weak-matrix environments [15].

2.5 Literature synthesis and research gap

The literature shows that weak-matrix organisations face blurred decision rights and contested authority over shared resources [3], [9]. It also shows that clients are the most powerful stakeholders and can override internal processes through directive priority changes [5], [12]. Classical change models such as Lewin's and Kotter's assume planned, internally initiated change [6], [7], and agile approaches respond to volatility mainly at team level, leaving governance and decision-rights conflicts unresolved [14], [15]. Emergent change theory explains unpredictable change but offers no practical guidance for managing it [13].

The gap is therefore the absence of a structured approach for managing externally driven priority changes in weak-matrix settings, which leaves managers reliant on ad hoc coping [8].

This gap leads directly to the two research questions: how managers currently cope with sudden shifts, and what structured framework can strengthen adaptability and decision-making. It also directs the research design. A qualitative, interview-based diagnosis was needed to understand current practice, and eADR was chosen because it supports building an artefact in response to a practical problem [16]. Finally, the gap shapes the conceptual model in Figure 1. Client-driven priority change acts on the weak-matrix context, producing the challenges identified in the findings. The framework layers respond to those challenges.

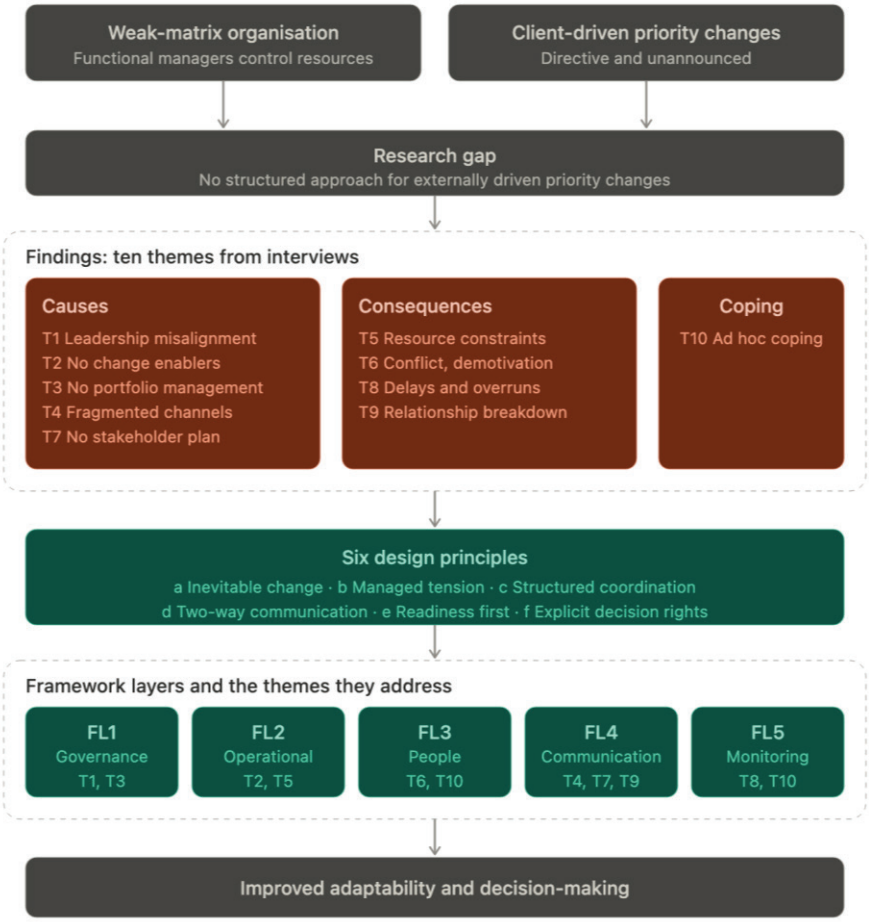


Figure 1: Conceptual model linking the research gap, findings and framework.

3 RESEARCH DESIGN

The study adopted the elaborated Action Design Research (eADR) methodology to develop and validate a framework for managing client-driven changes in project priorities within weak-matrix organisations. The use of eADR is justified as it allows for a new artefact to be created, also allowing an iterative, structured, and problem-oriented approach to the research, ensuring both practical relevance and theoretical contribution

3.1 Research approach and strategy

A qualitative research approach was adopted to capture participants' lived experiences and perceptions regarding client-driven priority changes. This approach allowed for an in-depth investigation of how participants interpret, respond to, and manage client-driven changes within a complex matrix organisational structure [17], [18], [19]. The study was phenomenological in nature, prioritising participants' subjective experiences to understand the effects of priority changes and associated coping strategies.

Semi-structured interviews were used to allow flexibility in probing participants' responses

while maintaining focus on the research objectives. This strategy facilitated the collection of rich, descriptive data, enabling participants to discuss their experiences in their own words while also allowing the researcher to explore emerging themes in detail [17].

4 RESEARCH METHOD

4.1 Sampling

The sampling for the study was purposive and expert-focused, aimed at selecting participants with relevant experience in managing client-driven priority changes within the organisation. The objective of the approach was to capture a range of perspectives and experiences rather than achieve statistical representation across the organisation. Purposive, expert sampling of nine participants was justified because the aim was analytical depth and rich contextual understanding of client-driven priority changes rather than statistical generalisation.

All participants provided informed consent before data collection. Table 1 presents the characteristics of the sample in terms of organisational level, business unit, and years of experience.

Table 1: Characteristics of the sample

Item	Category	Frequency	%
Organisational level	Project Team	2	22.2
	Project Manager	3	33.3
	Functional Manager	3	33.3
	Divisional Manager	1	11.1
Business unit	Projects and Planning	4	44.4
	Operations	2	22.2
	Site and Facilities	2	22.2
	Engineering Services	1	11.1
Years of total experience	2–5	1	11.1
	6–10	4	44.4
	11–15	3	33.3
	More than 16	1	11.1

The sample reflects a diverse range of organisational levels, with project team members, project managers, functional managers, and a divisional manager represented. Participants came from four different business units, ensuring that multiple perspectives on priority changes and decision-making were captured. The years of experience ranged from 2 to more than 16 years, with the majority having between 6 and 15 years of experience, indicating substantial organisational knowledge and exposure to the matrix operational environment.

This purposive and expert sampling approach ensured the collection of rich, contextually grounded understanding into the impact of client-driven priority changes and the coping strategies employed by participants across the organisation. The sample's diversity in role, experience, and business unit allowed for exploration of both shared and unique experiences, strengthening the depth and credibility of the study findings.

4.2 Data collection method

Data was collected through semi-structured, in-depth interviews with nine participants. Semi-structured interviews were chosen because they provide flexibility to explore participants' perceptions while maintaining focus on the research questions.

Interviews were conducted electronically via Microsoft Teams, scheduled at times convenient for each participant during working hours to minimise disruption to their regular responsibilities. Each interview session lasted between 45 minutes and an hour, providing sufficient time for participants to elaborate on their experiences. Participants were informed

at the start of each interview about their right to skip any question or withdraw from the interview at any time, ensuring voluntary participation and ethical compliance.

The researcher maintained a neutral stance, prompting participants only when clarification was needed and avoiding leading or suggestive questions. The interviews were guided by a pre-prepared interview schedule while allowing room for participants to introduce additional relevant experiences [20].

4.3 Data recording

All interviews were audio recorded with participants' explicit consent to ensure accurate capture of responses for subsequent analysis. The built-in Teams live transcription feature was used during each interview, generating a preliminary transcript of participants' spoken responses. These automated transcripts were subsequently reviewed and verified by the researcher to ensure accuracy, correct errors, and clarify any ambiguities, producing reliable verbatim transcripts for analysis.

Each transcript was carefully de-identified, with participant identifiers removed or replaced with codes to maintain confidentiality and anonymity. This allowed the researcher to focus solely on the content of participants' responses without reference to individual identities, roles, or business units.

In addition to transcription, notes were taken by the researcher during each interview to record subtle observations, including tone, emphasis, pauses, and other non-verbal cues. These notes captured the "feeling" of the interview, providing valuable contextual information that complemented the textual data.

All recorded and transcribed data were securely stored, with access restricted to the researcher to maintain data integrity. This thorough recording process ensured that the interviews were captured accurately, ethically, and in sufficient detail to support a rigorous applied thematic analysis.

4.4 Strategies to ensure data quality and integrity

To enhance credibility, data triangulation was employed through the integration of multiple data sources, including Ms Team transcripts, researcher notes, and observational reflections recorded during interviews to confirm consistency and contextual accuracy. The triangulation of these sources allowed for the comparison of perspectives and helped to identify converging patterns, thereby minimising the influence of individual bias and strengthening the dependability of the results.

4.5 Data analysis

An inductive qualitative data analysis was undertaken using an Applied Thematic Analysis (ATA) approach. Given the exploratory nature of the interviews, ATA allowed the researcher to move beyond surface-level descriptions to reveal deeper understandings into the experiences of project and functional managers operating in a matrix organisational structure [21]. The process was supported by ATLAS.ti, which facilitated the systematic organisation, coding, and retrieval of data. The analysis progressed through six interrelated phases.

Phase 1: Familiarisation with the data

The researcher reviewed the transcripts multiple times to develop a deep understanding of the data. Analytic memos were written to capture initial thoughts, observations, and potential links to the research questions.

Phase 2: Generating initial codes

An inductive line-by-line coding process was conducted to identify meaningful data segments

relevant to the study's objectives. Codes were developed directly from participants' words and contextual meanings rather than pre-determined categories. Codes that were semantically similar or contextually related were merged, forming the foundation for the development of a preliminary codebook.

Phase 3: Code refinement and reduction

To enhance analytical focus and ensure internal consistency, codes were continuously refined and consolidated. Redundant, unclear, or infrequently occurring codes that did not contribute meaningfully to the research objectives were either merged or removed. This iterative process ensured that only conceptually relevant and empirically grounded codes remained.

Phase 4: Searching for themes

The refined codes were organised into broader thematic categories that captured significant patterns and relationships in the data. The researcher examined co-occurrences and interdependencies among codes, grouping them into potential themes and subthemes. ATLAS.ti's network view supported this stage by visually mapping code relationships, enabling a clearer understanding of emerging thematic structures.

Phase 5: Reviewing themes

Each candidate theme was reviewed for coherence, relevance, and distinctiveness. The coded data extracts under each theme were examined to ensure they formed a logical and consistent narrative. Themes that overlapped or lacked sufficient supporting data were either refined or merged. The thematic structure was then validated against the full dataset to ensure it accurately reflected participants' experiences and perspectives.

Phase 6: Defining and naming themes

In the final phase, the core meaning of each theme was defined, clearly articulating how it related to the study's research questions. Ten final themes emerged from this process, each representing a key dimension of the challenges, coping mechanisms, and strategies associated with shifting stakeholder priorities in matrix organisations.

5 FINDINGS



Figure 2: Identified themes from interviews

Theme 1: Lack of leadership alignment

Participants consistently described differing signals from management when priorities shifted. Decisions are formed and communicated in parallel rather than through a shared alignment step. As P1 noted, *"Sometimes it feels like we're getting two versions of the same instruction, one from the project side and another from functional leadership, and both expect immediate execution."* This results in uncertainty regarding the immediate lead for the change window, the order in which work packages should proceed, and the criteria for pausing or continuing tasks. P7 reflected that *"We don't always have the luxury of pre-alignment meetings, but without them, we end up with teams pulling in different directions."* Consequently, early hours following a change are often marked by hesitation and duplicated effort.

Theme 2: Lack of change management enablers

There is no concise, agreed-upon guideline to initiate and govern sudden client-driven priority changes. P2 expressed frustration: *"When a client calls for a change, we respond immediately, but there's no formal mechanism to check readiness, we just start adjusting as we go."* Key elements such as rapid impact and readiness assessments do not exist. P3 added, *"If we had a predefined checklist or readiness protocol, we'd avoid half the disruptions that occur mid-task."* As a result, dependencies such as permits, isolations, inspection sequences, and access constraints are often discovered mid-execution, prompting disruption of activities and rework. P5 summarised the issue aptly: *"We are managing change reactively, not proactively."*

Theme 3: Lack of project portfolio management

Interviewees reported limited visibility of cross-project commitments and shared resources. Priority moves are actioned on local information, increasing the probability of double-booking scarce specialists, equipment, or spaces. P9 highlighted, *"The same welder could be scheduled by three different projects because there's no shared resource dashboard."* Conflicts typically surface late, on the job or during escalation, by which time rescheduling costs have already accrued. P7 emphasised the consequence: *"By the time it reaches my desk,*

it's no longer a scheduling problem, it's a financial one."

Theme 4: Fragmented communication channels

Change information commonly travels through multiple channels and at different levels of abstraction. P4 remarked, *"Sometimes the change notice is verbal, sometimes on email, sometimes in a WhatsApp group, and they don't all say the same thing."* Project teams frequently receive high-level notices without actionable detail (who leads, what must pause, and the expected duration). Inconsistent sequencing and duplication follow, with two or more teams arriving at the same workspace. P1 observed, *"You end up with two crews on-site, both thinking they're authorised to proceed. That's when confusion turns into conflict."*.

Theme 5: Resource constraints

High workload, overlapping change windows, and constrained access to specialist skills and critical equipment were recurring features. P6 reflected the frontline view: *"We're already stretched. When changes come in, we have to stop, pack up, and then redo setups later, it wastes half a day."* Mid-task diversions are particularly costly because partially completed work creates lock-outs and additional assurance steps before activities can resume. P2 noted, *"When one task stalls, it cascades, the next crew can't start, the safety officer has to revalidate permits, and the schedule just keeps slipping."* Resource contention, therefore, propagates delays beyond the initially affected task.

Theme 6: Personal conflict and demotivation

Inconsistent direction and frequent changes were associated with frustration, reduced morale, and avoidable friction between teams. P3 explained, *"People get demotivated when plans keep changing. It feels like all the work we did in the planning phase was for nothing."* Where clear directions with defined timeframes were provided, cooperation improved; whereas their absence created perceptions of arbitrariness and reduced willingness to contribute beyond formal requirements. P8 reflected, *"You start to see the small arguments, who gets priority, who 'owns' the space. These are symptoms of fatigue and confusion."*

Theme 7: Lack of stakeholder management plan

There is no shared approach for identifying affected stakeholders, sequencing engagement, and agreeing on the minimum information set during priority changes. P5 stated, *"We don't have a stakeholder map that shows who must be engaged first during a change. So, by the time someone is informed, it's already too late."* Without a basic plan, external expectations diverged, and operational interfaces (e.g., handovers, inspections, access windows) became sources of delay and complaint. P7 confirmed, *"When clients hear different updates from different people, credibility takes a hit. They start double-checking everything."*

Theme 8: Project delays and overruns

Project delays and cost growth were reported as routine consequences of the above conditions. P9 explained, *"When you stop midway, it's not just time lost, permits have to be reissued, QA has to redo inspections, and the client still expects delivery on the original date."* The mechanisms were concrete: repeated permit resets, re-establishment of safe states, re-testing after interruptions, and out-of-sequence work requiring rework. Delays accumulated across interdependent tasks and projects, creating compounding effects on cost and delivery schedules.

Theme 9: Stakeholder relationship breakdown

Late and inconsistent communications erode trust with both internal and external stakeholders. P4 observed, *"Once clients start getting mixed messages, they lose confidence in everything else we tell them."* Reduced confidence manifests as increased escalations,

tighter oversight demands, and lower tolerance for delivery risk, all of which further slowed project delivery. P7 added, *"We now spend more time explaining delays than preventing them, it's a credibility problem."*

Theme 10: Ad hoc unstructured coping mechanisms

In the absence of agreed-upon change guidelines, teams rely on improvised practices, informal meetings, personal initiative, and individual verification of controls to keep work moving. P1 described, *"We've developed our own mini-procedures, like quick morning huddles just to make sure we're not stepping on each other's toes."* P6 added, *"Sometimes it's just about calling the right person and making a plan, because waiting for an official directive will stall everything."* These responses are often effective locally but are uneven across shifts, difficult to audit, and seldom translated into organisation-wide learning. P5 summarised, *"Everyone is firefighting in their own way but there's no central place where these lessons are captured."*

6 DISCUSSION

The results of the interview analysis indicate that project decision-making within the weak matrix structure is significantly disrupted by overlapping factors such as misaligned leadership, insufficient change management mechanisms, fragmented communications, and ad hoc coping practices. These challenges collectively undermine the predictability and coherence of project execution and lead to recurrent inefficiencies that impact not only timelines and resources but also stakeholder trust and morale.

One of the most distinct themes emerging from the data is the impact of leadership misalignment. Several respondents noted that when functional and project leadership present a united front, coordination and client communication improve considerably; however, when divergent messaging is delivered, the project portfolio quickly becomes disjointed. This lack of coherence is intensified in high-pressure scenarios where priority changes occur without formal pre-alignment, reinforcing the need for leadership forums and alignment protocols to prevent cascading confusion and reactive workarounds.

Closely linked to this is the absence of formal change management enablers, which leaves teams reliant on informal meetings and makeshift communication efforts. In the absence of structured guidelines such as documented stakeholder communication strategies, readiness assessments, and change-impact assessments, the organization is left exposed to inconsistency in messaging, unclear decision paths, and duplication of effort. Best practice highlights the critical role of formalized change readiness procedures and feedback loops in adaptive environments, yet such mechanisms are noticeably absent here, creating vulnerabilities during transitions.

This vulnerability is compounded by the lack of centralized project portfolio management. Numerous interviewees expressed frustration that project managers rarely engage as a collective, resulting in siloed decisions and competing resource demands. In a matrix environment, where shared resources are inherently limited, such fragmentation invites unproductive negotiation cycles and escalates interpersonal conflict, particularly between project managers and functional managers. The recommendation by some interviewees to implement a "scrum-of-scrums" or daily stand-ups across the portfolio reflects an understanding of agile portfolio coordination as a valuable solution, aligning with current organizational agility frameworks.

A further contributing factor to the inefficiency is communication inconsistency. Several respondents acknowledged that communication across multiple channels (email, calls, and instant messaging) is not only unmanaged but often contradictory. This results in stakeholders receiving differing accounts of the same issue, which not only delays resolution but also damages credibility and fosters misalignment. Standardized communication protocols and stakeholder mapping tools were repeatedly recommended but appear to be lacking in current practice.

The cumulative strain of these deficiencies often manifests in resource exhaustion and psychological strain. When priorities change abruptly, field teams face uncertainty, idle time, and frustration, as evidenced by the description of a partially executed lift causing a full-day disruption across multiple crews. Additionally, staff morale is weakened when teams are pulled between conflicting project directives without a clear rationale or return-to-plan strategy. In several accounts, junior team members were noted as particularly vulnerable to anxiety in such conditions, while seniors coped through experience.

Personalised conflict also emerged as a by-product of these systemic gaps. Several participants noted that without structured forums or decision rules, resource negotiations become individualized and politicized, leading to perceptions of certain individuals being “bossy” or gatekeeping. This not only affects interpersonal trust but also undermines the credibility of functional leaders whose decisions appear subjective in the absence of formal prioritization frameworks.

In the absence of formal support systems, the organization relies on improvised coping mechanisms. While some practices, such as short meetings or 24-hour triage documents, do provide short-term value, they cannot substitute for a structured change gate, readiness assessments, and centralized oversight. This makes the organization reactive rather than proactive, susceptible to repeating the same errors in every new cycle of priority change. The long-term consequence is not only reduced productivity but also the erosion of institutional trust and accumulated stakeholder dissatisfaction.

7 DEVELOPED FRAMEWORK

The framework is built upon six core principles that emerged through triangulation of thematic findings of the SLR, surveys and interviews within the organisation under study. These principles serve as the philosophical and functional scaffolding of the framework and are as follows:

(a) Client priority changes are inevitable - The framework assumes that top-down reprioritisation from clients is a permanent feature, not an anomaly. It thus rejects rigid resistance in favour of structured adaptation.

(b) Matrix tensions must be actively managed - In weak matrix structures, functional and project managers frequently compete for authority over shared resources. The framework does not attempt to resolve this structural tension, but rather formalises coordination mechanisms to mitigate its disruptive effects.

(c) Structured coordination is preferable to ad-hoc reaction - Both the survey and interviews revealed a culture of improvisation under pressure. The framework instead promotes formalised, repeatable response protocols that preserve continuity and limit ambiguity.

(d) Communication must be bidirectional and context-sensitive - Communication breakdowns at operational levels were a recurring challenge. The framework thus includes layered messaging systems that reach from executive to floor-level staff, while also incorporating bottom-up feedback mechanisms.

(e) Organisational readiness must precede implementation - Change readiness emerged as a critical success factor. The framework mandates readiness assessments to identify structural and behavioural capacity before engaging in reprioritised work.

(f) Decision rights must be explicit and consensual - Unclear mandates and contested authority were frequently cited concerns. The framework responds by defining formal roles in decision-making using decision-rights matrices and escalation protocols.

7.1 Discussion of the framework

The framework as shown in figure 3. was designed to give organisations operating in a weak

matrix environment a structured response to client-induced changes in project priorities. The aim is not to eliminate such changes but to ensure that they are managed in a way that reduces disruption and improves decision-making. The framework is organised around five framework layers (FL): governance and decision rights, operational coordination, people and capacity, communication and stakeholder engagement, and monitoring and evaluation. Each area tackles a specific source of difficulty while reinforcing the others to create a coherent approach.

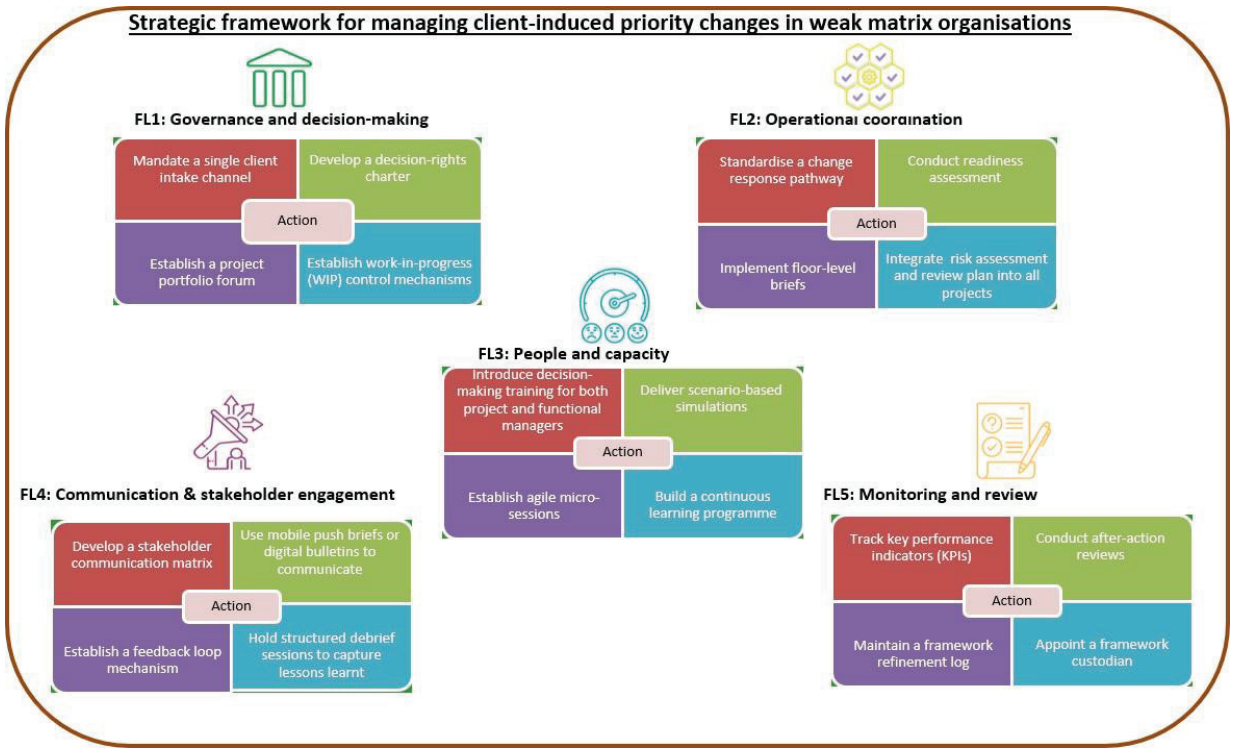


Figure 3: Strategic framework for managing client-induced priority changes in a weak-matrix organisation

Governance and decision rights provide the foundation by clarifying how authority is exercised. In environments where multiple managers influence the same resources, decisions are often contested or duplicated. To address this, the framework calls for a decision-rights charter that specifies who recommends, who approves, and who executes. A portfolio forum is introduced to rank priorities and document rulings with clear rationale, while a single intake channel ensures that all client requests enter the organisation in a controlled and traceable manner. Finally, limits on work in progress prevent overcommitment and balance external demands with internal capacity. Together, these measures stabilise the flow of decisions before they reach operational teams.

Operational coordination focuses on how changes are implemented once governance has defined the direction. Evidence from the organisation showed that teams frequently responded in a fragmented way when priorities shifted, leading to wasted effort and even safety risks. To counter this, the framework establishes a common response pathway for all priority changes. Mobilisation is supported by readiness checklists to confirm that resources, approvals, and information are available before work begins. Short, floor-level briefs communicate essential details such as leadership, equipment, and timelines directly to teams. In addition, sequencing plans and risk reviews help to manage dependencies and prevent cascading disruptions. These measures ensure that decisions are not only made but also executed in a consistent and coordinated manner.

The area focused on people and capacity recognises that processes alone cannot deliver stability. Managers and teams need to be equipped to act decisively under pressure. For this

reason, the framework recommends structured decision-making training for managers, scenario-based simulations that allow teams to rehearse responses, and short learning sessions that encourage agility in day-to-day work. Alongside these activities, a continuous learning programme ensures that knowledge is reinforced rather than lost after a single training event. By strengthening capability in this way, the framework reduces reliance on improvisation and builds confidence across different levels of the organisation.

Communication and stakeholder engagement address one of the most persistent challenges in the organisation, namely, inconsistent and delayed messaging. The workforce reported receiving conflicting instructions, while stakeholders expressed dissatisfaction with the lack of clarity. To resolve this, the framework introduces a stakeholder communication matrix that matches messages with the influence and interest of each group. Mobile bulletins or push notifications provide rapid and reliable updates to operational staff, while feedback loops create space for frontline concerns to be escalated. Debrief sessions are used to capture lessons after major shifts, ensuring that communication does not stop at the point of delivery but feeds into continuous improvement. In this way, communication becomes a central control function rather than a reactive afterthought.

Monitoring and review complete the framework by embedding accountability and learning. A key finding from the organisation was the absence of mechanisms to assess whether responses to client changes were effective. To close this gap, the framework identifies key performance indicators such as decision turnaround time, stakeholder satisfaction, and the frequency of resource conflicts. After-action reviews allow teams to reflect on both successes and failures, while a refinement log ensures that lessons are translated into changes in practice. Responsibility for maintaining these processes is assigned to a framework custodian, such as a project management office lead, who ensures continuity and avoids the drift that often undermines improvement efforts. By building feedback and ownership into the process, the framework becomes adaptive rather than static.

7.2 Adapting the framework to other contexts

The framework was developed in a single defence and engineering organisation, so its transferability is proposed rather than demonstrated. FL1 (governance and decision-making) and FL4 (communication and stakeholder engagement) address structural problems common to matrix settings and should transfer with little change. FL2 (operational coordination) and FL3 (people and capacity) depend on local safety, permitting and skills conditions, and need tailoring to each industry. In moderate or strong matrices, where project managers hold more authority, the decision-rights charter and portfolio forum would shift towards project-led arbitration. Testing in other organisations is needed to confirm these boundaries.

7.3 Readiness assessment before implementation

In line with principle (e), organisations should assess their readiness before adopting the framework. A short self-assessment, completed jointly by project and functional managers, rates four dimensions on a three-point scale (low, moderate, high):

1. Change maturity: whether any structured process exists for handling client-driven priority changes.
2. Leadership alignment: whether project and functional leaders give consistent direction when priorities shift.
3. Resource availability: whether specialist skills, equipment and time exist to support new coordination mechanisms.
4. Decision-rights clarity: whether it is agreed who recommends, approves and executes changes.

Dimensions rated low should be addressed first, beginning with FL1, before the remaining

layers are introduced.

7.4 Phased implementation roadmap

Following the readiness assessment in Section 7.3, the framework layers can be introduced in five phases. The timeframes are indicative and should be adjusted to organisational capacity.

Table 2: Implementation roadmap

Phase	Focus	Key actions	Timeframe	Owner
1	Governance and intake (FL1)	Mandate a single client intake channel, agree the decision-rights charter, and establish the portfolio forum and work-in-progress limits	Months 1-2	Divisional manager
2	Operational coordination (FL2)	Standardise the change response pathway, introduce readiness checklists, and begin floor-level briefs	Months 2-4	Project and functional managers
3	People and capacity (FL3)	Deliver decision-making training and scenario-based simulations, and start agile micro-sessions	Months 3-6	Functional managers
4	Communication and stakeholder engagement (FL4)	Develop the stakeholder communication matrix, launch mobile bulletins, and set up the feedback loop	Months 4-6	Project managers
5	Monitoring and review (FL5)	Track KPIs, hold after-action reviews, and maintain the refinement log under a framework custodian	From month 6, ongoing	Framework custodian (e.g. PMO lead)

Phases overlap deliberately, so that later layers build on the governance foundation set in Phase 1. A review at the end of each phase should confirm that its actions are working before the next phase is fully rolled out.

8 CONCLUSIONS AND RECOMMENDATIONS

The study provides project and functional managers with a dependable framework to guide decision-making when priorities shift. Its reception by practitioners indicates that it is not only conceptually sound but also implementable. If adopted, it has the potential to reduce ambiguity, strengthen coordination between project and functional managers, and improve the organisation's ability to respond effectively to external demands.

This study developed and validated the Strategic Change Coordination Framework within a single organisational context in the defence and engineering sector, addressing challenges such as fragmented communication, resource constraints, and leadership misalignment in a matrix environment. Future research should begin by testing the framework within the same organisation to evaluate its practical applicability and effectiveness in real-world project settings.

Future research should pilot the framework within the case organisation and then test and validate it across additional organisations and industries through further eADR cycles, so that its practical effectiveness and transferability can be evaluated. Future research should include client interviews to understand why priorities change and how clients experience the decision-making process, so that FL1 (the single intake channel) and FL4 (communication and stakeholder engagement) can be refined.

8.1 Limitations

The study was conducted in a single organisation with nine participants, so the findings and framework cannot be statistically generalised. Client perspectives were not included, and the framework has not yet been tested in practice. Future research should address these limitations through multi-organisation validation.

The study did not include the client's perspective, so the reasons behind priority changes and how clients view the decision-making process are inferred from the literature and from internal participants, which limits the balance of the findings

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