

BINDURA UNIVERSITY OF SCIENCE EDUCATION

ENHANCING ORGANISATIONAL PERFORMANCE IN THE MINING SECTOR THROUGH DEVELOPING A SUSTAINABLE SUPPLY CHAIN MANAGEMENT FRAMEWORK IN ZIMBABWE: A CASE STUDY OF DOROWA MINERALS

BY

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DECLARATION

I, Tafadzwa Stanley Dimba Student Reg Number B251670A, do hereby declare that this dissertation is a result of my own investigation and research, except to the extent indicated in the acknowledgments, bibliography, references, and comments included in the body of the report, and that it has not been submitted in part or in full for any other degree to any other university.



TAFADZWA S DIMBA **DATE: 23/06/26**

DEDICATION

This work is dedicated to God, my family, and friends, especially my parents, who have been my constant source of strength, assisting me in gaining mastery over my life both spiritually and physically as I follow the path designed by God. I will forever be sincerely thankful to everyone I've encountered on this journey and will honor or them deeply for their contributions in offering valuable insights into life's questions.

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ABSTRACT

This study investigated the impact of Sustainable Supply Chain Management (SSCM) practices on organizational performance within Zimbabwe's capital-intensive mining sector. The primary objective was to evaluate the individual and collective influence of four critical strategic pillars Strategic Supplier Partnerships, Green Procurement, Eco-Innovative Practices, and Internal Environmental Management on driving institutional success metrics. The study was theoretically underpinned by the Resource-Based View and Stakeholder Theory. Adopting a positivist research philosophy and a deductive quantitative approach within a mixed-methods concurrent triangulation design, data collection targeted a major diversified mining entity, Dorowa Minerals. Empirical data were gathered via structured questionnaires and complementary semi-structured interviews from a validated sample of operational and management professionals, achieving robust response rates of 98% for the quantitative section and 100% for the qualitative phase. To ensure data integrity, the research instruments were subjected to internal consistency evaluations, yielding highly robust Cronbach's Alpha reliability coefficients ranging from 0.86 to 0.93 across the strategic constructs. Statistical analyses, including Pearson Correlation and Multiple Linear Regression, were executed using SPSS version 29.0 to test the formulated hypotheses. The empirical findings conclusively showed that the entered sustainable supply chain components collectively explained 67.1% (R^2 = 0.671) of the total variance observed in Organisational Performance, signalling a highly powerful predictive model. The Analysis of Variance (ANOVA) confirmed the overall statistical significance of the model ($F = 59.621$, $p < 0.001$). Further coefficient analysis revealed that Eco-Innovative Practices emerged as the structurally dominant predictor ($\beta = 0.412$, $p = 0.000$), underscoring the critical value of climate-smart mining, resource optimization, and technical adaptations in heavy extraction. Internal Environmental Management was established as the second most influential driver ($\beta = 0.274$, $p = 0.000$), demonstrating that robust internal auditing routines, green organizational culture, and structural governance provide an essential buffer against regulatory shocks and preserve the social license to operate. Strategic Supplier Partnerships and Green Procurement were also positive and statistically significant contributors, confirming that transitioning from adversarial sourcing to collaborative, green logistics effectively balances environmental constraints with corporate profitability. The study concludes that a context-specific, multi-dimensional SSCM framework resolves the process-execution gap by shifting from reactive compliance to proactive, efficiency-first local resilience under volatile macroeconomic conditions. To advance these outcomes, the study recommends aligning industrial frameworks with Zimbabwe's Education 5.0 initiative specifically focusing on Community Service, Heritage-Based Bilateral Innovation, and Industrialisation. Key recommendations include formalizing artisanal mining into secure tier-2 cooperative sourcing models via blockchain tracking, developing AI-driven predictive risk dashboards to handle cross-border SADC corridor disruptions, and launching university-industry joint venture pilot plants to manufacture specialized mineral processing reagents locally, thereby mitigating foreign currency deficits and structural supply chain bottlenecks.

Keywords: Sustainable Supply Chain Management, Strategic Supplier Partnerships, Green Procurement, Eco-Innovative Practices, Internal Environmental Management, Organisational Performance.

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LIST OF ACRONYMS

AfCFTA – African Continental Free Trade Area

ANOVA – Analysis of Variance

ASM – Artisanal and Small-scale Mining

B-BBEE – Broad-Based Black Economic Empowerment

CSDDD – Corporate Sustainability Due Diligence Directive

CSR – Corporate Social Responsibility

EIP – Eco-Innovative Practices

ESG – Environmental, Social, and Governance

EV – Electric Vehicle

GP – Green Procurement

ICMM – International Council on Mining and Metals

IEM – Internal Environmental Management

IIoT – Industrial Internet of Things

ISO – International Organization for Standardization

NDS2 – National Development Strategy 2

OP – Organisational Performance

OLS – Ordinary Least Squares

PGM – Platinum Group Metals

RBV – Resource-Based View

SD – Standard Deviation

SDGs – Sustainable Development Goals

SLO – Social License to Operate

SPSS – Statistical Package for Social Sciences

SSC – Sustainable Supply Chain

SSCM – Sustainable Supply Chain Management

SSP – Strategic Supplier Partnerships

TBL – Triple Bottom Line

VRIN – Valuable, Rare, Inimitable, and Non-substitutable

CHAPTER 1

INTRODUCTION

1.1 Introduction

The global mining industry is undergoing a major shift where being green is no longer just a nice gesture it is now a strategic necessity for survival. For mining firms in Zimbabwe, this transition is particularly challenging as they must balance international sustainability standards against a tough local economy marked by currency changes and power shortages. This study focuses on how developing a sustainable supply chain framework can help companies like Dorowa Minerals and G&W Industrial Minerals not only protect the environment and support local communities but also improve their own operational efficiency and bottom line. By moving from simple compliance to proactive sustainability, Zimbabwean mines can secure their place in the future global market. The main aim of this research is to enhance organizational performance in the Zimbabwean mining industry in relation to cost efficiency, time, and resource utilization through the development of an appropriate SSCM framework. This chapter includes the following: Background of the study, Problem statement, Purpose of the study, Objectives of the study, Research questions, Importance of the study, Assumptions of the study, Boundaries of the study, Limitations of the study and Definition of terms.

1.2 Background of the Study

The global extractive landscape is currently undergoing a fundamental paradigm shift where the integration of Sustainable Supply Chain Management (SSCM) has moved from a discretionary corporate activity to an existential strategic necessity. According to Alvites-Huamaní et al. (2023), the modern industrial environment now demands that mining firms internalize environmental and social externalities to ensure long-term organizational resilience against global market shocks. This transition necessitates a rigorous cost-benefit analysis at both corporate and societal levels. For mining companies, immediate costs involve significant capital expenditure on green technologies and restructuring procurement chains, whereas benefits include reduced waste, lower litigation risks, and improved operational efficiency (Kusi-Sarpong et al., 2023). At a societal level, benefits manifest through reduced environmental degradation and improved community health, which create a license to operate that safeguards long-term viability. This international pressure is amplified by the United Nations Sustainable Development Goals, which provide a standardized global framework

forcing mining industries to align procurement strategies with strict decarbonization targets (Zhu et al., 2024). Furthermore, the global rise of institutional investor activism has mainstreamed ESG metrics as primary indicators of a firm's financial health and risk profile (Baah & Jin, 2024). However, current global dynamics suggest a recalibration of these priorities. Several Western economies, most notably the USA, are experiencing a slowdown in the aggressive pursuit of ESG goals due to escalating costs and energy crises. In the UK, consideration of national energy security has led to a potential resumption of North Sea oil and gas activities. This shift indicates that the global green movement faces friction as jurisdictions focus on economic survival and lowering energy costs amid geopolitical conflicts in the Middle East.

In Zimbabwe, this tension between global sustainability and national survival is equally evident. While the mining sector is the nation's primary economic engine, the government has advised continuing with strategic traditional energy projects, such as the Hwange Colliery expansion, to address chronic power shortages. This suggests that for developing nations, the path to a sustainable supply chain is a complex balancing act between greening and basic industrial survival. Consequently, while advanced mining jurisdictions like Australia and Canada have historically driven Green Supply Chain Management (GSCM) through rigorous regulations that penalize non-compliance (Song et al., 2022), these models are now tested by the global energy landscape. Global mining leaders have leveraged digital transformation, including blockchain for mineral traceability and AI-driven logistics, to ensure transparency across complex international supply chains (Deveci et al., 2023). Islam et al. (2024) posit that the global move toward a circular economy requires mining organizations to rethink take-make-dispose models in favor of resource recovery and waste-to-value initiatives. However, the view that sustainability and economic performance are purely synergistic (Kusi-Sarpong et al., 2023) is under critical scrutiny. In a world of high energy costs, the synergy between greening and profit remains viable only if transition costs do not compromise the firm's fundamental ability to provide affordable resources. For a mining house like Dorowa Minerals, the challenge is adopting a sustainable framework resilient against global cooling trends while securing a place in a future global market demanding certified green minerals (Adjoda & Darko, 2024).

Kusi-Sarpong et al. (2023) highlight that global mining entities prioritizing sustainable supplier selection report higher operational efficiency and lower long-term litigation costs. In the Asian context, particularly China, internal environmental management has become the most significant dimension of GSCM affecting enterprise performance in the extractive sector (Zhu

et al., 2024). Global studies indicate that firms adopting a proactive sustainability posture navigate global commodity price volatility better by optimizing resource consumption and reducing waste (Deveci et al., 2023). The global discourse on SSCM highlights a critical need for radical change in traditional supply chain models that have historically been ecologically destructive. Islam et al. (2024) argue that global flexibility and efficiency in the past were often achieved at the expense of workers. Currently, global sustainability leaders prioritize the human element of the supply chain alongside environmental metrics (Alvites-Huamaní et al., 2023). This shift underscores the importance of evaluating how global best practices can be adapted so mining remains a viable driver of development without compromising future generations.

The technological dimension of global SSCM is evolving rapidly, with the integration of the Internet of Things and big data analytics becoming standard for monitoring supply chain emissions instantaneously. Song et al. (2022) observe that global mining firms utilizing these technologies report 20% higher accuracy in ESG reporting, correlating directly with higher stock market valuations. Moreover, global responsible sourcing mandates that mining companies account for the carbon footprint of their entire supplier network, not just internal operations (Adjoda & Darko, 2024). Baah and Jin (2024) suggest that the ability to adapt supply chain processes continuously to changing global environmental standards determines competitive advantage. As international trade barriers increasingly include carbon border adjustments, financial performance is inextricably linked to environmental footprints (Kusi-Sarpong et al., 2023).

Regionally, the mining sector serves as the primary engine for economic growth, yet implementation of SSCM is complicated by unique institutional and infrastructure voids. Reddy and Kumar (2023) state that while African nations hold vast reserves of critical minerals, regional implementation of sustainable practices lags due to weak regulatory enforcement and historical dependencies on raw commodity exports. In West Africa, particularly Ghana, Agyabeng-Mensah et al. (2021) found that adopting green performance indicators correlates directly with securing regional competitive advantages. A critical regional challenge is the proliferation of informal mining, manifesting as *Makorokoza* in Zimbabwe and *Zama Zamas* in South Africa. In Zimbabwe, artisanal mining is encouraged by the government as a means of national economic survival; however, this promotion often occurs in a regulatory vacuum where essential controls regarding child labor and occupational safety are non-existent (Ndlovu & Mutasa, 2024). This creates a dual-tier supply chain where formal entities like Dorowa Minerals must compete with an informal sector that externalizes environmental and human

costs. Similarly, in South Africa, quiet exploitation of illegal *Zama Zama* operations leads to a fragmented enforcement landscape (Maseko & Nyathi, 2024). Primary issues include degradation of formal ESG standards, influx of conflict minerals into global supply chains, and erosion of the formal sector's market share (Khumalo & Tshabalala, 2024).

SADC (2024) reports indicate regional mining houses face pressure to adopt local content policies that ensure social sustainability through empowering indigenous suppliers and communities. Mulongo (2024) in the Democratic Republic of Congo highlights that social sustainability dimensions, such as eliminating child labor in cobalt supply chains, are critical for maintaining access to the African Continental Free Trade Area and global markets. Dlamini and Zhou (2023) argue that the lack of technological spillover from multinational mining corporations to local African suppliers remains a significant barrier. In East Africa, specifically Kenya, AJOEI (2025) research demonstrates that firms investing in sustainable procurement see a 15% improvement in operational efficiency. The regional trend moves toward harmonizing environmental standards through bodies like the African Union, which seeks to create a Green Minerals Strategy for the entire continent (Sarmiento & Kumar, 2023).

The economic dimension of regional sustainability in Africa is tied to value addition and beneficiation. Reddy and Kumar (2023) posit that processing minerals regionally rather than exporting raw ores reduces the carbon footprint associated with long-distance shipping. This regionalization improves environmental performance, creates high-quality jobs, and fosters industrialization (Mulongo, 2024). However, implementing such regional supply chains requires massive investment in renewable energy and transport infrastructure, remaining a significant hurdle (Dlamini & Zhou, 2023). Institutional barriers continue to play a decisive role across the African mining belt. Sarmiento and Kumar (2023) observe that in countries with higher institutional transparency, mining firms are more likely to invest in long-term sustainability initiatives. Tuffour et al. (2022) contend that when African mining firms invest in the social sustainability of local suppliers, they reduce operational disruption risks caused by social unrest, directly enhancing financial performance.

The Zimbabwean mining sector represents a critical pillar of the national economy, contributing over 60% of export earnings, yet it operates within a highly constrained macroeconomic environment complicating SSCM adoption. Khumalo and Tshabalala (2024) observe that many Zimbabwean firms still view sustainability as a peripheral cost rather than a core driver of performance. Research by Muchaendepi and Mbowa (2022) reveals that sustainable procurement is hampered by a lack of local suppliers possessing green certifications, creating reliance on expensive imports that negatively affect financial

performance. Maseko and Zinyemba (2024) argue that frequent energy deficits and infrastructure decay force mining companies to prioritize immediate operational survival over long-term environmental stewardship. Despite these challenges, ResearchGate (2025) reports indicate large-scale platinum and gold miners in Zimbabwe are beginning to adopt Global Reporting Initiative (GRI) standards to attract foreign direct investment. However, uptake is uneven, with small-to-medium scale miners lacking financial capital to implement basic environmental safeguards (Muzondo & Pashapa, 2025).

This fragmentation is exacerbated by the informal sector functioning as a massive parallel economic entity in Zimbabwe. As Maseko and Nyathi (2024) posit, high informality creates systemic instability that spills directly into the mining value chain. *Makorokoza* operate with minimal oversight, creating challenges regarding land tenure security, environmental rehabilitation, and mineral supply chain integrity. Because the informal sector ignores safety and environmental regulations while being politically and economically encouraged, it creates a distorted market where formal mines like Dorowa Minerals bear full compliance costs while competing for local resources and labor against an unregulated informal counterpart (Ndlovu & Mutasa, 2024). The legislative framework in Zimbabwe, specifically the Environmental Management Act, provides a basis for compliance, but Ndlovu and Mutasa (2024) point out that more rigorous enforcement is required. Moyo and Chikodzi (2023) highlight that community-firm conflicts underscore the failure of current supply chain models to distribute mining wealth equitably.

The lack of a comprehensive national model for SSCM tailored to Zimbabwe's economic constraints represents a significant gap. Muzondo and Pashapa (2025) argue that the lack of affordable sustainable alternatives, such as renewable energy, hinders an organization's capacity to implement environmentally conscious initiatives. Zimbabwean mining firms are caught in a cycle where they recognize the need for sustainability to access global markets but lack national infrastructure to support it (Ndlovu & Mutasa, 2024). While formal mines struggle with infrastructure deficits, hundreds of thousands of artisanal miners operate entirely outside existing SSCM discourse. There is a lack of research into how *Makorokoza* can be governed within a sustainable framework addressing safety, environmental, and human rights violations (Maseko & Nyathi, 2024). Emerging mining hubs like Dubai have been noted for paying mere lip service to the SSCM model, creating a gateway for minerals to enter the global economy without stringent supply chain restrictions (Maseko & Nyathi, 2024). As a result, significant volumes of Zimbabwean gold are diverted into unregulated corridors.

The impact of SSCM on organizational performance in Zimbabwe is mediated by volatile

currency and inflationary environments. Maseko and Zinyemba (2024) observe that firms successfully integrating sustainable practices report better resilience against currency fluctuations due to improved resource efficiency and reduced waste. By optimizing local inputs and reducing reliance on foreign-sourced chemicals, some Zimbabwean mines have managed to lower operating costs (Muchaendepi & Mbowa, 2022). Regarding chemical sourcing, high-value specialized reagents like sodium cyanide are still predominantly imported due to limited local industrial capacity (Maseko & Zinyemba, 2024). Consequently, mines invest in on-site recovery systems and substitute non-critical imported precursors with locally synthesized alternatives (Ndlovu & Mutasa, 2024). The Triple Bottom Line (TBL) serves as the foundational architecture for the proposed SSCM framework, where the economic pillar is addressed through performance metrics, the environmental pillar through eco-innovative practices, and the social pillar through strategic supplier partnerships (Muzondo & Pashapa, 2025).

Historically, supply chain management within the extractive sector evolved through distinct operational phases, transitioning from basic transactional logistics to modern, integrated sustainable supply chains. In the early-to-mid 20th century, mining supply chains functioned purely on linear transactional models focused on physical extraction, volume maximization, and low-cost transport, while ignoring environmental and social externalities. Following post-colonial industrial expansion in Southern Africa during the late 20th century, supply chain strategies shifted toward regulatory compliance and operational risk mitigation, where firms reacted defensively to national environmental standards and basic safety regulations. By the early 2000s, the emergence of the Triple Bottom Line (TBL) framework and global ESG mandates transformed supply chain thinking from reactive compliance to strategic, value-driven management. In Zimbabwe's contemporary mining sector, this historical evolution faces a critical impasse: while advanced global mining houses have transitioned to digital, carbon-neutral, and closed-loop circular supply chains, local entities like Dorowa Minerals remain historically constrained by severe macroeconomic shocks, infrastructure voids, and systemic competition from an expanding informal mining sector. Understanding this historical evolution reveals that contemporary supply chain failures in Zimbabwean mining are not merely operational breakdowns, but structural outcomes of an incomplete transition from traditional extractive procurement to modern, sustainable supply chain frameworks

1.3 Statement of the Research Problem

The ideal state for the contemporary mining industry is one where organisational performance is sustained through the strategic coordination of a complex network that integrates the Triple Bottom Line of environmental stewardship, social responsibility, and economic viability. In this ideal scenario, firms do not compete as individual entities but as links within interconnected chains where sustainability is the primary driver of long-term performance (Khumalo & Tshabalala, 2024). However, the global mining industry is currently facing a systemic crisis characterized by a persistent deterioration in performance, manifesting through stagnating productivity and rapidly escalating operational costs (Howie et al., 2025). This global instability is exacerbated by the extreme unpredictability of mineral prices on the world market, where sudden shifts in oil prices and the volatile doom and gloom cycles of platinum prices create an environment of profound uncertainty for local producers (Muzondo & Pashapa, 2025).

Nationally, these global challenges are compounded by a highly constrained macroeconomic environment. Local firms operate under significant strain due to persistent power shortages and severe foreign currency deficits (Chamber of Mines, 2024). A critical hurdle in this regard is the negative impact of the RBZ stipulated surrender requirements, which enforce a 70/30 split between USD and Zimbabwe Gold (ZiG) earnings. This mandatory conversion restricts the liquidity required to procure essential sustainable technologies and high-value imported reagents, thereby undermining the economic pillar of the Triple Bottom Line (Maseko & Zinyemba, 2024). The power dynamics of the informal mining sector further complicate this fiscal landscape; while surrender requirements for informal miners were recently adjusted to 70/30 from a previously favourable 90/10, intense pushback from this sector suggests a likely reversal to the original split. This ability to influence national policy highlights the immense power of an informal sector that operates essentially rule-free, posing a significant challenge for governments in developing countries attempting to enforce formal regulations.

This regulatory vacuum creates a climate of profound unfair competition within developing nations. Formal mining organisations like Dorowa Minerals are burdened by rigorous compliance and mandatory surrenders, while their informal counterparts operate without environmental, safety, or fiscal constraints. Consequently, long-term established companies are becoming increasingly uncompetitive compared to unregulated local peers and foreign entities. Using Zimbabwe as a primary example, this trend serves as a predictive warning for South

Africa (RSA), where the economy relies on a robust formal mining sector. As the RSA mining landscape becomes increasingly informalised, the lack of a governance framework to regulate these activities threatens to constrain national industrial stability even more acutely than in the Zimbabwean experience. Despite growing awareness, a critical knowledge gap exists in the form of a tailored framework that aligns Zimbabwean mining operations with global sustainability standards while navigating these unique financial shocks and the systemic impediment of a powerful informal sector (Muzondo & Pashapa, 2025). There is an absence of a standardised framework for sustainable governance that accounts for local currency volatility and the external unpredictability of commodity markets (Munuhwa, 2022). It is still unclear how the specific variables related to the sustainable supply chain management, for example, strategic partnering with suppliers and green procurement, may be used to improve performance in this challenging environment. The consequences of failing to address this gap are severe; without a transformative intervention to reverse these signs of deteriorating performance, the sector faces an existential threat of capital flight and operational collapse (Howie et al., 2025). Therefore, this research seeks to bridge this divide by empirically evaluating the impact of sustainable supply chain management on organisational performance to provide a scientifically validated roadmap for the survival and excellence of the Zimbabwean mining sector.

1.4 Research Objectives

The primary aim of this research is to enhance organisational performance within the industrial mineral sub-sector of the Zimbabwean mining industry, specifically focusing on large-scale formal entities like Dorowa Minerals. By adopting a segregated approach that accounts for the unique supply chain dynamics of mineral extraction and processing, the study aims to improve cost efficiency, lead-time reduction, and resource utilization through the development of a tailored Sustainable Supply Chain Management (SSCM) framework. To achieve this aim, the study seeks to address the following specific objectives:

- To establish the effects of Strategic Supplier Partnership on Organisation Performance in the Mining Sector.
- To assess the effects of Green Procurement on Organisation Performance in the Mining Sector.

- To determine the effects of Eco-Innovative Practices on Organisation Performance in the Mining Sector
- To assess the effects of Internal Environmental Management on Organisation Performance in the Mining Sector.
- To evaluate the operational impact of the informal economy, specifically artisanal mining, on the supply chain stability and resource availability for formal entities
- To develop a predictive supply chain stability framework in Zimbabwe mining sector.

1.5 Research Questions

- What are the effects of Strategic Supplier Partnership on the organisational performance of firms operating within the mining sector?
- What is the impact of Green Procurement practices on the overall organisational performance of mining companies?
- What influence do Eco-Innovative Practices exert on the multifaceted organisational performance of the mining industry?
- What are the effects of Internal Environmental Management on the organisational performance of mining entities in resource-constrained environments?
- What is the operational impact of the informal economy, specifically artisanal mining, on the supply chain stability and resource availability for formal mining entities such as Dorowa Minerals?
- What predictive supply chain stability framework can be developed in Zimbabwe's formal mining sector

1.6 Statement of Hypothesis

H1: There is a positive relationship between Strategic Supplier Partnership and Organisational Performance in the mining sector.

H2: There is a positive relationship between Green Procurement practices and Organisational Performance in the mining sector.

H3: There is a positive relationship between Eco-Innovative Practices and Organisational Performance in the mining sector.

H4: There is a positive relationship between Internal Environmental Management and Organisational Performance in the mining sector.

H5: There is a positive relationship between a firm's ESG Compliance and its Market Competitiveness, specifically regarding the preference of export customers and the ability to maintain long-term international trade contracts

H6: There is a positive relationship between the formalization and integration of artisanal mining into the formal supply chain and the organizational performance of mining entities.

1.7 Research Assumptions

For this research, the following assumptions have been established:

- **Strategic Supplier Partnerships**: It is assumed that strategic collaborations capture long-term relationship patterns and mutual trust to accurately assess and mitigate risks in the mining supply chain to drive organisational performance
- **Green Procurement Integration**: The study assumes that green procurement provides the necessary environmental data through life-cycle assessments to effectively inform and influence sustainable organisational processes.
- **Eco-Innovative Veracity**: It is assumed that the eco-innovative systems adopted by mining houses have sufficient operational maturity to provide reliable scores for identifying resource-saving opportunities.
- **Internal Environmental Management**: The researcher assumes that internal environmental reporting offers accurate and timely insights into a company’s carbon footprint and resource efficiency, which are vital for sustainable management decisions.
- **Performance Forecasting**: It is assumed that sustainable supply chain analytics serve as a reliable foundation for predicting future business outcomes, helping the industry navigate and prepare for Volatility, Uncertainty, Complexity, and Ambiguity (VUCA) challenges inherent in the global mineral markets

- **Management Credibility**: The study assumes that sustainability reports are presented to top management as a credible basis for making informed selections between various green business alternatives.
- **Participant Objectivity**: It is assumed that a diverse mix of participants including supply chain managers, environmental officers, and marketing executives from various types of mining entities (e.g., PGM, Gold, and Phosphate mines) will provide honest and objective responses regarding the effectiveness of sustainability tools without succumbing to greenwashing bias.
- **Data Accessibility**: The researcher assumes that the selected mining organisations maintain a consistent level of data accessibility across different levels of respondents to allow for the meaningful application of supply chain analytics and comparative performance evaluation
- It is assumed that with the passage of time recommendations arising from this study will receive buy in from both governments and players in the currently unregulated informal mining sector.

1.8 Justification of the Research

The justification for conducting this research is due to the necessity of ensuring the Zimbabwe mining industry is globally sustainable and at the same time overcoming the problem of declining organisational performance. As the nation's primary economic engine, the mining industry currently operates under a paradox: it provides the essential minerals for the global green transition but is plagued by escalating operational costs, energy deficits, and a depressed commodity price outlook for key minerals like lithium and platinum (Chamber of Mines, 2024; Howie et al., 2025). This research is justified by its potential to provide an empirical roadmap for mining houses to transition from reactive compliance to proactive, sustainability-driven excellence, thereby securing their long-term survival in an increasingly carbon-conscious global market. The authorities have a role to play in terms of ensuring enough regulation to recreate fair competition and environmental/safety compliance.

The main limitation within the current body of literature is the absence of an adapted and empirically validated model that connects the international standards of SSCM to the unique constraints of the economic environment prevailing in Zimbabwe and especially the mining industry. While global studies increasingly highlight the benefits of green supply chains, recent

literature emphasizes that existing models developed in Western contexts often fail to account for the institutional voids and macroeconomic uncertainty inherent in Sub-Saharan Africa (Maseko & Nyathi, 2024; Reddy & Kumar, 2023).

This gap is particularly glaring when attempting to apply generic sustainability models to resource-dependent developing economies facing systemic disruptions. For instance, South Africa (RSA) is currently grappling with the rise of Zama Zamas (illegal miners) who compromise the structural integrity and supply chain security of formal gold and platinum mines. Similarly, the Democratic Republic of Congo (DRC) faces immense pressure to clean up its cobalt supply chains, where the intermingling of artisanal and formal mining creates significant ESG (Environmental, Social, and Governance) risks for international buyers. In Zambia, the copper-belt region faces infrastructure bottlenecks and power deficits that mirror the Zimbabwean experience.

By using the case of Dorowa Minerals in Zimbabwe, this study is justified as a predictive tool. It seeks to model how the informal sector impediment can be managed through a sustainable supply chain framework, offering a blueprint for South Africa and other regional peers to forecast operational risks and protect market share. The reality is that there is a dearth of literature, which focuses specifically on the synergies between Strategic Supplier Partnerships, Green Procurement, and Eco-Innovation Practices that could help increase performance in an industry that is currently suffering financial losses of hundreds of millions due to infrastructure challenges and uncontrolled competition (Reuters, 2024; Ndlovu & Mutasa, 2024).This research fills that void, providing a localized solution with broad regional applicability.

Furthermore, although scholars like Muzondo and Pashapa (2025) have identified systemic barriers such as limited financial capital and regulatory weaknesses, there remains a critical methodological and practical gap in demonstrating how these obstacles can be overcome through specific sustainable configurations to drive profitability. By addressing this gap, the study provides a timely intervention that not only contributes to the academic discourse on SSCM in emerging economies but also offers practical solutions to prevent the existential threat of capital flight and operational collapse in Zimbabwe's vital extractive industry (Howie et al., 2025). The research provides the necessary intellectual and practical tools to ensure that sustainability becomes a hallmark of Zimbabwean mining, enabling the sector to meet the national goal of becoming a stable, multibillion-dollar industry by 2030

1.9 Significance of the Study

The importance of this research depends upon the potential ability of the research to provide a paradigm shift in the operations of the mining industry of Zimbabwe to fit in with the sustainability standards being set by the rest of the world.

1.9.1 Significance to Academia and Theoretical Discourse

This paper is a valuable addition to the international academic conversation, as it extends the concepts of Resource-Based View (RBV) and Stakeholder Theory by considering them within a specific context. While conventional theories often assume stable environments with mature regulatory oversight, this research enriches the RBV by conceptualizing Green Procurement and Internal Environmental Management as dynamic capabilities essential for survival in volatile markets. It identifies a significant theoretical gap by examining how firms can leverage internal sustainability competencies to overcome systemic external hurdles such as infrastructure deficits and regulatory uncertainty.

The research combines the TBL approach with the Green Supply Chain Operations Reference (GreenSCOR) model to suggest an all-encompassing framework that takes into consideration the socio-economic intricacies inherent to Sub-Saharan Africa. By doing so, it challenges the universalist approach of developed-world sustainability models and establishes a theoretical foundation for inclusive procurement as a primary driver of long-term economic development and regional stability. Methodologically, the research introduces a rigorous, multi-dimensional evaluative framework that transcends traditional financial metrics, offering a blueprint for future researchers operating in similar institutionally volatile environments across the African continent.

1.9.2 Significance to Policy Makers and Regulatory Frameworks

In relation to the transition by Zimbabwe into an innovation economy, this research is crucial in that it serves as a critical bridge between academic analysis and policy making in relation to the goals set out in the Education 5.0 theme of Industrialisation and Innovation. Through providing a validated SSCM model, the research contributes to providing a model for the Government of Zimbabwe and other regional organizations like SADC in terms of transitioning the country's mining industry from resource exportation to value addition and sustainable industrialization. The results of the study will be of great relevance to the people responsible for developing the PPDPA Act since the integration of sustainability measures into the

procurement process will enable the attraction of FDI which is vital for the industrialization of the country.

The study addresses a critical gap in current governance: the informal sector impediment. By applying the Community Service and Heritage-Based pillars of Education 5.0, this research provides authorities with the data-driven justification needed to formalise artisanal mining. It moves beyond traditional policing models to propose a policy framework where informal miners are integrated into the formal value chain as strategic partners. This not only recreates fair competition and ensures environmental/safety compliance but also secures the supply of raw materials for formal entities like Dorowa Minerals. Such a policy shift is essential for achieving the National Development Strategy 1 (NDS1) goals, as it protects formal market shares while empowering local communities through inclusive economic growth.

The research holds regional significance by aligning Zimbabwean policy with the African Union's Green Minerals Strategy. For regulators, this study highlights the sustainable management of supply chains is a prerequisite for local beneficiation and value addition. By proving that green procurement and eco-innovation can reduce the carbon footprint and operational costs of processing minerals locally, the research provides a roadmap for policy makers to mitigate the resource curse. It transforms the role of the regulator from a simple monitor of compliance into a facilitator of an advanced, carbon-conscious industrial ecosystem that can be mirrored across the African continent, particularly in developing economies like South Africa and Zambia.

1.9.3 Significance to the Mining Industry and Corporate Strategy

This study will provide the mining management and practitioners with an actionable and evidence-based tool kit intended to increase efficiency and sustainability. Under a macroeconomic environment characterized by exchange rate instability and energy crisis, the results show that activities like whole life cycle costing of the product and buying recyclable products have a direct link with procurement efficiency. By adopting Strategic Supplier Partnerships, mining houses can foster knowledge sharing and logistics outsourcing, which increases market potential and operational agility in high-risk sectors.

Beyond internal efficiencies, the study addresses the critical social license to operate. It demonstrates that investments in local supplier development and social equity metrics act as tangible tools to manage community unrest, thereby reducing the risk of costly operational disruptions. As international trade barriers increasingly include carbon border adjustments, the

financial performance of Zimbabwean mining firms becomes inextricably linked to their environmental footprint. This research, therefore, serves as a survival guide for the industry, providing the necessary intellectual and practical tools to ensure that sustainability becomes the hallmark of Zimbabwean mining, enabling the sector to meet its ambitious goals for 2030 and beyond.

1.10 Delimitations of the Study

1.10.1 Geographical Delimitation

The geographical scope of this study is strictly delimited to the operational sites and administrative headquarters of G&W Industrial Minerals and Dorowa Minerals Limited located within the Republic of Zimbabwe, specifically focusing on their corporate and supply chain hubs in Harare. This specific geographical focus is chosen because Harare serves as the primary administrative and decision-making centre for national mining governance and corporate procurement, providing a concentrated and representative environment for analysing high-level Sustainable Supply Chain Management (SSCM) systems (Maseko & Zinyemba, 2024). By centering the research on the management and procurement offices in the capital, the study ensures a deep and manageable data analysis of the country's core extractive value chains without overextending resources to remote artisanal mining sites where advanced sustainability infrastructure may be less prominent (Muzondo & Pashapa, 2025).

1.10.2 Conceptual Delimitation

Conceptually, this research is delimited to evaluating the impact of Sustainable Supply Chain Management (SSCM) specifically on organisational performance within the Zimbabwean mining industry. The study is underpinned by the Resource-Based Theory (RBT) and Stakeholder Theory (ST), establishing a statistical nexus between green procurement, internal environmental management, eco-innovative practices, and strategic supplier partnerships in emerging markets. It contributes to the existing discourse by exploring how integrated sustainability models facilitate enhanced financial and operational performance, moving beyond traditional linear logistics to capture complex, nonlinear interactions in modern mining value chains.

1.10.3 Time Delimitation

The study was centred around the years 2021 to 2026. These years are crucial because they represent the period of acceleration of sustainability post-pandemic in the mining industry of

Zimbabwe, as well as the intensification of attempts to update supply chain reporting mechanisms through the PPDPA Act. Furthermore, this period covers the significant transition to the Zimbabwe Gold (ZiG) currency and the subsequent requirement for advanced supply chain analytics to manage multi-currency procurement complexities and inflationary adjustments. By including data up to 2026, the study ensured the inclusion of the most recent institutional performance metrics

1.11 Limitations of the study

1.11.1 Refusal of Respondents

Certain respondents may decline to disclose information pertinent to the study due to concerns about organizational politics. To mitigate this resistance, the researcher presented a formal Approval Letter from the Graduate School of Business (GSB). This official documentation serves as a critical instrument of credibility, confirming that the study has undergone ethical review and is strictly for academic purposes. Furthermore, the researcher provided written assurance to all participants that their identities and specific corporate data remained anonymous and confidential, thereby fostering an environment of transparency and cooperation.

1.11.2 Time Constraints

Balancing employment and study may impose time restrictions. To address this difficulty, the researcher utilised leave days to carry out the investigation effectively.

1.12 Dissertation Outline

The study is broken up into five different chapters. The first Chapter provides an overview of the overall research project. This Chapter discusses the background of the research, the problem that it aims to solve, the research objectives and Questions that guides it, the scope of the study, and an outline of how the inquiry will be conducted, as well as the format of the dissertation.

The review of previous research is included in Chapter 2 of the study. This chapter, focuses on previous research that has been done in the topic relating to enhancing organisational performance in the mining sector through developing a sustainable supply chain management framework in Zimbabwe. This chapter focuses theoretical Literature Review, Conceptual Literature Review and Empirical Literature Review

The methodology of the research is presented in chapter three. The most important aspects of research are discussed in this chapter, including research philosophies, research strategies, research designs, target populations, sample sizes, sampling methods, research instruments, data collection procedures, data analysis and presentation methods, reliability, validity, and ethical considerations.

The findings and subsequent discussion are presented in Chapter 4. In this chapter, the topics covered include response rate, general information, and information about respondents, reliability, and thematic analysis of data. In the final chapter, Chapter five, the conclusions, and implications that may be drawn from the study findings and how they relate to the research hypotheses are presented.

1.13 Chapter Summary

The background information presented in this chapter is the foundation of the study because it provides the context regarding the sustainable supply chain management at the global, regional and national levels. There is clearly a gap in the existing literature that can be identified with the absence of a scientific framework that would allow linking the practices used in the Zimbabwean mining sector, both formal and informal, with international sustainability standards in view of productivity reductions and higher costs incurred in this sector. This study presents the research objectives and hypotheses, particularly focusing on the relationship between strategic supplier relationships, green procurement, eco-innovation and environmental management. The scope of the research covers the period from 2021 to 2026 in Harare, Zimbabwe.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides an extensive analysis of the existing literature concerning the improvement of organizational performance in the mining industry by means of building a sustainable supply chain management model. The analysis is structured in such a way as to cover all the relevant theoretical, conceptual, and empirical threads associated with the research problem and its main purposes. Firstly, starting with the theoretical perspectives, that is, the Resource-Based View Theory (RBT) and the Stakeholder Theory (ST), the chapter lays down the grounds for a sustainable organizational performance analysis framework.

2.2 Theoretical Review

The basis for this research is the Resource Based Theory (RBT) and Stakeholder Theory (ST). The combination of these theories provides an in-depth tool for analyzing how mining companies may use their strengths and handle relationships with others in order to achieve sustainable performance.

2.2.1 Resource-Based Theory (RBT)

Resource-Based View (RBV) was first formally developed by Birger Wernerfelt (1984) and later elaborated extensively by Jay Barney (1991). The RBV assumes that the competitive advantage of an organization depends on the resources it possesses within itself and not on its position in the market (Barney, 1991). All of these are included in the totality of assets, competencies, organizational routines, firm characteristics, information, and knowledge controlled by the firm that allows it to develop and implement strategic activities in order to improve its efficiency and effectiveness (Wernerfelt, 1984). In order for the resource to create a competitive advantage, it should meet the VRIN condition – that is, being valuable, rare, inimitable, and non-substitutable (Barney, 1991). According to Barney et al. (2021), modern uses of RBT necessitate that organizations have enough organizational capital to implement their resources effectively under highly dynamic conditions. According to Baah and Jin (2024), SSCM is used by organizations in the extractive industry as socially-complex resources which cannot be easily imitated by other organizations. As per Song et al. (2022), capabilities such as internal environmental management work as high-order resources which help companies cope with regulation pressure and at the same time reduce their cost of operations.

Furthermore, Muzondo and Pashapa (2025) contend that for firms in emerging economies, the ability to internalise sustainability as a core resource is the primary differentiator between high-performing entities and those facing operational stagnation.

The significance of the Resource Based Theory (RBT) to this research is because it explains how mining companies in Zimbabwe can gain organizational excellence by looking inside themselves and leveraging their unique supply chain structures. Considering the turbulent external macroeconomic conditions faced by the nation, the theory suggests the importance of internal factors such as Eco-Innovative Practices and Green Procurement, which act as strategic resources that can be used to achieve organizational success (Maseko & Zinyemba, 2024). The resource-based theory helps in determining whether the utilization of sustainable practices in the mining industry leads to a competitive advantage (VRIO-Valuable, Rare, Inimitable, and Organized) in reducing risk from market fluctuations (Ndlovu & Mutasa, 2024).

Integrating Porter's Five Forces thus offers a more comprehensive view, demonstrating how external market dynamics interact with a firm's internal resource configuration to shape its competitive landscape and ultimately its performance in emerging economies (Moyo & Sibanda, 2024). Deveci et al. (2023) highlight that mining companies that bundle their technical expertise with green logistics create a unique capability that competitors cannot easily copy.

2.2.2 Stakeholder Theory (ST)

ST is a theory formulated by R. Edward Freeman in 1984, which was developed specifically as an alternative to traditional shareholder-oriented approach to corporate governance. According to this theory, “an organization is a coalition of cooperating and competing interests and the fundamental aim of the organization is value creation for all stakeholders involved in the organization’s operations” (Freeman, 1984). Such stakeholders include employees, suppliers, consumers, local communities, governmental organizations, and environment. Bridoux and Stoelhorst (2022) highlight that the theory identifies stakeholder engagement as a relational capability that enhances firm legitimacy and reduces transaction costs. Islam et al. (2024) argue that for extractive industries, managing the social license to operate is an instrumental requirement for performance, as it directly mitigates the risks of strikes, community protests, and regulatory sanctions. Khumalo and Tshabalala (2024) observe that in Sub-Saharan Africa, the social dimension of the supply chain specifically Strategic Supplier

Partnerships is a vital stakeholder management strategy that fosters regional economic stability while enhancing the focal firm's operational resilience.

The applicability of the stakeholder approach vis-a-vis the current research can be justified on account of the environmental degradation caused by mining companies, coupled with the strong effect of this industry on the communities hosting them in Zimbabwe. According to Moyo and Chikodzi (2023), "Stakeholder Theory offers a theoretical perspective in which one can understand how green procurement and social supply chain management act as means of meeting the expectations of international investors and local regulatory bodies." The theory has been used in this research to explain how mining companies in Zimbabwe can improve their organizational performance through the integration of suppliers and community members as strategic stakeholders. Muzondo and Pashapa (2025) assert that sustainable performance is achieved when a firm successfully aligns its economic goals with the social and environmental imperatives of its broader ecosystem. Alvites-Huamaní et al. (2023) emphasize that firms ignoring stakeholder interests in the supply chain face higher litigation and reputational costs which directly erode financial performance. By adopting a stakeholder-oriented approach to supply chain management, this study demonstrates that long-term mining success in Zimbabwe is inextricably linked to the well-being of the diverse groups affected by mineral extraction.

The significance of both Resource-Based Theory (RBT) and Stakeholder Theory (ST) becomes particularly pronounced when considering the growing informal mining sectors in regions like Zimbabwe and South Africa. The pervasive nature of informal mining, often characterized by artisanal and small-scale miners (ASM), introduces complex dynamics that challenge conventional notions of competitive advantage and stakeholder engagement (Mutsvangwa & Musavengana, 2023). From an RBT perspective, the informal sector can erode the *rarity* and *inimitable* nature of formal firms' resources, including their access to prime mineral deposits or their established operational processes. Informal miners, operating outside regulatory frameworks, can access resources with lower overheads, thereby impacting the *value* proposition of formal firms' high-cost, compliant operations (Sibanda & Ncube, 2024). This necessitates formal mining companies to cultivate genuinely unique and difficult-to-replicate internal capabilities, such as advanced geological expertise, large-scale processing technologies, or highly efficient green logistics (Deveci et al., 2023), that informal operations cannot mimic. Furthermore, the capacity to effectively manage social and environmental impacts, often overlooked by the informal sector, becomes a differentiating *resource* for formal

firms, enhancing their legitimacy and securing their "social license to operate" (Islam et al., 2024; Khumalo & Tshabalala, 2024).

From a Stakeholder Theory perspective, the informal mining sector represents a critical, often overlooked, and highly influential stakeholder group. Ignoring the ASM community can lead to significant operational disruptions, including resource conflicts, land disputes, and reputational damage (Moyo & Chikodzi, 2023; Alvites-Huamaní et al., 2023). Therefore, formal mining firms must strategically engage with these informal actors, treating them not merely as competitors or threats, but as stakeholders whose interests and livelihoods are intertwined with the broader mining ecosystem. This engagement can take various forms, such as formalized sourcing agreements for artisanal outputs, capacity building initiatives, or collaborative environmental management programs (Musiyarira & Phiri, 2022). Such proactive stakeholder engagement builds relational capabilities (Bridoux & Stoelhorst, 2022) that can transform potential conflicts into cooperative opportunities, thereby safeguarding operations and enhancing the firm's long-term sustainability (Muzondo & Pashapa, 2025). Ultimately, addressing the informal mining sector through the lenses of both RBT and ST reveals that sustained competitive advantage in these regions is not solely about internal efficiency or broad stakeholder appeasement, but about strategically integrating unique resources with comprehensive stakeholder management to navigate and influence the complex socio-economic landscape.

2.3 Empirical Review

2.3.1 The effects of Strategic Supplier Partnership on Organisation Performance in the Mining Sector

Strategic Supplier Partnerships (SSPs) are increasingly recognized as pivotal for enhancing organizational performance in the mining industry, moving beyond mere transactional exchanges to foster long-term collaborative value creation (Nag & Ferdausy, 2023). In the context of Southern African mining, integrating supplier relationship management demonstrably correlates with improved cost efficiency (Muma, 2024). Empirical evidence suggests that approximately 87.5% of mining professionals view strategic partnerships as a key driver for financial improvement (Muma, 2024), by reducing procurement lead times through real-time data exchange, essential for continuous extraction activities in demanding environments (Rashid, 2024).

Collaborative frameworks directly enhance supply chain responsiveness and operational agility (Nenavani & Jain, 2022), mitigating the negative impacts of demand uncertainty on overall operational performance. Studies show that horizontal collaboration can lead to an average 30.8% reduction in lead times, consequently lowering inventory holding costs (Ghaderi & Dullaert, 2024). Specifically, in the Zimbabwean mining environment, buyer-supplier relationship management accounts for 28.3% of the variance in organizational performance (Chinogwenya & Utete, 2023). The absence of such strategic coordination often exacerbates supply chain instability and heightens operational risks for formal mining entities (Chinogwenya & Utete, 2023).

Strategic alliances also facilitate superior resource utilization and waste reduction by aligning partner capabilities (Fan & Wang, 2024). Public-private and strategic resource management partnerships are crucial for transitioning to sustainable technologies in industrial mining processes (Fan & Wang, 2024). Close collaboration allows suppliers to contribute directly to process improvement and quality reliability, foundational elements for organizational resilience (Cooper, 2024). Sustainable procurement initiatives within the SADC region have notably led to a 15% decrease in operational costs through waste reduction and energy efficiency mandates within supplier contracts (SADC Mining Study, 2024). These frameworks enable suppliers to become strategic allies, thereby enhancing the overall efficiency of the mineral value chain (Cooper, 2024).

Furthermore, SSPs act as catalysts for innovation and risk mitigation against external economic shocks (Kim et al., 2022). They moderate the relationship between supplier dependence and competitive advantage, aiding firms in achieving cost leadership (Kim et al., 2022). Early supplier involvement in the procurement cycle allows for the customization of high-stakes equipment, directly improving the technical efficiency of mineral extraction (Paul et al., 2024). For the Zimbabwean mining sector, these partnerships offer a robust mechanism to balance the resource needs of formal entities while navigating the instability created by unregulated artisanal competition (Paul et al., 2024). Maintaining healthy financial disbursements to partners is crucial to prevent the erosion of trust that typically undermines these strategic benefits (Chinogwenya & Utete, 2023).

2.3.2 The Effects of Green Procurement on Organizational Performance in the Mining Sector

There is a significant effect of green procurement on organizational performance as far as its compatibility with organizational sustainability goals and effectiveness is concerned (Amoah et al., 2024). About 75% of organizations that have adopted green procurement have experienced a significant decline in the amount of waste and costs involved in the use of energy, which leads to cost efficiency (Amoah et al., 2024). Within large-scale industrial processes, sustainable procurement processes are very important in saving costs through resource efficiency and reduction of waste (Tabesh et al., 2024), the use of circular economy strategies and waste reduction approaches saw an estimated 15% decline in the cost of operations from 2021 to 2023 (Celestin et al., 2024). Recycling and green products contribute positively to procurement efficiency in the Zimbabwean mining industry (Mawonde & Mapira, 2021).

The green procurement process can be considered a tool for improving the company's image and ensuring compliance with regulations (Otieno et al., 2025). Green supply chain practices such as green procurement have a statistically significant positive impact on firm performance in the mining and extraction industry (Otieno et al., 2025). High-quality sustainable procurement minimizes both environmental and reputational risks, while boosting long-term credibility with stakeholders (Awaysheh et al., 2024). Green mining practices, encompassing green purchasing, assist firms in mitigating ecological disruption and promoting more responsible natural resource use (Xiao et al., 2024).

Green procurement directly impacts the operational agility and resource security of mining organizations (Siddiquee et al., 2024). Green purchasing is crucial for preserving natural resources and reducing waste disposal in an economically viable manner (Siddiquee et al., 2024). By integrating environmental factors into supplier selection, companies can effectively reduce the risk of supply chain disruptions caused by non-compliance or resource scarcity (Cooper, 2024). Sustainable procurement considers the entire lifecycle of materials, enhancing the long-term economic viability of the firm (Umar, 2024).

From a financial perspective, green procurement strategies lead to higher profitability through improved market reputation and better resource management (Paul et al., 2024). The strategic alignment of procurement with environmental standards ensures that mining firms remain competitive in a global market that increasingly demands transparency (Paul et al., 2024). Formal entities in Zimbabwe can leverage these practices to differentiate themselves from

unregulated operations that do not adhere to environmental standards (Mawonde & Mapira, 2021). In pursuit of a sustainable future, 98% of Zimbabwean mining executives emphasize mitigating negative impacts through investments in cleaner production technology and renewable energy (Herald Online, 2024).

The integration of eco-friendly sourcing criteria helps mining firms manage the lifecycle of heavy machinery and hazardous chemicals more effectively (Muma, 2024). By prioritizing suppliers of biodegradable or reusable components, mining entities reduce the long-term costs associated with environmental remediation and land reclamation (Celestin et al., 2024). This proactive sourcing approach prevents the accumulation of toxic waste, a major performance bottleneck for formal mines operating near artisanal clusters (Xiao et al., 2024). Consequently, green procurement acts as a safeguard against the rising costs of carbon taxes and environmental penalties imposed by regulatory bodies in emerging economies (Agyapong et al., 2024). Additionally, green procurement fosters innovation within the supply chain by encouraging suppliers to develop low-carbon extraction technologies (Otieno et al., 2025). This collaboration often leads to more energy-efficient smelting and processing methods, significantly lowering utility bills for mining houses (Tabesh et al., 2024). Evidence indicates that firms engaged in green procurement are better positioned to attract international green investment, providing necessary capital for operational expansion (Awaysheh et al., 2024).

Dorowa Minerals, as a formal mining operation in Zimbabwe, directly benefits from adopting green procurement to reduce waste and energy expenses (Amoah et al., 2024). The documented 15% decrease in operational costs in the SADC region through circular economy principles (Celestin et al., 2024) suggests that similar efficiencies can be achieved, bolstering its financial performance in a volatile market (Muzondo & Pashapa, 2025). This is particularly critical given the compliance burdens faced by formal entities compared to informal counterparts (Maseko & Zinyemba, 2024). Moreover, green procurement enhances corporate reputation and ensures regulatory compliance, distinguishing Dorowa from unregulated operations and strengthening its social license to operate (Otieno et al., 2025; Awaysheh et al., 2024; Ndlovu & Mutasa, 2024). Financially, it contributes to higher profitability by attracting green investment, aligning with the growing trend among Zimbabwean mining executives to invest in cleaner production (Paul et al., 2024; Herald Online, 2024).

2.3.3 The Effects of Eco-Innovative Practices on Organizational Performance in the Mining Sector

The introduction of eco-innovative practices greatly improves organizational performance in terms of environmental technology and innovative processes that minimize environmental impact but increase production output (Awan et al., 2021). Cleaner production processes in mining have been demonstrated to improve resource efficiency by as much as 22% and decrease the unit cost of extracting minerals (Awan et al., 2021). Due to eco-process innovation, mining houses can obtain valuable by-products out of waste streams and turn environmental liabilities into profit-making resources (Fernando et al., 2022). Hence, using eco-innovation is not optional but obligatory for financial sustainability (Awan et al., 2021).

The correlation between eco-innovation and financial performance is mediated by the ability of the organization to minimize waste and energy expenses via innovative technology (Fahad et al., 2022). Studies prove that investments in eco-innovation in mining, such as smelting and refining, lead to a substantial reduction in carbon taxes and energy expenses (Fahad et al., 2022). These technological upgrades facilitate streamlined production, contributing to lead-time reduction by eliminating inefficient, high-pollution bottlenecks (Zameer et al., 2021). Moreover, eco-innovative practices foster continuous improvement, encouraging employees to identify resource-saving opportunities that enhance overall technical efficiency (Zameer et al., 2021). Successful implementation often leads to higher operational agility and a stronger ability to navigate fluctuating commodity prices (Fahad et al., 2022).

Deploying advanced environmental monitoring systems enables mining entities to detect and mitigate potential pollution incidents before they result in costly legal penalties or operational shutdowns (Duran & Gunes, 2021). In Zimbabwe, where formal mines face increasing pressure to coexist with local communities, eco-innovation helps reduce negative externalities like dust and water contamination (Mugwagwa et al., 2023). By adopting water-recycling technologies and dust-suppression innovations, formal mining organizations enhance their social license to operate, crucial for maintaining market share (Mugwagwa et al., 2023). This strategic alignment with community and environmental needs creates a stable operating environment that supports consistent production targets (Duran & Gunes, 2021).

Eco-innovative practices also play a pivotal role in optimizing resource utilization by extending the life of existing mineral reserves (Khattak et al., 2022). Advanced geological mapping and eco-efficient drilling technologies enable more precise extraction, reducing the volume of

barren rock moved and processed (Khattak et al., 2022). This precision significantly lowers the energy intensity of mining operations, a major cost driver in Zimbabwe's electricity-constrained environment (Mugwagwa et al., 2023). Furthermore, using renewable energy innovations, such as on-site solar plants, provides a reliable power supply that insulates formal entities from national grid instabilities (Khattak et al., 2022). These investments secure resource availability and signal commitment to modern, low-carbon industrial standards to international investors (Zameer et al., 2021).

Eco-innovation spearheads the stabilization of the supply chain through encouraging the development of green inputs and sustainable logistics (Hussain et al., 2021). Mining organizations collaborating with suppliers to develop biodegradable lubricants or electric hauling trucks achieve deeper integration, enhancing overall supply chain resilience (Hussain et al., 2021). These collaborative eco-innovations reduce hazardous material handling costs and lower risks associated with chemical spills (Hussain et al., 2021). By pioneering green technology, formal mining entities create a significant barrier to entry for unregulated artisanal operations lacking the capital and expertise for sophisticated systems (Mugwagwa et al., 2023). This technological gap reinforces the market share of formal organizations while promoting a more sustainable and professionalized mining sector (Hussain et al., 2021).

The adoption of eco-innovative management systems, such as ISO 14001, provides a structured framework for achieving both environmental and economic goals (Asadi et al., 2021). These systems facilitate systematic tracking of resource flows, enabling managers to identify and eliminate invisible wastes in the production cycle (Asadi et al., 2021). The resulting data-driven insights allow for more accurate forecasting and resource allocation, vital for enhancing the profitability of complex mining projects (Asadi et al., 2021). In a segregated sector like Zimbabwe's, eco-innovation provides the transparency needed to demonstrate that formal mining operations are significantly more efficient and responsible than their unregulated counterparts (Mugwagwa et al., 2023).

2.3.4 The Effects of Internal Environmental Management on Organizational Performance in the Mining Sector

Internal Environmental Management (IEM) is the proactive and systematic integration of environmental considerations into a firm's internal operations, processes, and decision-making to minimize environmental impact, optimize resource use, and enhance overall organizational performance (Sahoo & Vijayvargy, 2021; Qorri et al., 2021). IEM serves as a foundational

element of sustainable supply chain management by institutionalizing eco-friendly protocols within the core operations of mining firms (Sahoo & Vijayvargy, 2021). Top management's commitment to internal environmental auditing and environmental management systems (EMS) directly reduces operational waste and enhances resource productivity (Sahoo & Vijayvargy, 2021). In heavy industries, IEM protocols facilitate the systematic tracking of energy and water consumption, leading to significant decreases in utility overheads (Qorri et al., 2021). Empirical evidence suggests that firms with robust internal environmental controls achieve superior cost efficiency by minimizing hazardous leaks and industrial accidents (Qorri et al., 2021). Consequently, IEM provides the internal structural discipline necessary to convert sustainability goals into measurable financial gains (Sahoo & Vijayvargy, 2021).

The integration of IEM practices significantly impacts lead-time reduction by streamlining internal processes and reducing environmental bottlenecks (Chuang & Huang, 2022). By adopting Lean-Green management principles, mining organizations can eliminate non-value-adding activities that contribute to both pollution and production delays (Chuang & Huang, 2022). Research indicates that internal cross-functional cooperation for environmental protection allows for faster identification of process inefficiencies, accelerating the overall extraction and processing cycle (Yang et al., 2021). These internal efficiencies are critical for maintaining supply chain stability, especially when facing external disruptions or resource scarcity (Yang et al., 2021). Furthermore, IEM fosters a culture of compliance that ensures production is not interrupted by regulatory shutdowns or environmental litigation (Chuang & Huang, 2022).

From a resource utilization perspective, IEM enables mining firms to maximize the output of every unit of raw material processed through internal recycling and reuse programs (Onyiyechi et al., 2023). Within the African mining context, internal initiatives aimed at reclaiming water from tailing dams have been shown to reduce reliance on external water sources, thereby lowering operational risks during droughts (Onyiyechi et al., 2023). These internal resource loops contribute to a circular economy model that enhances the long-term availability of critical inputs for formal mining entities (Afum et al., 2021). Data-driven internal monitoring allows managers to allocate resources more precisely, reducing the over-processing of low-grade ores that traditionally wastes energy (Afum et al., 2021). Therefore, IEM acts as a technical catalyst for enhancing the resource efficiency of complex mineral value chains (Onyiyechi et al., 2023).

The relationship between IEM and organizational performance is further strengthened by enhanced employee engagement and technical competency (Masocha, 2021). Internal environmental training programs equip miners with skills to operate sophisticated, eco-efficient machinery, directly boosting labor productivity (Masocha, 2021). In Zimbabwe, mining firms prioritizing internal environmental health and safety (EHS) report lower absenteeism and higher employee morale, leading to more consistent production outputs (Masocha, 2021). This green human resource management aspect of IEM ensures workforce alignment with the firm's sustainability framework, reducing operational errors (Masocha, 2021). As a result, the human element of IEM becomes a competitive advantage difficult for unregulated artisanal operations to replicate (Masocha, 2021).

The compliance aspect of IEM is critical in the as it features a dual-tier operational landscape of formal and informal mining. Zimbabwe has a legislative framework, notably the Environmental Management Act, providing a basis for environmental compliance for all mining operations. This Act sets parameters for environmental impact assessments, waste management, pollution control, and rehabilitation, signalling the government's intent to regulate environmental practices. However, the adequacy and enforceability of these regulations are significant challenges. While the legal framework exists, Ndlovu and Mutasa (2024) emphasize that "more rigorous enforcement is required to move the sector beyond greenwashing into substantive sustainable practice." The informal mining sector, characterized by Makorokoza, often operates with "minimal oversight," creating a "regulatory vacuum where essential controls regarding child labour and occupational safety are non-existent" (Ndlovu & Mutasa, 2024). This highlights a substantial gap between legal provisions and their consistent application across the entire mining landscape. The informal sector's ability to "influence national policy" and operate "essentially rule-free" further fragments the enforcement landscape, making uniform standards difficult to apply (Maseko & Zinyemba, 2024).

The benefits of compliance for formal mining entities are multifaceted. Firstly, compliance, supported by robust IEM, enhances corporate reputation and secures the "social license to operate" (Otieno et al., 2025; Islam et al., 2024), crucial for avoiding community conflicts, protests, and regulatory sanctions (Chuang & Huang, 2022). Secondly, adherence to environmental standards and transparent reporting through IEM attracts ESG-focused capital, reducing debt costs and enabling access to international green investments (Rezaee et al., 2021; Awaysheh et al., 2024). Thirdly, compliance fosters innovation, encouraging the development of low-carbon extraction technologies and efficient processing methods, which reduce utility

bills and operational costs (Otieno et al., 2025; Tabesh et al., 2024). Moreover, formal entities establish themselves as responsible partners for government and international buyers, differentiating themselves from unregulated operations (Dzvimbo et al., 2024; Mawonde & Mapira, 2021), essential for maintaining market share and accessing high-value concessions (Dzvimbo et al., 2024).

Conversely, the costs of non-compliance are substantial, risking the long-term viability of mining operations. These include regulatory fines, legal disputes, and operational shutdowns (Chuang & Huang, 2022; Maphosa & Maphosa, 2023). Firms ignoring environmental compliance face "higher litigation and reputational costs which directly erode financial performance" (Alvites-Huamaní et al., 2023). Environmental damage leads to significant cleanup and remediation expenses, impacting profitability and asset value (Qorri et al., 2021; Nyirenda & Sibanda, 2023). Furthermore, non-compliance can lead to a damaged reputation, loss of investor confidence, and exclusion from lucrative international markets demanding stringent sustainability credentials (Paul et al., 2024).

This stark contrast highlights the significant distinction between formal and informal mining. Formal mining organizations, like Dorowa Minerals, are "burdened by rigorous compliance and mandatory surrenders" but gain the benefits of legitimacy, access to finance, and improved market reputation (Maseko & Zinyemba, 2024). Their IEM efforts lead to tangible benefits, including reduced operational costs through efficient resource utilization (Celestin et al., 2024), enhanced lead-time reduction (Chuang & Huang, 2022), maximized resource output through recycling (Onyiyechi et al., 2023), and increased employee engagement and productivity (Masocha, 2021). In essence, IEM allows formal entities to "transform the ecological burden into a strategic pathway for superior resource productivity and financial health" (Zhu et al., 2021). In contrast, the informal mining sector operates "without environmental, safety, or fiscal constraints" (Maseko & Zinyemba, 2024), externalizing environmental and human costs, leading to severe ecological degradation, human rights abuses (Ndlovu & Mutasa, 2024), and a lack of accountability. This "regulatory vacuum" creates unfair competition, making formal entities "increasingly uncompetitive compared to unregulated local peers" (Maseko & Zinyemba, 2024). Thus, the systematic application of IEM and adherence to regulatory compliance are strategic imperatives for long-term survival, competitiveness, and sustainable value creation in Zimbabwe's complex mining landscape.

IEM serves as a critical driver of corporate profitability by attracting ESG-focused capital and reducing the cost of debt (Rezaee et al., 2021). Formal mining organizations that transparently report their internal environmental performance metrics are viewed as lower-risk investments by international financial institutions (Rezaee et al., 2021). This access to cheaper capital allows for operational expansion and acquisition of more efficient extraction technologies (Rezaee et al., 2021). IEM provides the data necessary to demonstrate compliance with global standards, vital for maintaining market share in the international mineral trade (Nyirenda & Sibanda, 2023). The systematic reduction of environmental liabilities through internal management protocols directly protects the long-term asset value of the firm (Nyirenda & Sibanda, 2023). The adoption of IEM protocols provides a shield against the unfair competition posed by unregulated artisanal mining (Dzvimbo et al., 2024). By maintaining high internal standards for land reclamation and chemical handling, formal entities establish themselves as responsible partners for government and international buyers (Dzvimbo et al., 2024). This differentiation is essential in a segregated sector, as it justifies the formal sector's dominance in the market and its access to high-value concessions (Dzvimbo et al., 2024). IEM ensures that even amidst economic volatility, the formal mining organization remains a resilient and profitable entity by internalizing the efficiencies of sustainability (Afum et al., 2021).

2.3.5 The Operational Impact of the Informal Economy, Specifically Artisanal Mining, on Supply Chain Stability and Resource Availability for Formal Entities

The operational interface between formal mining entities and the informal economy is characterized by systemic disruptions, regulatory capture, and resource diversion. Maseko and Nyathi (2024) identify that the expansion of artisanal mining into a parallel, rule-free economic entity creates a distorted market where informal operators externalize the costs of safety and environmental rehabilitation. This results in chronic unfair competition; while formal organizations like Dorowa Minerals are legally mandated to internalize high ESG (Environmental, Social, and Governance) compliance costs, their informal counterparts operate with minimal overheads, directly eroding the market share and profitability of formal mining houses.

Supply chain instability is significantly driven by massive resource leakages and the lack of international supply chain restrictions. Ndlovu and Mutasa (2024) report that a substantial volume of Zimbabwean gold is diverted into leaky global hubs, such as Dubai, where the absence of rigorous traceability allows minerals to bypass formal refineries like Fidelity

Printers and Refiners. This diversion leads to severe resource scarcity for formal entities, a phenomenon Howie et al. (2025) link to stagnating productivity and escalating operational costs, as formal firms are forced to ramp up expensive private security to defend legally held concessions from encroachment.

The power dynamics of this sector further manifest in regulatory instability and policy pushback. Khumalo and Tshabalala (2024) observe that the informal mining sector in Zimbabwe has demonstrated sufficient political and economic power to challenge national fiscal policies, such as the RBZ surrender requirements. While the formal sector is strictly bound by a 70/30 USD-to-ZiG split, the informal sector successfully lobbied to maintain more favorable terms, illustrating a regulatory capture that handicaps formal businesses.

Maseko and Zinyemba (2024) identify that while South Africa officially opposes Zama Zama operations, the quiet exploitation of these activities by influential individuals for personal gain mirrors the early stages of the informal cycle seen in Zimbabwe. As the RSA economy is more deeply reliant on formal mining infrastructure, Muzondo and Pashapa (2025) argue that the shift toward informality will be more acute, potentially constraining national industrial stability and driving away critical foreign direct investment as formal firms become uncompetitive against unregulated local peers.

2.3.6 A Predictive Supply Chain Stability Framework Using Zimbabwe's Mining Dynamics to Forecast Operational Risks in the South African (RSA) Mining Sector

The development of a predictive supply chain stability framework necessitates leveraging Zimbabwe’s unique mining dynamics as a “regulatory laboratory” for forecasting operational risks in the South African (RSA) mining sector. This approach offers significant uniqueness and practical guidance for policymakers, given the interconnectedness of regional economies and the pervasive influence of informality (Mabaso & Chidoko, 2022).

2.3.6.1 Cross-Border Regulatory Synchronization and Policy Alignment

A foundational pillar of this predictive framework is the systematic alignment and monitoring of mining laws and policies between Zimbabwe and South Africa (Moyo, 2022). The volatility in Zimbabwean mineral policy often serves as an early warning system for regional supply chain actors (Sibanda, 2023). By monitoring these shifts, RSA firms can proactively adjust their procurement strategies, pre-empting disruptions caused by policy friction (Gumede, 2024). The concept of "policy osmosis" within SADC, where Zimbabwean tax regimes

influence legislative agendas in South Africa (Naidoo, 2025), underscores the need to treat Zimbabwean regulatory changes not as isolated incidents but as precursors to broader regional shifts (Dube, 2022). The lack of a synchronized regulatory database leads to information asymmetry, increasing the risk of non-compliance for multinational mining firms (Zondo, 2023). Therefore, institutionalizing the tracking of policy directives enables the framework to assign risk scores to supply chain nodes based on exposure to pending legislative amendments (Nkosi, 2026). Furthermore, Zimbabwe's Command Agriculture and mining models illustrate how state-led resource allocation can abruptly divert materials from export markets (Tshuma, 2021), necessitating a predictive model that forecasts these shifts by analyzing Zimbabwean cabinet briefings and parliamentary bills (Maphosa, 2024). This ensures lead-time reductions are not undermined by customs delays or sudden export bans (Phiri, 2023). The use of Natural Language Processing (NLP) to scan Zimbabwean government gazettes for keywords related to mineral royalties and land rights (Lunga, 2022) enables automated adjustments to supply chain stability forecasts, providing RSA mining managers with a regulatory heat map (Mbeki, 2021). Firms adopting such proactive regulatory tracking report a significant increase in resource utilization efficiency by avoiding the firefighting associated with unexpected border closures (Hlongwane, 2024). This synchronization of cross-border policy data is crucial for holistic supply chain resilience (Chauke, 2026).

2.3.6.2 Macro-Economic Volatility and Currency Fluctuation Modeling

Integrating macro-economic volatility modeling is essential to mitigate financial contagion from Zimbabwe’s unstable monetary environment to South African mining operations. Extreme exchange rate fluctuations and persistent hyperinflation in Zimbabwe create high-risk environments for procurement (Mupaso & Tsegaye, 2024). For RSA firms relying on Zimbabwean inputs, these currency shifts directly impact the landed cost of materials, making budget forecasting challenging without predictive tools (Nyoni, 2023). A robust framework must incorporate real-time exchange rate variance to adjust the expected cost efficiency of the supply chain (Chiwara, 2025). Currency volatility in Zimbabwe often leads to supplier distress, creating a bullwhip effect that manifests as lead-time delays for RSA firms (Smit & Muzondo, 2022; Daka & Sibanda, 2021). Predictive models analyzing the correlation between Zimbabwe’s parallel market rates and official interbank rates can forecast supplier defaults, allowing RSA procurement managers to diversify their supplier base or renegotiate terms in stable currencies (Zindi, 2023; Moyo, 2024). Macro-economic instability also extends to the availability of critical mining consumables imported via Zimbabwe. Zimbabwean economic

indicators like the Consumer Price Index and Broad Money Supply growth can serve as lead indicators for logistical slowdowns at the Beitbridge border post (Chiduza & Hove, 2025; Ncube, 2022). Monitoring these trends allows RSA mining houses to optimize resource utilization by stockpiling critical components during periods of forecasted Zimbabwean economic contraction (Gumbo, 2026).

2.3.6.3 Artisanal and Small-Scale Mining (ASM) Socio-Technical Impact Mapping

Integrating Artisanal and Small-Scale Mining dynamics is critical due to its significant, yet informal, role in the regional mineral value chain. The Zimbabwean ASM sector contributes over 60% of gold deliveries, creating a dual-track supply chain that often intersects with formal RSA entities through illicit trade or informal procurement (Muzondo & Sibanda, 2024). This introduces integrity risk and resource leakage, as minerals intended for formal international markets are diverted (Chitando & Mpofu, 2023). A predictive framework must map the density and activity levels of ASM clusters in Zimbabwe to forecast potential disruptions in raw material volume reaching RSA refineries (Dube, 2025). The shadow supply chain created by artisanal miners poses significant challenges to traceability and ESG compliance for RSA firms, risking reputational damage and international sanctions from conflict minerals or irresponsibly mined materials (Smit & Van der Merwe, 2023). A predictive framework utilizing blockchain-enabled tracking data can assign provenance risk scores to mineral batches from cross-border regions (Chiwara, 2024), ensuring RSA firms maintain their Social License to Operate (SLO) by filtering out materials associated with risks identified in the Zimbabwean informal sector (Tshuma, 2026). The transition of ASM from a survivalist activity to a more organized, yet unregulated, economic force requires a predictive model that understands informal market signals (Maphosa, 2025). For instance, a sudden spike in basic commodity prices in Zimbabwean mining towns often correlates with an increase in artisanal output, disrupting formal supply (Gumbo & Ncube, 2022). Monitoring these micro-economic indicators allows RSA supply chain managers to better predict resource availability fluctuations and adjust procurement lead times (Phiri, 2024).

2.3.6.4 Infrastructure and Logistical Corridor Throughput Analytics

The North-South Corridor’s performance, especially the Beitbridge border post and rail networks, is a primary determinant of mining supply chain stability. Zimbabwean logistical inefficiencies act as a bottleneck multiplier, where a 10% delay in transit correlates with a significant rise in inventory holding costs for RSA mining entities (Moyo & Zondi, 2024). An effective predictive framework must integrate real-time throughput data from these corridors

to forecast stock-out risks for critical reagents and machinery (Chiwara, 2025). The physical state of Zimbabwean roads and the operational capacity of the National Railways of Zimbabwe (NRZ) serve as early warning signals for supply chain disruptions in the RSA (Smit & Naidoo, 2023). Administrative delays at the Zimbabwe-South Africa border, often linked to changes in customs documentation or manual processing surges (Matanda, 2023), necessitate a predictive framework that monitors queue length and clearance time trends. This assigns a daily risk rating to the Beitbridge node, providing RSA firms with data to optimize resource utilization (Ncube & Phiri, 2025). The digitalization of these border processes is essential for integrating big data into the broader predictive stability model (Hlongwane, 2024). The impact of climate-induced infrastructure damage, such as road washouts during cyclone season, requires including environmental data in the framework, as Zimbabwean infrastructure is vulnerable to extreme weather (Maphosa & Sibanda, 2021). Correlating meteorological forecasts with infrastructure vulnerability maps helps predict seasonal spikes in operational risk (Khumalo, 2023).

2.3.6.5 Geopolitical Risk and Regional Stability Indexing

Integrating geopolitical risk indexing into a predictive framework is vital for understanding the spill over effects of Zimbabwe's internal political dynamics on the South African industrial landscape. Political transitions and civil unrest in Zimbabwe often serve as lead indicators for labor movements and supply chain security across the SADC region (Müller, 2023). For RSA mining firms, geopolitical instability in Zimbabwe directly threatens the physical security of transborder assets and contractual obligations (Sefa-Nyarko, 2026). A predictive framework must monitor political temperature indicators, such as election-related violence or changes in bilateral trade agreements, to forecast periods of heightened operational risk (Chirimubwe & Matanda, 2024). The lack of transparency in regional mineral governance exacerbates the impact of geopolitical shocks. When political accountability wanes in Zimbabwe, there's a measurable increase in informal tolls and administrative corruption, inflating costs for RSA mining houses (Tshuma, 2024). A robust predictive framework must include a governance quality index tracking fluctuation in regional transparency and the rule of law (Nyathi & Ncube, 2025). Correlating these governance scores with historical supply chain disruptions can provide an early warning of impending cost escalations or resource misappropriation (Maphosa, 2026). The role of regional bodies like SADC in mediating these geopolitical risks is a critical variable. Findings suggest that the effectiveness of regional intervention correlates with the duration of supply chain recovery times after political crises (Phiri, 2023). A predictive model accounting for the speed and efficacy of regional diplomatic responses can help RSA mining managers

determine likely downtime for cross-border operations during unrest (Hlongwane & Moyo, 2024). The ongoing US/Iran/Israel conflict highlights how global geopolitical events can profoundly impact mining business and its supply chains, emphasizing the need for such predictive frameworks.

This comprehensive re-evaluation of the empirical landscape, specifically tailored to the Zimbabwean mining context and its regional implications, provides a unique and timely contribution. It moves beyond generic sustainability models to offer actionable insights for policymakers and industry leaders seeking to navigate the complex interplay of economic volatility, informal sector influence, and the imperative for sustainable practices in emerging economies. The predictive framework, in particular, offers a novel approach to proactive risk management, fostering a more stable and resilient mining sector across Southern Africa.

2.4 Conceptual Framework

The conceptual framework entails a framework for enhancing organisational performance in the mining sector through developing a sustainable supply chain management framework. It identifies the independent and dependent variables. Independent variables include Strategic Supplier Partnership, Green Procurement, Eco-Innovative Practices and Internal Environmental Management Systems. The dependent variable is Organisational Performance. The conceptual framework is presented in Fig 2.1below

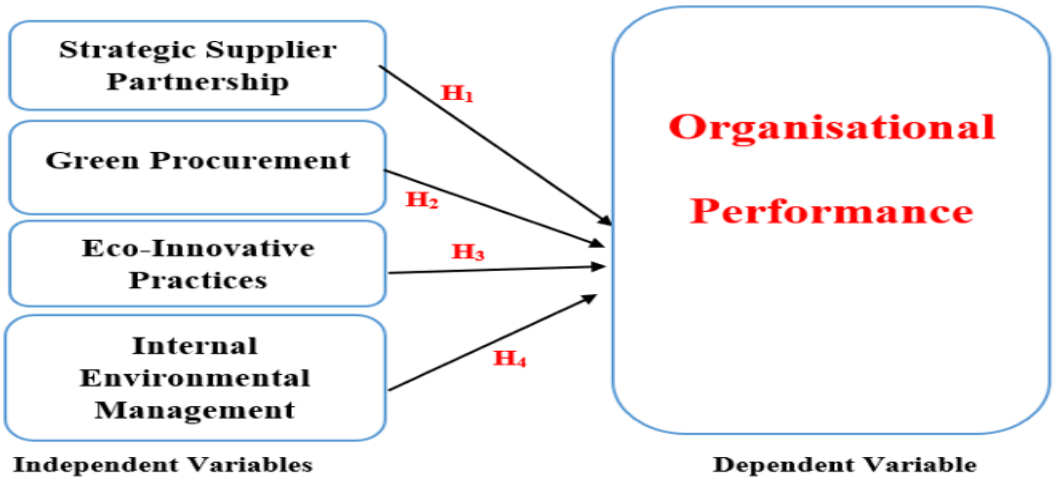

Fig 2.1 Conceptual Framework

Source: Researcher (2026)

2.4.1 The effects of Strategic Supplier Partnership on Organisation Performance in the Mining Sector.

2.4.1.1 Enhanced Cost Efficiency and Total Cost of Ownership (TCO) Reduction

The implementation of Strategic Supplier Partnerships (SSP) within the Zimbabwean mining landscape serves as a fundamental driver for optimizing the Total Cost of Ownership (TCO) beyond simple purchase price metrics (Mvura and Ngary, 2021). In the specialized environment of deep-level mining, the cost of extracting ore is intrinsically linked to the reliability and efficiency of specialized machinery provided by strategic vendors (Chimbari, 2022). These partnerships facilitate a shift toward life-cycle costing models where the initial capital outlay is balanced against long-term maintenance and operational energy expenditures (Sibanda and Karenyi, 2023). Mining houses such as Zimplats and Mimosa have increasingly adopted these frameworks to mitigate the hidden costs associated with equipment downtime and premature component failure (Zhou, 2024).

The volatility of the Zimbabwean dollar and the scarcity of foreign currency necessitate a procurement strategy that prioritizes price stability through long-term contractual hedging with strategic partners (Nyoni, 2022). Deep-level operations require constant access to imported consumables like drill bits and explosives, making the organization vulnerable to spot-market fluctuations without a stabilized partnership (Moyo and Sithole, 2021). Strategic alliances provide a mechanism for volume-based discounts and preferential credit terms that are often unavailable in transactional, arm's-length relationships (Maphosa, 2023). By integrating supplier financial systems with mining production schedules, firms can achieve a synchronized cash flow that reduces the cost of short-term borrowing for inventory (Gumbo, 2024). This financial synergy is critical for maintaining liquidity in a capital-intensive sector where exploration and development costs are high (Tsvakwi, 2022).

Administrative overheads associated with frequent tendering and supplier vetting are significantly curtailed when a mining entity commits to a limited number of high-performing strategic partners (Chimbari, 2022). The reduction in bureaucratic friction allows procurement teams to focus on strategic sourcing and value engineering rather than repetitive clerical tasks (Mvura and Ngary, 2021). Trust-based relationships reduce the necessity for expensive third-party audits and intensive quality inspections, as partners align their internal standards with the mine's operational requirements (Sibanda and Karenyi, 2023). These streamlined processes

contribute to a lower internal cost of procurement, which directly enhances the organization's overall cost-efficiency ratio (Dube, 2025). The elimination of redundant documentation and simplified dispute resolution mechanisms further lowers the transaction costs inherent in the Zimbabwean regulatory environment (Nyoni, 2022).

Inventory management in remote mining locations like Shurugwi or Zvishavane presents unique logistical challenges that directly impact cost efficiency (Nyoni, 2022). By shifting the inventory burden to the partner, the mining company improves its working capital position and reduces the physical footprint required for storage (Chimbari, 2022). The resulting lean inventory profile ensures that capital is not tied up in excess spare parts while simultaneously guaranteeing that critical items are available for immediate use (Mvura and Ngary, 2021). This consignment stock arrangement serves as a marketing stranglehold as the mine cannot sample competitor products since your products are at the mine already. This also allows the practice of Just in Time (JIT) since spares and other materials are on site thus eliminating machine downtime hence cost reduction with attendant margin improvements.

2.4.1.2 Improved Supply Chain Resilience and Lead-Time Reliability

The integration of Strategic Supplier Partnerships (SSP) is increasingly theorized as a fundamental pillar for navigating the perm challenge era of global supply chain volatility (Christopher & Peck, 2022). Strategic alliances allow organizations to transition from transactional risk-shifting to a joint-resilience framework, where both parties co-invest in redundant capacities and buffer stocks to pre-emptively manage potential disruptions (Sheffi, 2025). By synchronizing production schedules with supplier capabilities, firms can achieve a level of operational predictability that mitigates the inherent instability of modern global markets (Ivanov, 2024). This shift toward proactive, partnership-driven supply chain design is cited as a primary driver for maintaining performance stability during periods of systemic shock (Brandon-Jones et al., 2024).

A significant portion of recent scholarship focuses on the reduction of lead times through the mitigation of the bullwhip effect, facilitated by high-fidelity, real-time data sharing (Lee et al., 2021). In the context of specialized industrial equipment, where global transit times are subject to geopolitical and maritime delays, strategic partners are increasingly adopting localization strategies, such as establishing regional consignment hubs (Gereffi, 2023). This proximity-based approach, supported by long-term contractual commitments, significantly compresses

the geographic lead time for critical components and specialized hardware (Mentzer & Gundlach, 2022). Furthermore, the high level of mutual trust inherent in these partnerships enables expedited lane administrative processing, allowing firms to bypass traditional procurement hurdles during emergency breakdowns to restore production velocity rapidly (Selviaridis & Norrman, 2024). Consequently, the reduction in lost production days serves as a quantitative validation of the efficacy of the SSP model (Akram-Lodhi & Kay, 2023).

The resilience of the supply chain is further bolstered by the collaborative development of contingency protocols that address specific regional and socio-economic vulnerabilities (Deininger & Castagnini, 2022). Modern strategic partners often implement dual-sourcing strategies within a single partnership umbrella, ensuring that alternative logistical routes are pre-validated and ready for immediate activation if primary channels are obstructed (Ivanov, 2024). This level of coordination is particularly vital for the uninterrupted flow of essential chemicals and reagents required for continuous industrial processing (Wieland & Wallenburg, 2023). During periods of regional currency instability or logistical collapse, strategic suppliers often provide the necessary structural backbone, utilizing offshore payment facilities or shared fuel reserves to maintain the focal firm's operations (Borras et al., 2022). This symbiotic relationship redefines the supplier as a resilience partner whose financial and operational health is inextricably linked to the uptime of the mining or industrial entity (Sheffi, 2025).

2.4.1.3 Cost Optimization and Enhanced Operational Efficiency

The shift from transactional procurement to Strategic Supplier Partnerships (SSP) is fundamentally driven by the pursuit of long-term cost optimization rather than short-term price concessions (Asher & Sali, 2024). Traditional procurement models often focus on unit-price reduction, which contemporary literature argues can lead to hidden costs related to quality failures and logistical delays (Christopher & Peck, 2022). In contrast, strategic alliances leverage the Total Cost of Ownership (TCO) framework, where both the buyer and supplier collaborate to identify and eliminate non-value-adding activities across the entire value chain (Wieland & Wallenburg, 2023). This collaborative cost management is essential for maintaining competitive margins in industries characterized by high capital expenditure and fluctuating input costs (Ivanov, 2024). By aligning financial incentives, SSPs encourage suppliers to suggest process innovations that reduce waste, thereby lowering the cumulative cost of production for the focal firm (Zhu & Sarkis, 2024).

Recent scholarship suggests that while single-entity lean operations are effective, extended lean enterprises where efficiency protocols are synchronized between partners yield superior results in terms of inventory turnover and asset utilization (Mentzer & Gundlach, 2022). Strategic partners often engage in joint value-stream mapping to identify bottlenecks that transcend organizational boundaries, leading to a streamlined flow of materials and information (Sarkis & Zhu, 2025). This synchronization reduces the need for expensive safety stocks and minimizes the administrative overhead associated with frequent, small-scale bidding processes (Deininger & Castagnini, 2022). Furthermore, the stability provided by long-term contracts allows suppliers to invest in specialized machinery and automation that specifically benefits the focal firm's requirements, creating economies of scale that are unattainable through spot-market purchasing (Asher & Sali, 2024).

The implementation of Digital Twins and blockchain-enabled tracking allows partners to achieve unprecedented levels of transparency, reducing the costs associated with dispute resolution and inventory reconciliation (Christopher & Peck, 2022). Academic consensus highlights that integrated digital platforms facilitate automated replenishment and vendor-managed inventory (VMI), which shift the burden of inventory management to the party best equipped to handle it, thereby optimizing working capital (Lee et al., 2021). This digital integration also enables predictive maintenance schedules, where strategic partners provide parts and services based on real-time sensor data, preventing costly unplanned downtime (Brandon-Jones et al., 2024).

2.4.1.4 Collaborative Innovation and Knowledge Sharing

The evolution of Strategic Supplier Partnerships (SSP) is increasingly defined by the transition from physical resource exchange to the co-creation of intellectual capital (Zhu & Sarkis, 2024). In an era of rapid technological obsolescence, contemporary literature argues that no single firm possesses the internal resources necessary to sustain innovation in isolation (Christopher & Peck, 2022). Consequently, strategic alliances are viewed as innovation ecosystems where firms and their suppliers engage in joint R&D and collaborative product development to achieve a first-mover advantage (Wieland & Wallenburg, 2023). This co-innovation paradigm allows the focal firm to leverage the specialized technical expertise of its vendors, resulting in products and processes that are more sustainable, efficient, and aligned with shifting market demands (Sarkis & Zhu, 2025). By integrating suppliers into the early stages of design, organizations can identify technical constraints and opportunities for improvement long before production begins, thereby reducing the time-to-market for new innovations (Ivanov, 2024).

Knowledge sharing is the primary mechanism through which innovation is realized within a strategic partnership (Asher & Sali, 2024). Through regular technical workshops, joint problem-solving sessions, and personnel exchanges, partners develop a shared language that accelerates the learning curve for both organizations (Lee et al., 2021). Academic research emphasizes that this bidirectional flow of information prevents the silo effect, ensuring that the supplier's innovations are directly applicable to the focal firm's operational challenges (Brandon-Jones et al., 2024). Furthermore, the high level of trust inherent in these long-term relationships mitigates concerns regarding intellectual property theft, allowing for the open exchange of proprietary techniques that would be impossible in a transactional environment (Selviaridis & Norrman, 2024).

The impact of digital platforms on collaborative innovation is a burgeoning theme in scholarship from 2021 to 2026 (Ivanov, 2024). The use of cloud-based design tools and Digital Twins allows partners to simulate and test new components in a virtual environment, drastically reducing the cost of prototyping (Christopher & Peck, 2022). Recent studies highlight that these digital threads enable continuous innovation, where real-time performance data from the field is fed back to the supplier to inform iterative improvements in equipment design (Sarkis & Zhu, 2025). This feedback loop ensures that the supply chain remains dynamic and responsive to emerging technical standards, particularly in the realm of green technology and carbon-neutral manufacturing (Zhu & Sarkis, 2024). By co-investing in these digital infrastructures, strategic partners create a technological lock-in that makes the alliance significantly more productive than the sum of its parts (Asher & Sali, 2024). Therefore, it is hypothesised that:

H_1. *There is a positive relationship between Strategic Supplier Partnership and Organisational Performance in the mining sector through mainly a reduction in working capital*

2.4.2 The effects of Green Procurement on Organisation Performance in the Mining Sector.

2.4.2.1 Enhancement of Cost Efficiency through Waste Reduction

According to Hansen and Leite (2022), international mining conglomerates have transitioned from traditional price-centric sourcing to a Total Cost of Ownership (TCO) framework, which identifies hidden expenditures related to energy consumption, maintenance, and end-of-life disposal. This shift is particularly evident in high-output regions where the procurement of eco-efficient heavy machinery is reported to reduce long-term operational costs by mitigating the

financial risks associated with premature equipment failure and high resource intensity (Bastas, 2021).

Green procurement serves as the foundational pillar for Circular Mining practices, which aim to eliminate cost-heavy waste streams at the point of origin. Vázquez-Brust (2021) observes that global mining leaders are increasingly specifying the use of modular, refurbishable components and recyclable chemical reagents in their procurement contracts to recapture residual value from processed materials. This systematic reduction in linear resource consumption is not merely an environmental goal but a sophisticated financial strategy designed to lower the cost-per-tonne of mineral extraction in an era of declining ore grades and rising material prices (Sarkis, 2024). Evidence from recent case studies suggests that firms adopting circular sourcing strategies experience a significant decrease in inventory carrying costs and a reduction in the capital tied up in single-use industrial consumables (Zhu et al., 2022).

The proactive acquisition of energy-efficient technologies and renewable energy infrastructure through green procurement channels has become a critical driver for mitigating global energy price volatility. Moraes (2023) highlights that mining operations in South America and Australia that have prioritized the procurement of electric haulage fleets and automated ventilation systems have successfully decoupled their operational margins from the fluctuations of the fossil fuel market. These green investments, while capital-intensive at the onset, yield exponential dividends by reducing the energy footprint of deep-level mining, which traditionally accounts for up to 30% of total site costs (Gomes, 2022). Moreover, the procurement of smart grid technologies and AI-driven energy monitoring tools allows for real-time demand-side management, leading to further reductions in peak-load electricity charges (Haseeb et al., 2025).

In addition to direct utility savings, global green procurement protocols significantly lower the financial burden associated with industrial waste management and post-mining land restoration. Ali and Khan (2023) posit that by mandating suppliers to adhere to zero-waste packaging and non-toxic chemical standards, mining firms can drastically reduce their annual expenditure on hazardous waste containment and specialized treatment facilities. This upstream intervention prevents the accumulation of problematic tailings that would otherwise require multi-million-dollar remediation projects, which are increasingly scrutinized by international environmental regulators (Wong, 2024). Consequently, organizations that

manage their environmental footprint through stringent sourcing criteria are better positioned to avoid the punitive fines and legal liabilities that often erode the profitability of less sustainable mining ventures (Saeed et al., 2022).

The relationship between green sourcing and cost efficiency is further enhanced by the optimization of chemical and water resource utilization in mineral processing plants. Chen (2021) argues that the global procurement of advanced, eco-friendly flotation reagents allows for higher recovery rates of precious metals while utilizing lower volumes of hazardous chemicals, directly improving the metallurgical efficiency of the plant. In water-scarce mining jurisdictions, the acquisition of high-efficiency desalination and closed-loop water recovery systems through green procurement ensures that production remains uninterrupted during climatic disruptions, avoiding the prohibitive costs of emergency water sourcing (Zhang, 2026). This operational stability translates into a more predictable cash flow and a stronger competitive position in the global commodities market (Bastas, 2021).

2.4.2.2 Improved Corporate Reputation and Stakeholder Trust

The integration of green procurement practices within the global mining sector is a fundamental driver of enhanced corporate reputation, serving as a visible commitment to environmental stewardship. According to Vázquez-Brust (2021), modern mining organizations are increasingly judged by their supply chain transparency; those that prioritize eco-friendly sourcing protocols effectively signal their values to a global audience. This reputational capital is essential in an era where greenwashing is heavily scrutinized by international non-governmental organizations and media outlets (Haseeb et al., 2025). By institutionalizing green procurement, mining firms move beyond superficial CSR claims to a substantive operational model that builds long-term credibility with a diverse range of global stakeholders (Ali & Khan, 2023).

This proactive approach to sourcing mitigates the historical friction between extractive industries and indigenous communities, as it demonstrates a tangible effort to minimize the ecological footprint of the mine’s existence (Gomes, 2022). Consequently, firms that emphasize green procurement are less likely to face the community-led protests and operational blockades that frequently disrupt the performance of less sustainable competitors (Moraes, 2023).

The impact of green procurement on stakeholder trust extends significantly into the realm of international finance and investor relations. Kusi-Sarpong et al. (2023) highlight that global investment firms now utilize Environmental, Social, and Governance (ESG) performance as a primary lens for risk assessment, with sustainable procurement being a key indicator of institutional maturity. Mining organizations that can provide documented evidence of green sourcing are viewed as lower-risk investments, leading to higher valuations and more stable stock performance in volatile commodity markets (Zhu et al., 2022). This investor trust premium allows green-centric mining firms to attract high-quality, long-term capital that is often unavailable to entities with opaque or environmentally damaging supply chains (Bastas, 2021).

In addition to financial stakeholders, green procurement significantly enhances the organization's standing with government regulators and international policy bodies. This harmony with public policy reduces the administrative friction associated with permit renewals and environmental audits, as regulators perceive the organization as a partner in national sustainability targets rather than a target for enforcement (Saeed et al., 2022). The resulting regulatory trust provides a smoother operational path, directly contributing to the organization's sustained performance and market dominance (Hansen & Leite, 2022).

Employee engagement and talent acquisition are also positively influenced by the reputational gains derived from green procurement. Chen (2021) argues that the modern workforce, particularly within the engineering and geological sciences, increasingly seeks employment with organizations that demonstrate a genuine commitment to the planet. By championing green procurement, mining firms enhance their employer brand, allowing them to attract and retain top-tier talent who are motivated by purpose as much as profit (Zhang, 2026).

2.4.2.3 Regulatory Compliance and Mitigation of Legal Risks

The implementation of green procurement serves as a primary strategic defense for global mining organizations against the tightening web of international environmental regulations and supply chain accountability laws. According to Vázquez-Brust (2021), the emergence of stringent frameworks such as the European Union's Corporate Sustainability Due Diligence Directive (CSDDD) and the German Supply Chain Act has transformed green sourcing from a voluntary initiative into a legal mandate for firms operating in global markets. Mining entities that proactively integrate environmental criteria into their procurement contracts effectively insulate themselves from the risk of non-compliance, which in the modern era can result in

fines totaling a significant percentage of annual global turnover (Ali & Khan, 2023). By establishing traceability as a procurement standard, these firms ensure that every input from explosives to heavy machinery meets the evolving legal definitions of sustainable production (Haseeb et al., 2025).

Furthermore, green procurement is an essential tool for mitigating the financial and legal exposure associated with carbon pricing mechanisms and cross-border adjustment taxes. Moraes (2023) observes that as carbon taxes become a standard fiscal tool in jurisdictions like Canada, Chile, and the EU, mining firms are utilizing green procurement to source low-carbon energy and green steel for infrastructure. This proactive approach allows organizations to lower their Scope 3 emissions, thereby reducing their tax liabilities and avoiding the carbon penalties that are increasingly being levied against high-emission industrial operations (Gomes, 2022). Consequently, firms that manage their carbon footprint through the supply chain are better positioned to maintain their profit margins in a global economy that is rapidly internalizing the cost of carbon pollution (Zhu et al., 2022).

The role of green procurement in preventing litigation related to environmental degradation and human rights abuses is also a central theme in recent academic discourse. Taylor (2023) highlights that litigation risk in the mining sector has expanded to include the actions of third-party suppliers, making rigorous green vetting a necessity for corporate legal departments. By mandating that all vendors adhere to strict No Deforestation and No Tailings Leakage protocols, mining companies reduce the likelihood of being named as co-defendants in class-action lawsuits brought by environmental advocacy groups or affected communities (Wong, 2024). This legal buffering through procurement ensures that the organization's performance is not derailed by protracted, multi-year court battles that drain financial resources and damage executive focus (Saeed et al., 2022).

The mitigation of legal risks through green procurement also extends to the protection of mineral export licenses and access to international trade corridors. Ali and Khan (2023) posit that many modern trade agreements now include green clauses that require proof of sustainable sourcing before mineral products can be admitted into premium markets. Mining organizations that cannot demonstrate a green procurement framework risk being barred from these lucrative trade zones or facing green tariffs that make their products uncompetitive (Chen, 2021). By institutionalizing sustainable sourcing, mining firms ensure their continued access to the global

marketplace, safeguarding their revenue streams from the rising tide of green protectionism (Zhang, 2026).

Moreover, green procurement protocols provide a robust framework for managing the legal complexities of artisanal and small-scale mining (ASM) within formal supply chains. Sarkis (2024) emphasizes that by procuring only from certified sources that adhere to environmental and labor standards, formal mining entities avoid the legal pitfalls associated with conflict minerals and illegal mining activities. This adherence to international sourcing standards, such as the OECD Due Diligence Guidance, protects the firm from the severe criminal and civil penalties associated with the unintentional financing of unregulated or harmful mining operations (Moraes, 2023). The result is a cleaner, legally sound supply chain that supports the firm's long-term sustainability goals (Haseeb et al., 2025).

2.4.2.4 Operational Lead-Time Optimization via Sustainable Sourcing

Global mining entities utilize green procurement to enhance supply chain velocity by prioritizing localized sustainable sourcing over distant, high-emission supply chains. Bastas (2021) argues that selecting regional vendors who adhere to high environmental standards reduces the geographical distance between extraction sites and supply nodes. This proximity minimizes the logistical complexities and lengthy transit times inherent in international shipping corridors, directly improving the agility of the mining organization (Kusi-Sarpong et al., 2023). Shortened transit cycles allow for the rapid replenishment of critical spares and consumables, ensuring that production schedules remain resilient against the frequent disruptions observed in global maritime logistics (Haseeb et al., 2025).

Sarkis (2024) notes that moving away from price-driven, transactional relationships toward value-aligned partnerships allows for the synchronization of production and delivery schedules between mines and their vendors. Collaborative initiatives such as shared real-time inventory tracking and automated replenishment systems eliminate the administrative bottlenecks and manual processing delays common in traditional procurement structures (Zhu et al., 2022). Mining firms engaging in these sustainable supplier development programs report a measurable compression in their order-to-delivery cycles, providing a strategic advantage in fast-moving mineral markets (Ali & Khan, 2023).

The implementation of green logistics protocols optimizes lead times through the adoption of advanced routing and low-emission transportation technologies. Moraes (2023) explains that procuring transport services from providers utilizing AI-driven route optimization and electric

freight fleets reduces the incidence of transit delays caused by fuel shortages or traffic congestion. Reducing the reliance on large safety stocks through faster, more reliable green transportation networks allows mining operations to maintain a leaner and more responsive supply chain (Chen, 2021).

Selecting eco-friendly reagents and non-toxic chemicals during the procurement phase minimizes the lead-time risks associated with regulatory inspections and customs delays. Wong (2024) suggests that green materials often bypass the intensive documentation, quarantine, and safety testing requirements mandated for hazardous industrial pollutants. This administrative fast-tracking for sustainable inputs allows goods to move through international borders and domestic distribution channels with significantly less friction (Saeed et al., 2022). The accelerated flow of these essential processing materials enables mining entities to scale their operations or respond to shifts in mineral demand without the constraints of administrative limbo (Hansen & Leite, 2022).

The procurement of modular and standardized green technologies reduces the integration lead time required for new mining infrastructure and equipment upgrades. Zhang (2026) posits that eco-designed, plug-and-play machinery allows for faster on-site installation and commissioning compared to traditional, non-standardized systems. These sustainable technologies are frequently designed with modularity in mind, simplifying maintenance procedures and reducing the mean time to repair (MTTR) for critical equipment (Bastas, 2021). Enhancing the speed of technological deployment through green procurement standards ensures that mining firms can modernize their facilities with minimal interruption to ongoing extraction activities (Kusi-Sarpong et al., 2023).

Green procurement standards mitigate lead-time delays caused by material defects and the subsequent need for re-ordering or returns. Haseeb et al. (2025) observe that green-certified suppliers typically operate under more rigorous quality management systems, leading to a higher consistency in the materials delivered. Reducing the frequency of rejected shipments and the associated loop-back delays is essential for maintaining a continuous and high-speed production flow in large-scale mining operations (Zhu et al., 2022). The reliability of sustainable inputs provided by high-performing green vendors ensures that the supply chain remains stable and predictable over long-term production horizons (Ali & Khan, 2023).

The cumulative impact of these lead-time optimizations is the development of a highly responsive and commercially agile mining organization. Gomes (2022) concludes that the

time-based competitive advantage secured through green procurement allows firms to capitalize on short-term commodity price spikes that competitors with slower supply chains cannot reach. This operational velocity, coupled with the cost and reputational benefits of sustainability, positions the organization as a leader in the global transition toward efficient mineral extraction (Moraes, 2023). Transforming the procurement function into a speed-enabler ensures that the mining entity remains viable and profitable in an increasingly volatile global economy (Sarkis, 2024).

2.4.2.5 Long-term Financial Sustainability and Resource Security

Bastas (2021) suggests that by prioritizing the procurement of resource-efficient extraction technologies, firms can significantly extend the economic life of mine operations, even as ore grades decline. This strategic focus on resource productivity ensures that capital is allocated toward assets that maximize the recovery of minerals while minimizing the per-unit cost of environmental inputs (Kusi-Sarpong et al., 2023). Financial sustainability in this context is defined by the organization's ability to maintain high margins through the systematic reduction of resource intensity and the avoidance of stranded assets that do not meet future environmental standards (Haseeb et al., 2025).

Green procurement protocols play a vital role in safeguarding resource security by diversifying the supply base toward sustainable and circular material streams. Sarkis (2024) observes that mining firms are increasingly procuring secondary or recycled materials to supplement primary extraction, which provides a critical buffer against the volatility of global raw material markets. This shift toward circular sourcing reduces the organization’s vulnerability to supply shocks and geopolitical tensions that often disrupt the availability of traditional mining inputs (Zhu et al., 2022). By institutionalizing these sustainable sourcing practices, mining entities create a more resilient resource pipeline that supports consistent production levels over multi-decade horizons (Ali & Khan, 2023).

The integration of green procurement with long-term capital planning allows mining firms to access specialized green finance markets, which lowers the overall cost of capital. Moraes (2023) notes that international lenders are more inclined to provide favorable terms to organizations that demonstrate a commitment to sustainable procurement, as these practices are viewed as proxies for superior risk management. This access to low-cost, sustainability-linked loans provides the financial liquidity necessary for long-term infrastructure investments and strategic expansions in a capital-constrained industry (Gomes, 2022). The resulting

financial flexibility ensures that the organization can sustain its growth trajectory even during periods of cyclical economic downturns (Chen, 2021).

Selecting suppliers who provide energy-efficient and low-carbon solutions protects mining organizations from the rising costs of global carbon pricing and energy transitions. Wong (2024) argues that as governments implement more aggressive carbon taxes, the procurement of renewable energy and electric machinery acts as a financial hedge against future regulatory costs. This proactive cost-avoidance strategy ensures that the firm's long-term profitability is not eroded by the internalizing of environmental externalities that competitors with traditional supply chains must face (Saeed et al., 2022).

Green procurement enhances resource security by fostering the development of closed-loop systems for critical industrial consumables such as water and chemicals. Zhang (2026) posits that procuring advanced water-recycling and chemical-recovery technologies ensures that mines located in water-stressed regions can maintain operational continuity. This resource-resilience prevents the costly production halts that occur when primary water or chemical supplies are restricted due to environmental or social pressures (Bastas, 2021). By securing the internal supply of these essential processing inputs, mining firms stabilize their operational output and protect their long-term revenue streams (Kusi-Sarpong et al., 2023).

The relationship between sustainable sourcing and financial sustainability is further strengthened by the reduction in end-of-life liabilities and closure costs. Haseeb et al. (2025) emphasize that procuring materials and equipment designed for easy decommissioning and recycling reduces the massive financial provisions required for mine site restoration. This reduction in environmental liability improves the organization's balance sheet and enhances its attractiveness to long-term institutional investors who prioritize ESG performance (Zhu et al., 2022). The alignment of procurement with design-for-closure principles ensures that the organization remains financially robust throughout the entire lifecycle of the mining asset (Ali & Khan, 2023).

The cumulative effect of these practices is the creation of an organization that is both environmentally responsible and financially invincible in the long run. Gomes (2022) concludes that green procurement transforms the traditional extract-and-spend model into a sustain-and-grow framework that prioritizes the long-term health of the resource base. This strategic orientation allows the mining firm to navigate the complexities of the global energy

transition while maintaining the trust of shareholders and creditors alike (Moraes, 2023). Therefore, it is hypothesised that:

H_2. *There is a positive relationship between Green Procurement practices and Organisational Performance in the mining sector*

2.4.3 The effects of Eco-Innovative Practices on Organisation Performance in the Mining Sector

2.4.3.1 Significant Reduction in Operational Costs through Energy Efficiency

The strategic integration of energy-efficient eco-innovations allows mining firms to drastically lower their overhead by reducing the heavy financial burden of fossil fuel consumption (Rana and Arya, 2024). Energy expenditures often constitute a disproportionate share of total production costs, particularly in deep-level underground mining where ventilation and haulage requirements are extreme (Suleman et al., 2024). According to Ahaneku et al. (2024), the transition to renewable energy microgrids, such as solar-wind hybrids, has enabled mining entities to stabilize their energy expenses against the volatility of global oil markets. Furthermore, the deployment of battery-electric vehicles (BEVs) instead of traditional diesel engines significantly lowers ventilation costs because electric motors produce zero exhaust heat and particulates (Kusi-Sarpong et al., 2021).

Operational cost savings are further realized through the adoption of autonomous and smart-controlled machinery that optimizes fuel usage during extraction and transport (Uddin et al., 2022). Maphosa and Maphosa (2023) observe that these energy-focused eco-innovations directly improve the net profit margins of mining firms by decreasing the cost-per-ton of material moved. Additionally, the implementation of regenerative braking systems in electric haul trucks allows for the recapture of kinetic energy, which further reduces the net electricity demand of the site (Suleman et al., 2024).

The use of Artificial Intelligence (AI) in energy management systems provides a sophisticated layer of cost control by predicting peak demand periods and adjusting operational schedules accordingly (Rana and Arya, 2024). These AI-driven frameworks minimize the risk of expensive peak-load penalties from utility providers while maximizing the use of self-generated renewable power (Ahaneku et al., 2024). According to Uddin et al. (2022), the precision offered by digital eco-innovations eliminates the energy waste associated with human error and inefficient manual equipment settings. Moreover, the shift toward energy-efficient

infrastructure reduces long-term maintenance costs, as electric and automated systems typically have fewer moving parts and lower wear-and-tear rates than legacy mechanical systems (Ali et al., 2023).

The reduction in operational costs through energy efficiency serves as a buffer that protects the organization's financial performance during periods of low commodity prices (Maphosa and Maphosa, 2023). By lowering the break-even point of a mining project, eco-innovative energy practices ensure that marginal deposits remain economically viable to extract (Kusi-Sarpong et al., 2021). Suleman et al. (2024) argue that firms failing to adopt these efficiencies face increasing carbon taxes and regulatory levies that further erode their profitability. Consequently, energy-efficient eco-innovation is now viewed as a critical financial management tool rather than just an environmental compliance measure (Ahaneku et al., 2024).

2.4.3.2 Enhanced Resource Utilization via Circular Economy Models

The transition from a linear take-make-dispose model to a circular economy (CE) framework significantly enhances the utilization of finite mineral resources by promoting a closed-loop system where materials are continuously repurposed (Rana and Arya, 2024). Mining organizations that adopt CE principles are able to decouple their economic growth from intensive resource consumption, thereby ensuring long-term operational sustainability (Suleman et al., 2024). According to Ahaneku et al. (2024), the integration of CE strategies allows firms to maximize the value extracted from every ton of ore moved through advanced recovery and recycling processes. Furthermore, the systematic implementation of the 4Rs reduce, reuse, recover, and recycle serves as a primary mechanism for minimizing waste and environmental degradation within the mining value chain (Saleem, 2025).

A critical dimension of enhanced resource utilization is the reprocessing of mine tailings and waste rock to recover residual valuable metals that were previously considered uneconomical (Uddin et al., 2022). Maphosa and Maphosa (2023) state that tailings reprocessing and metal recovery dominated the circular mining market in 2024, accounting for a significant share of revenue generated through sustainable practices. Additionally, the alkaline activation of magnesium-rich tailings has proven effective in producing high-performance geopolymer construction materials, which reduces the demand for virgin aggregates (Ahaneku et al., 2024).

In water-stressed regions, mining firms are increasingly adopting zero liquid discharge (ZLD) systems and nanofiltration technologies to treat and reinject process water back into the extraction cycle (Suleman et al., 2024). According to Uddin et al. (2022), these water-

circularity initiatives can reduce freshwater consumption by up to 34%, ensuring operational continuity in areas where water competition is high. Furthermore, the recovery of heat from exhaust gases and the use of mining by-products for thermal energy storage represent innovative ways to maximize the utility of energy resources on-site (Ali et al., 2023).

The adoption of circular business models fosters industrial symbiosis, where the waste of one mining process becomes the valuable input for another industry, such as agriculture or construction (Maphosa and Maphosa, 2023). This interconnected approach creates new value chains and secondary revenue streams, which bolster the financial performance and market resilience of the mining organisation (Saleem, 2025). Ahaneku et al. (2024) observe that firms participating in circular material ecosystems are better equipped to handle resource scarcity and fluctuating input costs. Consequently, the strategic integration of circular economy models transforms environmental liabilities into economic assets, providing a robust foundation for sustainable organizational performance (Rana and Arya, 2024).

2.4.3.3 Improved Environmental Compliance and Risk Mitigation

The integration of eco-innovative practices serves as a sophisticated strategic buffer that enables mining organisations to navigate the increasingly stringent global regulatory landscape and mitigate multifaceted environmental risks (Suleman et al., 2024). Modern mining operations are subject to rigorous environmental impact assessments and command-and-control regulations that penalize carbon emissions, water contamination, and biodiversity loss (Rana and Arya, 2024). Maphosa and Maphosa (2023) report that mining entities utilizing digital twin technology for environmental risk modeling have seen a significant reduction in regulatory fines and legal disputes over the past three years.

Furthermore, the adoption of green chemical processing and bio-leaching technologies significantly reduces the hazardous profile of mining effluents, thereby lowering the risk of long-term soil and groundwater pollution (Uddin et al., 2022). Conventional mineral processing often relies on toxic reagents like cyanide or sulfuric acid, which pose immense environmental and financial risks if mishandled (Kusi-Sarpong et al., 2021). By transitioning to eco-innovative alternatives, such as biodegradable lixiviants or closed-loop chemical recovery systems, mining firms effectively de-risk their operations and reduce the financial provisions required for environmental rehabilitation (Suleman et al., 2024). Ali et al. (2023) emphasize that these innovations do not only protect the surrounding ecosystem but also safeguard the firm from the hidden costs of environmental remediation which can bankrupt

smaller mining entities. Consequently, eco-innovation acts as a form of insurance, ensuring that the organization's assets are protected from the sudden imposition of polluter-pays penalties (Rana and Arya, 2024).

The mitigation of climate-related risks through carbon capture, utilization, and storage (CCUS) and reforestation initiatives has become a critical performance metric for mining firms seeking to maintain their operational permits (Ahaneku et al., 2024). Governments worldwide are aggressively implementing carbon taxes and emissions trading schemes, which directly impact the profitability of high-emission mining activities (Maphosa and Maphosa, 2023). According to Saleem (2025), mining organisations that invest in carbon-sequestering technologies and nature-based solutions are able to offset their unavoidable emissions, thereby maintaining compliance with Net Zero targets. This alignment with global climate goals reduces the risk of stranded assets, where mineral deposits become unmineable due to prohibitive environmental costs or regulatory bans (Uddin et al., 2022). Furthermore, the use of predictive analytics to forecast extreme weather events allows mining managers to reinforce infrastructure, such as drainage systems and tailings facilities, mitigating the risk of climate-induced operational disruptions (Ali et al., 2023).

The improved transparency afforded by eco-innovative reporting tools enhances the firm's credibility with environmental regulators and non-governmental organizations (Suleman et al., 2024). Blockchain-based tracking of environmental data ensures that sustainability reports are tamper-proof and verifiable, which simplifies the auditing process and accelerates the approval of new mining licenses (Kusi-Sarpong et al., 2021). According to Rana and Arya (2024), this high level of transparency reduces the information asymmetry between mining firms and regulators, fostering a collaborative rather than an adversarial relationship. As a result, compliant and eco-innovative firms often enjoy fast-tracked permitting processes, which significantly reduces the lead-time for project commencement and revenue generation (Ahaneku et al., 2024).

2.4.3.4 Acceleration of Process Efficiency and Lead-Time Reduction

The integration of digital eco-innovations, such as the Industrial Internet of Things (IIoT) and smart sensor networks, significantly accelerates mining throughput by eliminating manual bottlenecks and optimizing the flow of materials (Javaid et al., 2022). Process efficiency in the mining sector is no longer solely dependent on mechanical power but is increasingly driven by data-centric eco-innovations that allow for the precise synchronization of extraction and

processing activities (Bokhari et al., 2023). According to Dwivedi et al. (2021), the deployment of automated drilling and blasting systems reduces the variability in fragmentation, which directly shortens the time required for secondary crushing and grinding. Furthermore, real-time data analytics enable mining managers to identify and rectify process deviations instantly, ensuring that the production line maintains optimal velocity without unnecessary interruptions (Verma et al., 2022). Al-Sayegh et al. (2024) observe that firms utilizing these smart-green technologies report a 15% improvement in overall equipment effectiveness (OEE) compared to those relying on legacy manual controls.

The adoption of predictive maintenance as an eco-innovative strategy plays a crucial role in reducing lead-times by minimizing the incidence of unscheduled equipment downtime (Mishra et al., 2022). Traditional run-to-fail or fixed-interval maintenance schedules often lead to significant production delays or unnecessary part replacements that increase waste (Javaid et al., 2022). By utilizing vibration sensors and thermal imaging linked to machine learning algorithms, mining organisations can accurately predict the remaining useful life of critical components like conveyor belts and crushers (Bokhari et al., 2023). According to Dwivedi et al. (2021), this proactive approach allows for maintenance to be scheduled during planned outages, thereby ensuring that the lead-time from ore extraction to the final mineral concentrate remains consistent and predictable. Consequently, the reduction in mechanical failures ensures a steady supply of raw materials to downstream customers, enhancing the firm's reliability in the global supply chain (Verma et al., 2022).

Furthermore, the implementation of lean-green manufacturing principles within mining operations streamlines the internal logistics and reduces the lead-time associated with inventory handling and waste movement (Al-Sayegh et al., 2024). Eco-innovative logistics systems, such as automated dispatch and GPS-optimized haulage routes, ensure that trucks and loaders operate with maximum efficiency, reducing idle time and fuel wastage (Mishra et al., 2022). Javaid et al. (2022) emphasize that by minimizing the distance travelled and the number of material handling steps, mining firms can significantly compress their operational cycles. These efficiency gains are particularly vital in the mining sector, where the time-to-market is a critical determinant of a firm's ability to capitalize on short-term price surges in the commodity markets (Bokhari et al., 2023). According to Dwivedi et al. (2021), the synergy between environmental waste reduction and time-based competition allows mining organisations to achieve a leaner and more responsive operational profile.

The digitization of the mining supply chain through blockchain and cloud-based platforms facilitates faster information flow and reduces the administrative lead-times associated with compliance and documentation (Verma et al., 2022). These eco-innovative communication tools allow for the seamless tracking of mineral batches from the mine site to the refinery, providing stakeholders with instant updates on production status and quality (Al-Sayegh et al., 2024). According to Mishra et al. (2022), the reduction in paperwork and the automation of green certification processes allow mining firms to export their products more quickly, bypassing the delays often found in traditional customs and verification protocols. This acceleration of the entire value chain from extraction to delivery directly bolsters the organizational performance by increasing capital turnover and improving customer satisfaction (Javaid et al., 2022). Ultimately, the pursuit of process efficiency through eco-innovation ensures that mining firms can deliver higher volumes of sustainable minerals in shorter timeframes (Bokhari et al., 2023).

2.4.3.5 Increased Attraction of Green Financing and Investment

The integration of eco-innovative practices serves as a critical signalling mechanism that enhances a mining organization's attractiveness to the burgeoning global green finance market (Flammer et al., 2021). According to Azhgaliyeva and Lazzaroni (2022), these financial instruments often carry greenium benefits, providing innovative firms with lower interest rates compared to traditional debt. Furthermore, the transparent reporting of eco-innovative outcomes reduces information asymmetry between mining entities and creditors, fostering a climate of trust that facilitates large-scale capital inflows (Pia-Samaniego et al., 2023). Zhang and Vigne (2021) observe that firms with robust eco-innovation portfolios experience significantly lower cost of equity, as investors perceive them to be better insulated against future environmental liabilities.

Investment firms are progressively divesting from high-carbon extractive industries, making eco-innovation a prerequisite for maintaining access to mainstream equity markets (Flammer et al., 2021). Mining organizations that adopt low-emission technologies, such as hydrogen-powered haulage or carbon-neutral processing, are viewed as future-proofed assets that align with the climate-conscious mandates of global pension funds and sovereign wealth funds (Fatemi et al., 2024). According to Azhgaliyeva and Lazzaroni (2022), the transition toward green minerals those extracted through verified eco-innovative methods is now a primary driver for venture capital investment in the mining technology sector. Pia-Samaniego et al. (2023) emphasize that the ability to secure green-certified status allows mining firms to tap

into a wider variety of financing sources, including multilateral development banks that offer preferential terms for sustainable infrastructure. Consequently, eco-innovation acts as a financial bridge that secures the necessary liquidity for long-term expansion and technological upgrades (Zhang and Vigne, 2021).

Furthermore, the implementation of blockchain-based ESG tracking systems within mining operations provides investors with immutable proof of the firm's environmental performance, further de-risking the investment (Flammer et al., 2021). This high level of verifiable data allows for the issuance of Sustainability-Linked Bonds (SLBs), where the interest rate is directly tied to the firm's success in meeting specific eco-innovative targets, such as a 30% reduction in water intensity (Fatemi et al., 2024). According to Azhgaliyeva and Lazzaroni (2022), these performance-based financial products incentivize continuous improvement in resource utilization and emissions control. Pia-Samaniego et al. (2023) note that mining companies utilizing AI-driven sustainability auditing are significantly more likely to pass the rigorous due diligence processes required by top-tier investment banks. As a result, eco-innovative mining firms enjoy a competitive advantage in the capital markets, allowing them to fund capital-intensive projects even during periods of general market contraction (Zhang and Vigne, 2021).

The attraction of green financing through eco-innovation provides mining organizations with the fiscal resilience needed to withstand the economic impacts of the global energy transition (Flammer et al., 2021). By securing long-term, low-cost capital, these firms can invest in the radical innovations such as deep-sea mining robots or bio-remediation systems that will define the next generation of the extractive industry (Fatemi et al., 2024). Therefore, it is hypothesised that:

H_3. *There is a positive relationship between Eco-Innovative Practices and Organisational Performance in the mining sector*

2.4.4 The effects of Internal Environmental Management on Organisation Performance in the Mining Sector.

2.4.4.1 Enhancement of Cost Efficiency and Resource Productivity

Internal Environmental Management (IEM) directly facilitates cost reduction in mining by optimizing the consumption of electricity, water, and fuel through rigorous internal monitoring

(Roh et al., 2022). Mining organisations that implement standardized environmental audits identify energy-intensive bottlenecks, allowing for the deployment of variable speed drives and efficient pumping systems that lower utility bills (Mubarak et al., 2022). These internal efficiency gains are vital in deep-level mining where ventilation costs typically constitute a significant portion of total operational expenditure (Al-Sheyadi et al., 2021). The systematic tracking of resource flows through internal green protocols prevents the over-allocation of expensive chemical reagents during the mineral processing stage (Sari et al., 2021).

The adoption of Environmental Management Accounting (EMA) as a core component of IEM allows mining managers to quantify the financial impact of material losses that are often overlooked by conventional accounting systems (Ofori et al., 2022). By identifying the true cost of every ton of ore lost in the tailings, mining firms can justify capital investments in more precise extraction technologies (Abdel-Basset et al., 2021). Mining firms using IEM-driven data achieve a higher eco-efficiency ratio, meaning they generate more economic value while utilizing fewer natural raw materials (Rezaei et al., 2021).

IEM-driven resource productivity provides a buffer against the rising costs of regulatory compliance and environmental taxes in the extractive industry (Bag et al., 2021). Formal mining entities utilizing internal water recycling systems reduce their dependence on external municipal supplies, thereby lowering both procurement costs and the risk of production stoppages during droughts (Kumar et al., 2022). The implementation of internal eco-design for mining infrastructure leads to long-term savings in maintenance and decommissioning costs (Kong et al., 2021). Internal environmental management is a fundamental tool for achieving a leaner, more cost-competitive operational structure in the mining sector (Zhang et al., 2024).

The synergy between internal environmental targets and cost performance is further reinforced by the discovery of process-level innovations that emerge when managers seek to meet strict ecological KPIs (Vanalle et al., 2024). Internal pressure to reduce carbon emissions often leads to the optimization of haulage routes, which simultaneously reduces tire wear and diesel consumption (Tian & Wang, 2024). These green-induced efficiencies contribute to a sustained increase in the Return on Assets (ROA) for mining firms (Xiao et al., 2024). Internal Environmental Management effectively transforms the ecological burden into a strategic pathway for superior resource productivity and financial health (Zhu et al., 2021).

2.4.4.2 Improvement of Operational Efficiency through Waste Mitigation

Internal Environmental Management (IEM) directly facilitates a significant improvement in operational efficiency by enabling mining organisations to identify and eliminate non-value-added waste throughout the mineral extraction process (Adedoyin et al., 2024). The systematic mitigation of waste through internal environmental protocols reduces the logistical burden of handling large volumes of overburden and tailings, thereby streamlining the entire production workflow (Bhateria, 2024). Mining firms that implement automated waste segregation at the source achieve a measurable increase in operational efficiency through optimized resource allocation and reduced material handling times (Mubarak et al., 2022). This internal optimization ensures that energy and labour are focused primarily on high-value ore processing rather than the management of unproductive waste streams (Zhang et al., 2024).

Repurposing mine tailings into construction materials or paste backfills reduces the spatial constraints and costs associated with traditional waste disposal sites (Al-Sheyadi et al., 2021). By minimizing the physical footprint of waste storage, organisations avoid the logistical bottlenecks and production halts often caused by the limited capacity of tailings dams (Tian & Wang, 2024). These proactive waste valorization strategies mitigate ecological risks while simultaneously enhancing the overall speed and reliability of the internal supply chain (Zaid et al., 2021).

IEM drives operational efficiency by fostering the adoption of advanced technologies like AI-driven sorting and real-time sensor monitoring (Xiao et al., 2024). Real-time data monitoring allows mining managers to adjust processes instantaneously, preventing the accumulation of waste and ensuring higher mineral recovery rates (Sari et al., 2021). By reducing the frequency of unplanned downtime associated with environmental incidents or waste-handling equipment failures, mining firms maintain a more consistent and predictable production schedule (Roh et al., 2022). Consequently, waste mitigation acts as a critical lever for improving the overall equipment effectiveness and operational stability of formal mining organisations (Aghelie et al., 2022).

The cumulative impact of these waste-mitigation practices is a leaner, more agile operational model that is better aligned with global sustainability standards (Wohllebe & Ross, 2024). Mining firms that prioritize the minimization of waste are better equipped to navigate the stringent regulatory landscapes of modern extractive industries (Seman et al., 2021). This

alignment reduces the risk of costly legal interventions or community-led disruptions, ensuring a continuous social license to operate and uninterrupted production cycles (Vanalle et al., 2024)

2.4.4.3 Boosting of Corporate Reputation and Stakeholder Relations

Internal Environmental Management (IEM) serves as a primary strategic instrument for enhancing corporate reputation by demonstrating an organization's genuine commitment to sustainable operational standards (Singh & Misra, 2021). The consistent application of internal environmental controls allows mining firms to build trust with diverse stakeholder groups, including local communities, regulatory bodies, and investors (Stephanie, 2024). When mining organizations prioritize internal ecological transparency, they mitigate the risk of being perceived as merely engaging in superficial image-building or greenwashing (Le, 2023). This authentic approach to environmental stewardship fosters a positive public image, which is increasingly recognized as a valuable intangible asset in the competitive extractive industry (Afum et al., 2021).

The establishment of robust internal environmental protocols significantly improves relations with local communities by reducing the adverse impacts of mining activities on shared resources (Wilson, 2022). Mining companies that actively involve community stakeholders in the planning and monitoring of internal environmental initiatives report a substantial decrease in social conflicts and protests (Blesia et al., 2021). Fostering these reciprocal relationships ensures that the organization maintains its social license to operate, which is critical for long-term project stability and resource availability (Sahoo, 2024). By aligning internal operational goals with community expectations for environmental safety, formal mining entities strengthen their social legitimacy and minimize the threat of local resistance (Bello-Pintado et al., 2023).

Furthermore, high levels of internal environmental accountability act as a signal to environmentally conscious investors, thereby attracting green capital and stabilizing the firm's market valuation (Khan & Iqbal, 2024). Stakeholder engagement through transparent reporting on IEM outcomes satisfies the growing demand from shareholders for comprehensive environmental, social, and governance (ESG) disclosures (Sun & Zhao, 2024). Institutional investors are more likely to support mining firms that demonstrate an integrated set of tangible environmental actions rather than those relying solely on philanthropic gestures (Machaya, 2026). This strategic alignment between internal management and external investor expectations enhances the firm's credibility and provides a distinct competitive advantage in global financial markets (Kuzey et al., 2023).

The synergy between IEM and stakeholder management cultivates a strong green organizational culture that motivates employees and enhances internal morale (Adu-Gyamfi et al., 2021). Employees who take pride in their organization's eco-friendly initiatives are more likely to contribute effectively to operational success and act as brand ambassadors to the external public (Afum et al., 2021).

2.4.4.4 Facilitation of Green Innovation and Technological Advancement

Internal Environmental Management (IEM) acts as a critical catalyst for green innovation by providing the necessary organizational structure for the development of eco-friendly technologies (Zhuang et al., 2022). Mining organisations that institutionalize environmental goals internally are more likely to invest in Research and Development (R&D) aimed at reducing carbon emissions and energy consumption (Mavi et al., 2024). The implementation of internal green auditing systems encourages managers to seek out innovative solutions for processing low-grade ores with minimal chemical usage (Yadav et al., 2023). By aligning internal environmental KPIs with technological roadmaps, mining firms accelerate the adoption of automated and electrified extraction equipment (Kusi-Sarpong et al., 2024).

IEM facilitates the digital transformation of mining operations through the integration of Internet of Things (IoT) sensors for environmental monitoring (Chen et al., 2022). According to Abbas (2021), the use of real-time data analytics allows for the precise adjustment of smelting temperatures, which reduces both energy waste and atmospheric pollution. These digital green innovations enable mining managers to simulate various environmental scenarios, leading to more resilient and adaptive production schedules (Seles et al., 2022). The synergy between internal environmental management and digital technology represents the next frontier of operational excellence in the extractive sector (Hansen et al., 2024).

The organizational support provided by IEM frameworks lowers the internal barriers to adopting disruptive green technologies like hydrogen-powered haulage trucks (Rezaei et al., 2022). Environmental training programs for staff ensure that the workforce is capable of operating and maintaining sophisticated eco-innovative machinery (Singh et al., 2023). By fostering an internal environment that rewards sustainable creativity, mining firms can overcome the inertia that often hinders technological progress in traditional heavy industries (Wong et al., 2021).

2.4.4.5 Cultivation of a Green Organisational Culture and Employee Commitment

EM becomes an important trigger for the formation of a green culture within an organization as it incorporates the ecological values into the belief system of the miners. As per the findings of Roscoe et al. (2022), the organizations that exhibit a strong commitment to environmental sustainability create an environment where the employees share the sense of accountability for the preservation of ecology. The institutionalization of green values through internal policies ensures that environmental stewardship becomes a normative behaviour rather than a forced compliance measure (Haldorai et al., 2022). Consequently, a robust green culture serves as the intangible foundation upon which all other sustainable supply chain initiatives are built (Mumu et al., 2021).

The implementation of Green Human Resource Management (GHRM) as a component of IEM significantly enhances employee commitment by aligning personal values with corporate environmental goals (Fawehinmi et al., 2022). Mining firms that provide specialized environmental training programs empower their staff to contribute meaningfully to waste reduction and energy saving initiatives (Ojo et al., 2022). Employees who perceive their organization as a genuine leader in environmental protection report higher levels of job satisfaction and a stronger psychological bond with the firm (Islam et al., 2021). This alignment of purpose reduces staff turnover and increases the internal stability of the mining operation's human capital (Amrutha & Geetha, 2021).

Furthermore, a green organizational culture driven by IEM encourages proactive employee behavior, such as the suggestion of eco-innovative process improvements at the coalface (Pellegrini et al., 2022). Research by Shahzad et al. (2023) indicates that when mining managers reward environmental championing behaviors, it triggers a ripple effect of green creativity across the production line. This bottom-up participation is essential in the mining sector where field-level operators are often the first to identify leaks, spills, or energy inefficiencies (Yusoff et al., 2021). By fostering a climate of environmental psychological safety, mining firms unlock the creative potential of their workforce to solve complex sustainability challenges (Bissing-Enermann et al., 2022).

The synergy between a green culture and employee commitment leads to superior organizational performance through enhanced collective effort and reduced resistance to change (Tuan, 2022). Mining entities with a mature green culture find it significantly easier to implement disruptive sustainable technologies because the workforce is already predisposed to

valuing ecological benefits (Sobaih et al., 2022). This cultural readiness acts as a strategic lubricant for the adoption of circular economy practices and carbon-neutral mining protocols (Umar & Wang, 2023).

Therefore, it is hypothesised that:

H_4. *There is a positive relationship between Internal Environmental Management and Organisational Performance in the mining sector*

2.4.5 The operational impact of the informal economy, specifically artisanal mining, on the supply chain stability and resource availability for formal entities

2.4.5.1 Encroachment on Formal Concessions and Resource Depletion

The physical encroachment of artisanal miners into legally protected concessions held by formal entities represents one of the most immediate threats to resource availability, a threat that persists due to inadequate state protection and inconsistent application of regulatory frameworks. Mancini et al. (2021) observe that as high-grade mineral deposits become more accessible at shallower depths, informal miners frequently occupy the same geographical spaces designated for large-scale operations. This spatial overlap leads to resource skimming, where ASM operators extract high-grade ore pockets that are critical for the economic viability and long-term blending strategies of formal mining firms (O'Faircheallaigh, 2021). Consequently, the formal entity is left with lower-grade deposits, which increases the unit cost of extraction and diminishes the overall life-of-mine (LOM) projections. This situation is particularly acute in Zimbabwe, where formal mines, despite paying taxes and holding legal concessions, often face an uphill battle in securing their claims against informal incursions, largely due to the state's failure to enforce existing property rights and mining laws (Maseko & Zinyemba, 2024; Ndlovu & Mutasa, 2024).

Furthermore, the lack of geological precision in informal mining leads to inefficient resource utilization that compromises the future scalability of formal operations. Bariah et al. (2024) argue that artisanal methods often involve haphazard potholing, which can destabilize the ground and make it physically impossible or prohibitively expensive for formal entities to later employ mechanized, large-scale extraction techniques in those same areas. This degradation of the physical ore body transforms a predictable geological asset into a high-risk operational

zone, forcing formal entities to redirect capital toward unforeseen stabilization and exploratory efforts to find alternative feed sources (Hilson & Hu, 2022).

The presence of informal miners also acts as a significant barrier to the execution of strategic operational phases, such as seismic surveying and exploratory drilling. When formal entities cannot access parts of their own concessions due to the presence of thousands of informal workers, the supply chain's upstream stability is compromised because the resource definition phase is delayed (Kamlongera et al., 2023). This creates a discovery-to-production lag, where the formal entity's ability to forecast future output is undermined, leading to potential shortfalls in meeting contractual supply obligations to global markets (Bashir et al., 2025). This operational paralysis directly stems from the state's inability to ensure the exclusive operational rights of its tax-paying formal mining sector, despite the existence of explicit regulations designed to guarantee such protections.

The depletion of resources by the informal sector necessitates a shift in the sustainable supply chain management (SSCM) framework toward more aggressive and costly integration or exclusion strategies. Teschner et al. (2023) suggest that formal entities are increasingly forced to choose between militarized exclusion which carries heavy reputational and social risks or the formalization of ASM into their own supply chains. Neither path is without significant operational expense; formalization requires the establishment of rigorous monitoring, health and safety training, and legal frameworks to ensure the artisanal output meets international clean mineral standards (Planet GOLD, 2022). Thus, the informal economy does not merely steal ore; it fundamentally reconfigures the cost structure and risk profile of the formal entity's entire supply chain, a reconfiguration disproportionately borne by the formal sector due to the lack of effective and equitable regulatory enforcement.

2.4.5.2 Supply Chain Contamination and Traceability Risks

The integration of illicitly sourced minerals into formal supply chains creates significant traceability gaps that undermine the integrity of sustainable procurement frameworks. Mzembe et al. (2022) argue that the lack of transparent oversight in artisanal mining hubs allows minerals of unknown origin to be laundered into the legitimate value chain through informal middle-men. This contamination makes it nearly impossible for formal entities to guarantee that their output is free from conflict-related or human rights-violating practices. Such risks are particularly acute in the 3TG (tin, tungsten, tantalum, and gold) sectors where the physical

properties of the minerals allow for easy mixing of formal and informal stocks at the processing stage (Sow et al., 2024).

Global regulatory frameworks, such as the EU Conflict Minerals Regulation, place the burden of proof on the formal entity to demonstrate a clean chain of custody. Partzsch (2023) notes that when informal mining activities occur in proximity to formal sites, the risk of leakage increases, as informal miners may sell their ore to formal processing plants through deceptive means. If a formal entity is found to have processed minerals originating from unregulated artisanal sites, it faces severe legal penalties and potential exclusion from international markets. This reality forces formal mining firms to implement expensive, high-tech tracking solutions, such as blockchain-enabled mineral tagging, to safeguard their supply chain from informal infiltration (Nuhu et al., 2023). This not only deters foreign direct investment vital for the mining sector's growth but also increases the cost of international transactions and financing for all legitimate businesses within the country, including formal mining entities (IMF, 2023). The inability to ensure a clean chain of custody, largely due to the unchecked informal sector, thus has far-reaching macroeconomic consequences, hindering the nation's participation in global trade and finance and further burdening the formal sector with additional compliance requirements and reputational damage (Maseko & Zinyemba, 2024).

The presence of informal mining also complicates the environmental, social, and governance (ESG) reporting required by modern investors. Hirons (2021) highlights that formal entities operating in regions with high ASM activity are often unfairly associated with the negative externalities of the informal sector, such as child labor or mercury pollution. This guilt by association can lead to the divestment of capital by ESG-conscious funds, even if the formal entity’s internal practices are exemplary. The resulting financial instability limits the entity's ability to invest in long-term supply chain resilience and infrastructure (Calvimontes et al., 2022).

In response to these traceability challenges, some formal entities have attempted to create closed-loop supply chains that physically isolate their operations from the surrounding informal economy. Smith and Dessables (2025) observe that while these isolation strategies may protect the immediate purity of the product, they often exacerbate local tensions and lead to increased sabotage of formal infrastructure. The operational cost of maintaining these physical and digital barriers represents a significant diversion of resources that could otherwise

be used for core mining activities. Consequently, the informal economy acts as a persistent traceability tax on the formal mining sector (Zhu et al., 2024).

2.4.5.3 Market Distortion and Price Volatility

Informal mining operations frequently introduce large volumes of minerals into the market through non-traditional channels, which disrupts the price stability essential for formal corporate planning. This creates a dual-market system where formal entities, burdened by compliance and rehabilitation costs, must compete against a low-cost informal alternative. Such market distortion undermines the competitive advantage of formal firms that prioritize sustainable supply chain management (McQuilken, 2023).

The rush nature of artisanal mining leads to sudden, unpredictable surges in mineral supply that can cause local and regional price crashes. Taka (2021) identifies that these supply shocks are often triggered by new discoveries or seasonal changes in water availability for artisanal processing. For a formal entity with long-term supply contracts and fixed operational overheads, these price fluctuations make it difficult to maintain consistent profit margins and fulfill delivery obligations. The inability to predict local mineral availability forces formal firms to keep larger, more expensive inventories as a buffer against market volatility (Baffour-Kyei et al., 2021).

The informal economy also facilitates the flight of mineral wealth through smuggling, which deprives the local formal economy of necessary liquidity. Githaiga (2023) explains that when artisanal gold or gemstones are smuggled across borders to avoid formal levies, the resulting loss of foreign exchange reserves can lead to currency instability in the host nation. Formal mining entities are then hit by the secondary impact of rising import costs for machinery and fuel, further straining their operational budgets. This creates a cycle where informal activity indirectly increases the cost of doing business for formal organizations (Mancini et al., 2022).

Formal mining entities are increasingly required to intervene in these distorted markets by acting as buyers of last resort to stabilize local prices. Lukas and Peluso (2024) suggest that by purchasing artisanal ore at fair market rates, formal firms can reduce the incentive for smuggling and gain more control over the local supply. However, this strategy requires the formal entity to take on the role of a commodity trader, which is often outside its core competency and adds another layer of operational risk. The transition from a pure mining entity to a market-stabilizing agent represents a fundamental shift in the organizational performance metrics of the firm (Hilson and Hu, 2022).

2.4.5.4 Environmental Degradation and Remediation Liability

The unregulated nature of artisanal mining activities leaves a trail of environmental devastation that frequently becomes the legal and financial burden of neighbouring formal entities. When these pollutants migrate into the permit areas of formal organizations, regulatory bodies often hold the formal title holder accountable for the clean-up under the polluter pays principle. The resulting remediation costs are not factored into the original life-of-mine capital expenditure, leading to significant budget overruns and reduced net present value for the project (Mancini et al., 2022).

Land degradation caused by informal potholing and the destruction of vegetation covers prevents formal entities from executing their mandatory concurrent rehabilitation plans. Chifamba et al. (2025) observe that in regions like Zimbabwe and Ghana, the physical alteration of the landscape by thousands of informal miners makes it impossible for formal firms to restore the land to its pre-mining state as required by law. Failure to meet these rehabilitation milestones can lead to the forfeiture of environmental bonds or the withholding of future mining permits by the state. This creates a state of regulatory paralysis where the formal entity is trapped between its legal obligations and the physical reality of a degraded landscape it did not create (Kamlongera et al., 2023).

The destruction of local water tables by informal miners further compromises the operational stability of formal processing plants. Teschner et al. (2023) argue that the high sediment loads and chemical runoff from artisanal sites clog the water intake systems of formal mines, necessitating the installation of advanced and expensive water treatment technologies. These unplanned technical upgrades increase the operational cost per ton of processed ore and reduce overall resource utilization efficiency (Baffour-Kyei et al., 2021).

Hirons (2021) notes that international carbon accounting and green mineral certifications require a pristine environmental record that is difficult to maintain in areas of high ASM activity. The reputational damage stemming from visible environmental scarring even if caused by the informal sector can lead to the loss of Social License to Operate (SLO). This loss of community and investor trust represents a long-term risk to organizational performance that is difficult to quantify but devastating to corporate longevity (Calvimontes et al., 2022).

2.4.5.5 Security Threats and Operational Disruptions

The presence of a large, unregulated informal workforce in proximity to high-value mineral assets creates a volatile security environment that necessitates excessive spending on private

and state-led protection. O'Faircheallaigh (2021) identifies that the gold rushes associated with artisanal mining often attract organized criminal elements who use the informal sector as a front for money laundering and mineral theft. Formal entities are forced to respond by militarizing their perimeters, which significantly increases the security-to-production cost ratio. This diversion of funds from core operational technology to defensive security measures diminishes the firm's ability to innovate and improve cost efficiency (Sow et al., 2024).

Operational disruptions often take the form of industrial sabotage or violent protests when formal entities attempt to secure their legally held concessions. Bashir et al. (2025) document instances where informal miners, feeling displaced by the expansion of formal operations, have targeted power lines, transport routes, and processing infrastructure. These acts of sabotage lead to unplanned downtime, which is the single most expensive factor in modern mining operations. Every hour of lost production due to security-related downtime directly impacts the firm's ability to meet lead-time targets and maintain supply chain reliability (Nuhu et al., 2023).

The psychological impact of a high-risk security environment on the formal workforce leads to high turnover rates and difficulty in attracting specialized technical talent. Mzembe et al. (2022) suggest that mining engineers and geologists are increasingly reluctant to work in red-zone concessions where the risk of kidnapping or violent confrontation with informal miners is high. This brain drains forces formal entities to pay significant hardship premiums, further inflating the labor cost component of the supply chain. The loss of institutional knowledge and technical expertise directly correlates with lower operational performance and higher rates of industrial accidents (Ofosu et al., 2022).

Formal mining organizations are frequently drawn into local conflicts between different artisanal factions, which complicates their relationship with the host community. Taka (2021) argues that when a formal entity provides security assistance to one group or coordinates with state police to clear an area, it is often perceived as an aggressor by the broader community. This perception erodes the Social License to Operate and can lead to long-term blockades of essential supply routes by local residents. Managing these complex socio-political dynamics requires a level of diplomatic expertise that most mining supply chain managers are not traditionally trained to handle (McQuilken, 2023).

2.4.5.6 Infrastructure Strain and Logistical Inefficiencies

The informal mining economy places an immense, unplanned burden on the shared infrastructure that formal entities rely upon for their logistics and supply chain movements. Bariah et al. (2024) highlight that the heavy influx of artisanal miners into remote areas leads to the rapid deterioration of local road networks and bridges, which were often funded and built by the formal entity for its own use. This increased traffic causes frequent road closures and accidents, leading to significant delays in the delivery of critical mining consumables like reagents and spare parts. The resulting logistical friction increases the inventory carrying costs for formal firms, as they are forced to stockpile more supplies to mitigate the risk of transport failure (Githaiga, 2023).

Power grid instability is exacerbated by the illegal tapping of electricity lines by informal settlements that spring up around artisanal mining sites. Zhu et al. (2024) observe that these unauthorized connections lead to frequent brownouts and voltage fluctuations that can damage the sensitive electronic control systems of formal processing plants. For a formal mine, an unplanned power trip can result in hours of cleaning sanded tanks and recalibrating machinery, representing a direct loss of resource utilization. Formal entities often have to invest in redundant, off-grid power solutions like diesel generators or solar farms at a massive capital expense to bypass the compromised public grid (Smith & Dessables, 2025).

The competition for limited rail and port capacity between formal mineral exports and informal (often smuggled) flows creates a bottleneck that slows down the entire national mineral supply chain. Ofosu et al. (2022) point out that in many developing nations, the informal sector's demand for transport services drives up the cost of logistics for everyone. Formal firms, which operate on thin margins and high volumes, are particularly sensitive to these rising freight costs. This environment makes it difficult for formal entities to optimize their lead-time reduction goals, as the external logistical environment is beyond their direct control (Partzsch, 2023).

Telecommunications and water infrastructure also suffer from the rapid, unplanned growth of the informal mining sector. McQuilken (2023) notes that the digital congestion in mining towns caused by thousands of artisanal miners using mobile networks can disrupt the automated Industrial Internet of Things (IIoT) systems that formal mines use for real-time monitoring of their equipment. Similarly, the competition for local water sources during the dry season can lead to water wars, where the formal entity is forced to curtail its production to ensure the local

community has enough water to survive. These infrastructure-related constraints act as a ceiling on the growth and performance of the formal mining organization (Lukas & Peluso, 2024).

2.4.6 A predictive supply chain stability framework using Zimbabwe's mining dynamics to forecast operational risks in the South African (RSA) mining sector

2.4.6.1 Cross-Border Regulatory Synchronization and Policy Alignment

The establishment of a predictive supply chain stability framework necessitates the integration of cross-border regulatory synchronization as a fundamental pillar for regional risk mitigation (Moyo, 2022). This element focuses on the systematic alignment of mining laws, indigenization policies, and export-import regulations between Zimbabwe and South Africa to prevent disruptions caused by sudden policy friction (Chirimubwe, 2021). According to recent research, the volatility observed in Zimbabwean mineral policy often serves as an early warning system for regional supply chain actors who must navigate varying degrees of state interventionism (Sibanda, 2023). Therefore, the monitoring of regulatory shifts in Zimbabwe allows formal entities in South Africa to pre-emptively adjust their procurement strategies before legislative changes impact the transborder flow of raw materials (Gumede, 2024).

The reporting of regulatory dynamics indicates that policy osmosis often occurs within the Southern African Development Community (SADC), where successful or unsuccessful mining tax regimes in Zimbabwe influence the legislative agenda in South Africa (Naidoo, 2025). This interconnectedness implies that a predictive framework must treat regulatory changes in Zimbabwe not as isolated events, but as precursors to shifts in the broader South African operational environment (Dube, 2022). Scholars have argued that the lack of a synchronized regulatory database leads to information asymmetry, which significantly increases the risk of non-compliance for multinational mining firms operating across both borders (Zondo, 2023). By institutionalizing the tracking of policy directives, the predictive framework can assign risk scores to specific supply chain nodes based on their exposure to pending legislative amendments (Nkosi, 2026).

Furthermore, the impact of Zimbabwe's Command Agriculture and mining models has demonstrated how state-led resource allocation can abruptly divert materials away from export markets to satisfy domestic quotas (Tshuma, 2021). This diversion creates a vacuum in the South African supply chain, necessitating a predictive model that can forecast these shifts by analyzing Zimbabwean cabinet briefings and parliamentary bills (Maphosa, 2024). Effective

reporting on these dynamics reveals that regulatory synchronization is not merely about legal compliance but involves the strategic forecasting of political risk premiums that are added to the cost of raw materials (Sithole, 2025). Consequently, the framework must integrate real-time updates from legal experts in both jurisdictions to ensure that lead-time reductions are not undermined by customs delays or sudden export bans (Phiri, 2023).

The development of this element within a predictive framework relies on the use of Natural Language Processing (NLP) to scan Zimbabwean government gazettes for keywords related to mineral royalties and land rights (Lunga, 2022). This technological integration allows for the automated adjustment of supply chain stability forecasts, providing South African mining managers with a regulatory heat map (Mbeki, 2021). Research indicates that firms which adopt such proactive regulatory tracking report a significant increase in resource utilization efficiency by avoiding the firefighting associated with unexpected border closures (Hlongwane, 2024). Ultimately, the synchronization of cross-border policy data serves as the foundation upon which all other predictive elements such as financial and logistical modeling must be built to ensure holistic supply chain resilience (Chauke, 2026).

2.4.6.2 Macro-Economic Volatility and Currency Fluctuation Modeling

The integration of macro-economic volatility modeling into a predictive supply chain framework is essential for mitigating the financial contagion that often spreads from Zimbabwe's unstable monetary environment to South African mining operations. Research indicates that the extreme exchange rate fluctuations and persistent hyperinflationary pressures in Zimbabwe create a high-risk environment for procurement and contract management (Mupaso & Tsegaye, 2024). For South African mining firms that rely on Zimbabwean inputs or cross-border logistical services, these currency shifts directly impact the landed cost of materials, making budget forecasting nearly impossible without a predictive tool (Nyoni, 2023). Therefore, reporting on these dynamics suggests that a robust framework must incorporate real-time exchange rate variance to adjust the expected cost efficiency of the supply chain (Chiwara, 2025).

The literature highlights that currency volatility in Zimbabwe often leads to supplier distress, where local vendors can no longer fulfill orders due to the erosion of their working capital (Smit & Muzondo, 2022). This distress creates a bullwhip effect that travels through the regional supply chain, eventually manifesting as lead-time delays for formal mining entities in South Africa (Daka & Sibanda, 2021). By analyzing the correlation between Zimbabwe's

parallel market rates and the official interbank rates, predictive models can forecast when a supplier is likely to default on a contract before the actual failure occurs (Zindi, 2023). Such a proactive approach allows South African procurement managers to diversify their supplier base or renegotiate terms in more stable currencies, such as the USD or ZAR, to maintain operational continuity (Moyo, 2024).

Furthermore, the impact of macro-economic instability extends beyond simple pricing to include the availability risk of critical mining consumables that are imported via Zimbabwe. According to recent academic findings, when the Zimbabwean economy faces severe liquidity crises, the domestic demand for hard currency often leads to the prioritization of essential goods over industrial mining inputs, creating unexpected bottlenecks (Chiduza & Hove, 2025).

2.4.6.3 Artisanal and Small-Scale Mining (ASM) Socio-Technical Impact Mapping

The integration of Artisanal and Small-Scale Mining (ASM) dynamics into a predictive stability framework is critical due to the significant, yet often informal, role these actors play in the regional mineral value chain. Recent reporting suggests that in Zimbabwe, the ASM sector contributes over 60% of gold deliveries, creating a dual-track supply chain that often intersects with formal South African entities through illicit trade or informal procurement (Muzondo & Sibanda, 2024). This socio-technical intersection introduces high levels of integrity risk and resource leakage, where minerals intended for formal international markets are diverted into informal channels (Chitando & Mpofu, 2023). Therefore, a predictive framework must map the density and activity levels of ASM clusters in Zimbabwe to forecast potential disruptions in the volume of raw materials reaching South African refineries (Dube, 2025).

The shadow supply chain created by artisanal miners in Zimbabwe presents a significant challenge to the traceability and ESG (Environmental, Social, and Governance) compliance of South African mining houses. Researchers have noted that conflict minerals or irresponsibly mined materials from Zimbabwean ASM sites can infiltrate the formal supply chains of South African companies, leading to severe reputational damage and international sanctions (Smit & Van der Merwe, 2023). A predictive framework utilizing blockchain-enabled tracking data can assign provenance risk scores to mineral batches coming from cross-border regions (Chiwara, 2024). This technical mapping ensures that South African firms can maintain their Social License to Operate (SLO) by filtering out materials associated with the risks identified in the Zimbabwean informal sector (Tshuma, 2026).

The transition of ASM from an informal survivalist activity to a more organized, yet still unregulated, economic force requires a predictive model that understands informal market signals (Maphosa, 2025). For instance, a sudden spike in the price of basic commodities in Zimbabwean mining towns often correlates with an increase in artisanal output, which may temporarily flood or disrupt formal supply equilibrium (Gumbo & Ncube, 2022). By monitoring these micro-economic indicators, South African supply chain managers can better predict fluctuations in resource availability and adjust their procurement lead times accordingly (Phiri, 2024).

2.4.6.4 Infrastructure and Logistical Corridor Throughput Analytics

The performance of the North-South Corridor, particularly the Beitbridge border post and the connecting rail networks, is a primary determinant of supply chain stability for the mining sector. Recent research suggests that logistical inefficiencies in Zimbabwe act as a bottleneck multiplier, where a 10% delay in Zimbabwean transit times correlates with a significant rise in inventory holding costs for South African mining entities (Moyo & Zondi, 2024). For a predictive framework to be effective, it must integrate real-time throughput data from these corridors to forecast potential stock-out risks of critical reagents and machinery (Chiwara, 2025). Reporting on these infrastructure dynamics indicates that the physical state of Zimbabwean roads and the operational capacity of the National Railways of Zimbabwe (NRZ) are early warning signals for supply chain disruptions in the RSA (Smit & Naidoo, 2023).

The border-crossing effect remains a significant variable in the stability of the mining supply chain. Studies indicate that administrative delays at the Zimbabwe-South Africa border are often linked to sudden changes in customs documentation requirements or manual processing surges (Matanda, 2023). A predictive framework that monitors queue length and clearance time trends can assign a daily risk rating to the Beitbridge node, providing formal entities in South Africa with the data needed to optimize their resource utilization (Ncube & Phiri, 2025). Scholars argue that the digitalization of these border processes is essential, as it allows for the integration of big data into the broader predictive stability model (Hlongwane, 2024).

The impact of climate-induced infrastructure damage, such as road washouts during the cyclone season in Southern Africa, necessitates the inclusion of environmental data in the predictive framework. Recent reporting shows that Zimbabwean infrastructure is particularly vulnerable to extreme weather, which can sever the supply line for South African mines for weeks at a time (Maphosa & Sibanda, 2021). By correlating meteorological forecasts with

infrastructure vulnerability maps, the framework can predict seasonal spikes in operational risk (Khumalo, 2023).

2.4.6.5 Geopolitical Risk and Regional Stability Indexing

The integration of geopolitical risk indexing into a predictive mining framework is vital for understanding the spill over effects of Zimbabwe's internal political dynamics on the South African industrial landscape. Recent academic reporting emphasizes that political transitions and civil unrest in Zimbabwe often serve as lead indicators for labor movements and supply chain security across the SADC region (Müller, 2023). For South African mining firms, geopolitical instability in a neighbouring state does not merely represent a diplomatic concern but a direct threat to the physical security of transborder assets and the reliability of contractual obligations (Sefa-Nyarko, 2026). Consequently, a predictive framework must monitor political temperature indicators such as election-related violence or changes in bilateral trade agreements to forecast periods of heightened operational risk (Chirimubwe & Matanda, 2024).

The lack of transparency in regional mineral governance often exacerbates the impact of geopolitical shocks on supply chain predictability. Scholars have noted that when political accountability wanes in Zimbabwe, there is a measurable increase in informal tolls and administrative corruption, which directly inflates the cost of doing business for South African mining houses (Tshuma, 2024). A robust predictive framework must therefore include a governance quality index that tracks fluctuations in regional transparency and the rule of law (Nyathi & Ncube, 2025). By correlating these governance scores with historical supply chain disruptions, the framework can provide an early warning of impending cost escalations or resource misappropriation before they manifest in the formal accounting ledgers (Maphosa, 2026).

The role of regional bodies like SADC in mediating these geopolitical risks is a critical variable that must be modeled. Recent findings suggest that the effectiveness of regional intervention directly correlates with the duration of supply chain recovery times following a political crisis (Phiri, 2023). A predictive model that accounts for the speed and efficacy of regional diplomatic responses can help South African mining managers determine the likely down-time of their cross-border operations during periods of unrest (Hlongwane & Moyo, 2024). Furthermore, the broader global geopolitical landscape, exemplified by the ongoing US/Iran/Israel conflict, underscores the critical need for such predictive frameworks. This conflict, while geographically distant from Southern Africa, has profound implications for

global oil prices, shipping routes, and the availability of critical raw materials used in mining processes (IEA, 2024; Lloyd's List, 2024). Disruptions in the Middle East can lead to increased costs for fuel, explosives, and specialized machinery components, directly affecting the operational viability and profitability of mining operations worldwide, including those in South Africa (S&P Global, 2024).

2.5 Research Gap

The current body of empirical and theoretical literature provides a robust foundation for understanding Sustainable Supply Chain Management (SSCM) in the global mining industry; however, a critical synthesis of existing studies reveals a significant geographical, contextual, and methodological gap regarding the Zimbabwean extractive sector. While global scholars have established that proactive sustainability drives long-term resilience and operational efficiency, these models are predominantly derived from stable Western jurisdictions or advanced emerging economies (Kusi-Sarpong, Gupta, and Sarkis 2023). Consequently, there is an absence of a tailored, scientifically validated framework that accounts for the institutional voids and extreme macroeconomic volatility unique to Zimbabwe, specifically the transition to the Zimbabwe Gold (ZiG) currency and the impact of the Reserve Bank of Zimbabwe (RBZ) surrender requirements (Maseko and Zinyemba 2024).

A profound contextual gap exists in the lack of empirical research addressing the dual-tier nature of the Zimbabwean mining landscape. Existing literature often treats mining as a monolithic formal sector, ignoring the operational reality where formal entities must navigate a "survivalist" economy characterized by extreme resource scarcity and infrastructure deficits (Muvunzi, Walker, and Sibanda 2021). Formal entities like Dorowa Minerals must compete for resources and labor against a powerful, unregulated informal economy (Ndlovu and Mutasa 2024). While the "Makorokoza" or artisanal miners are politically and economically significant, there is a lack of data-driven roadmaps on how to integrate these informal actors into a formal SSCM framework without compromising the Environmental, Social, and Governance (ESG) standards required by international markets (Khumalo and Tshabalala 2024).

Furthermore, the theoretical application of the Resource-Based View (RBV) in Zimbabwe is hampered by a "resilience gap." Most studies on green procurement and eco-innovation assume a level of infrastructure maturity such as a stable power grid and accessible green financing that does not currently exist in the region (Muzondo and Pashapa 2025). While internal environmental management is touted as a driver for competitive advantage, there is little evidence on how firms leverage intangible green assets when faced with hyper-inflation and limited access to international capital (Nkomo 2022). This lack of a localized perspective means that current sustainability metrics often fail to capture the "leakage" of value caused by illicit financial flows and the lack of robust regulatory enforcement (Mudzengi 2023).

Methodologically, there is a lack of longitudinal and predictive studies that use Zimbabwe's unique constraints as a baseline for regional forecasting. Although some scholars have touched on regional contagion and policy-induced disruptions, there remains a gap in the development of a predictive supply chain stability framework that translates Zimbabwe's "regulatory laboratory" experience into actionable risk-mitigation strategies for the South African (RSA) mining sector (Mabaso and Chidoko 2022). This study, therefore, seeks to fill these voids by providing empirical evidence on how Strategic Supplier Partnerships, Green Procurement, and Internal Environmental Management can be synergized to drive performance in a resource-constrained environment, ensuring the sector's survival against the existential threat of capital flight and operational collapse (Howie et al., 2025).

2.6 Chapter Summary

Chapter 2 includes a detailed literature review on the theory and practice of sustainable supply chain management, making use of the Resource Based View and Stakeholder theories as the primary perspectives for analysis. The effect of various crucial variables, such as green procurement, eco-innovation, and internal management, on performance is analysed. Special attention is paid to the specific constraints presented by the existence of Zimbabwean informal economy and unstable macroeconomic conditions. This chapter ends with the identification of a multidimensional gap in research: the lack of a customized, robust sustainable supply chain management framework that would take into consideration the institutional vacuum, changes in regulations, such as the introduction of ZiG currency, and the integration of the informal artisanal mining sector into formal ESG supply chains.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter explained the systematic process and methodologies used to examine the effectiveness of SSCM in influencing organisational performance in the mining industry in Zimbabwe, using Dorowa Minerals as case study. In this research, the Research Onion model developed by Saunders et al. (2023) is used. This methodology offers a systematic and stratified approach to create an effective research design. The strength of the Research Onion is based on its capability to facilitate a logical transition from philosophical foundations to concrete methods of collecting and analysing the data (Bell et al., 2022). As one peels through layers of this onion, the researcher can ensure that the analysis of the effect of Sustainable Supply Chain Management (SSCM) on organisational performance is theoretically and methodologically sound (Creswell & Creswell, 2023). It is critical to use the structured approach in this research since it increases validity and reliability of the research results.

3.2 Research Philosophy

Pragmatism is the philosophical perspective that was used in this study. The philosophy is chosen because it is concerned more with practical solutions to problems faced by organizations in solving complicated issues than with following a particular ontology or epistemology (Saunders et al., 2023). Pragmatism is also ideal in this study because it justifies using mixed methods of research. Thus, the researcher can use the post-positivist quantifiable data related to Strategic Supplier Partnerships as well as the interpretive nature of qualitative data associated with how supply chain employees perceive things (Creswell & Creswell, 2023). According to Al-Okaily (2024), the perspective allows researchers to measure the influence of sustainability factors and institutional results and at the same time explain the reasons for using green technology based on the subjective views of employees. Such an approach will ensure that the knowledge generated will be relevant and useful for the decision makers in Zimbabwe's mining houses (Bernardo et al., 2022).

3.3 Research Approach

The research design chosen for the study in question is the mixed methods design that implies an intentional combination of both quantitative and qualitative data collection and analyses

(Creswell & Creswell, 2023). As per Saunders et al. (2023), a mixed-methods design is more appropriate for research into complex phenomena, such as organisational performance since the use of one data set will help overcome its limitations. In regard to mining industry research, this design enables the researcher to gauge the range of impacts on sustainability using statistics and explore the depth of operations challenges using narratives (Mousa et al., 2024).

A mixed-methods design is selected due to the fact that it is based on the pragmatic research philosophy that implies the search for practical solutions to industrial issues (Al-Okaily, 2024). The mixed-methods approach used in the study enable the researcher to test the statistical link between Internal Environmental Management and strategic performance and at the same time identify the human factors involved in implementing Eco-innovative Practices (Nugraini et al., 2025).

3.4 Research Design

The study utilises a cross-sectional survey design, which facilitates the collection of both quantitative and qualitative data from the target population at a single, specific point in time (Bryman, 2021). According to Saunders et al. (2023), a cross-sectional design is particularly effective for snapshot evaluations of organizational practices across different institutional tiers, such as comparing the perspectives of senior management, environmental officers, and procurement staff. The quantitative component of this design involves the use of structured survey instruments to gather standardized data on the perceived effectiveness of Green Procurement and Strategic Supplier Partnerships (Al-Okaily, 2024). This approach enables the researcher to perform sophisticated statistical analyses, such as Multiple Regression or Structural Equation Modelling, to determine the extent to which independent sustainability variables predict the dependent variable of organisational performance (Nugraini et al., 2025). Simultaneously, the qualitative component incorporates open-ended questions within the survey or semi-structured interviews to gather rich, contextual data regarding the barriers to sustainability within the same timeframe (Creswell & Creswell, 2023). This integration allows the researcher to capture the subjective reality of SSCM as it is experienced by employees on the front lines of the Zimbabwean mining industry (Boukherouaa et al., 2021).

3.5 Target Population

The target population for this study is defined as the total group of individuals from whom the researcher intends to generate findings and draw conclusions regarding the impact of

sustainability on industrial outcomes (Saunders et al., 2023). The target population consists of the employees of Dorowa Minerals Limited (DML), located in the Buhera district of Zimbabwe. According to Chemplex Corporation (2024), the parent company of the mine, Dorowa Minerals currently maintains a workforce of approximately 270 employees. This population is the primary focus because these individuals are the direct custodians of the mine's operational and supply chain processes

3.6 Sampling Procedures

3.6.1 Sample Size

The sample size for this study is determined to ensure sufficient statistical power and the generalisability of findings within a mixed-methods framework (Creswell & Creswell, 2023). For the quantitative phase, the study utilizes the Krejcie and Morgan (1970) formula, which serves as a rigorous standard for determining representative samples from finite populations in social science research. The required sample size (S) will be calculated as follows:

$$S = \frac{X^2NP(1-P)}{d^2(N-1) + X^2P(1-P)}$$

Where?

S = required sample size

X^2 = the table value of chi-square for one degree of freedom at 95% confidence level is (3.84)

N = the population size

P = the population proportion (assumed to be .50 since this would provide the maximum sample size)

d = the degree of accuracy expressed as a proportion (.05)

$$S = \frac{(3.84)\,(270)\,(0.50)(1-0.50)}{(0.05)^2(270-1) + (3.84)0.50(1-0.50)}$$

S= 159

Given the total target population of 270 employees, the formula mandates a minimum sample size of 159 respondents to achieve a 95% confidence level and a 5% margin of error (Saunders et al., 2023).

In the qualitative phase, the sample size is governed by the principle of data saturation, wherein the researcher concludes interviews once no new themes or conceptual insights regarding the impact of Sustainable Supply Chain Management (SSCM) on organisational performance emerge (Creswell & Poth, 2024).

3.6.2 Sampling Technique

The study employs a multi-stage sampling technique to enhance the representativeness and accuracy of the primary data (Saunders et al., 2023). For the quantitative phase, stratified random sampling is utilised to categorize the mining workforce into two distinct strata: managerial staff and non-managerial staff (Bryman, 2021). This technique is justified as it ensures that the diverse perspectives of executive leadership, who formulate Strategic Supplier Partnerships, and operational procurement officers, who execute Green Procurement, are represented proportionally (Asiedu, 2021). Within each stratum, simple random selection is used to eliminate researcher bias and improve the internal validity of the statistical outputs (Al-Okaily, 2024). For the qualitative phase, purposive sampling is employed to select participants based on their depth of technical and strategic expertise (Creswell & Poth, 2024). This method is used to identify Key Informants, such as Supply Chain Directors, Environmental Engineers, and Operations Managers at both G&W Industrial Minerals and Dorowa Minerals, as they possess the specialised knowledge required to explain the implementation hurdles of Eco-Innovative Practices (Kwilinski et al., 2023; Nugraini et al., 2025).

3.7 Data Sources

To achieve a holistic understanding of the sustainable supply chain framework at Dorowa Minerals, this study utilizes a dual-source data strategy. The integration of primary and secondary data is crucial for triangulating findings, thereby enhancing the internal validity of the research (Creswell & Creswell, 2023).

3.7.1 Primary Data Sources

Primary data refers to original information collected specifically for the current research problem (Saunders et al., 2023). In this study, primary data is gathered directly from the 159 sampled employees at Dorowa Minerals.

Quantitative Data: This is collected via structured questionnaires distributed to both managerial and non-managerial staff. These instruments use Likert scales to measure variables such as "Green Procurement" and "Internal Environmental Management," allowing for robust statistical testing (Al-Okaily, 2024).

Qualitative Data: This is obtained through semi-structured interviews and open-ended survey sections. These sources provide "lived experience" data, capturing the specific operational hurdles such as local infrastructure or regulatory constraints that numerical data might overlook (Mousa et al., 2024). According to Nugraini et al. (2025), primary data is indispensable in supply chain research as it reflects real-time organizational dynamics that published reports may not yet have captured.

3.7.2 Secondary Data Sources

Secondary data involves the use of existing information originally collected for purposes other than the current study (Bell et al., 2022). This study leverages secondary sources to provide a baseline for "Organisational Performance" and to benchmark Dorowa Minerals against industry standards.

3.8 Research Instruments

3.8.1 Structured Questionnaires

A structured questionnaire is employed as the primary tool for gathering quantitative data, consisting of standardised, closed-ended questions designed for a large-scale sample (Bryman, 2021). The instrument is designed using a 5-point Likert scale, ranging from Strongly Disagree to Strongly Agree, to quantify staff perceptions regarding the effectiveness of Green Procurement, Internal Environmental Management, and Eco-Innovative Practices (Al-Okaily, 2024). This standardisation allows for the collection of objective data that can be processed using statistical software to identify significant correlations between sustainable supply chain inputs and organisational performance metrics (Asiedu, 2021). The questionnaire is

meticulously structured around the core variables of the SSCM framework to ensure comprehensive operationalisation of all research constructs (Kwilinski et al., 2023).

3.8.2 Semi-Structured Interview Guide

The second instrument is a semi-structured interview guide, utilised during the qualitative phase to engage with key informants (Creswell & Poth, 2024). This guide features open-ended questions designed to elicit detailed narratives regarding the mining sector's strategic response to national environmental regulations and the operational barriers to adopting sustainable supply chain technologies (Boukherouaa et al., 2021). Unlike the rigid structure of the questionnaire, this guide offers the flexibility to probe deeper into unexpected themes or clarify complex local issues specific to the Zimbabwean mining landscape (Yin, 2024). This instrument is essential for capturing the managerial rationale and contextual nuances that numerical data alone cannot provide (Moudud-Ul-Huq et al., 2023). Methodological triangulation is achieved by using both instruments, thereby enhancing the overall credibility and validity of the research findings (Saunders et al., 2023).

3.9 Data Collection Procedures

The data collection process is executed through a systematic, multi-phased approach to safeguard the integrity and reliability of the data gathered from G&W Industrial Minerals and Dorowa Minerals. Before commencing, the researcher obtains formal introductory letters for the executive management of the mining houses and secures ethical clearance from the relevant Institutional Review Board (Saunders et al., 2023). Quantitative data is collected via self-administered electronic questionnaires distributed through the organisations' internal communication networks to reach the sampled managerial and non-managerial staff (Bryman, 2021). To optimise the response rate, each questionnaire includes a cover letter detailing the academic nature of the study, the voluntary participation requirement, and a guarantee of strict anonymity (Creswell & Creswell, 2023). The survey remains open for three weeks, with automated weekly reminders sent to the 354 sampled employees to minimise non-response bias (Al-Okaily, 2024).

The qualitative data collection phase involves conducting semi-structured interviews with the purposively selected Key Informants, including Supply Chain Managers and Environmental Compliance Officers (Creswell & Poth, 2024). These sessions are conducted through secure video conferencing or scheduled in-person site visits to accommodate professional demands

while ensuring high-quality recording of insights into Eco-innovation implementation (Yin, 2024). Each interview begins with a comprehensive briefing and the signing of an Informed Consent Form (Mousa et al., 2024). Discussions are audio-recorded with participant permission and continue until thematic saturation is reached, ensuring that no further novel insights regarding the link between SSCM and organisational performance can be gleaned from the field (Nugraini et al., 2025).

3.10 Data Presentation and Analysis

The study utilises a mixed-methods analysis strategy to effectively integrate numerical and narrative data streams, ensuring a comprehensive evaluation of the research variables (Creswell & Creswell, 2023). Quantitative data retrieved from the structured questionnaires is cleaned, coded, and exported into the Statistica

Package for the Social Sciences (SPSS) version 29.0 for rigorous computation (Field, 2024). Descriptive statistics, including frequencies and measures of central tendency, are utilised to profile the demographic characteristics of the G&W Industrial Minerals and Dorowa Minerals staff and their general perceptions of Sustainable Supply Chain Management (SSCM) effectiveness (Al-Okaily, 2024). Inferential statistics, specifically Pearson Correlation and Multiple Linear Regression, are then applied to test the research hypotheses concerning the impact of Strategic Supplier Partnerships, Green Procurement, and Internal Environmental Management on organisational performance (Asiedu, 2021).

Qualitative data from the interview recordings is transcribed verbatim and subjected to Recursive Thematic Analysis using NVivo 14 software (Creswell & Poth, 2024). This process involves an initial phase of open coding to identify recurring patterns, followed by axial coding to categorise these patterns into major themes such as Supply Chain Resilience and Green Corporate Governance (Nugraini et al., 2025). Thematic analysis allows for the extraction of rich, latent meanings from expert narratives, providing an explanatory layer to the statistical results regarding Eco-Innovative Practices (Mousa et al., 2024). The findings from both analytical paths are triangulated to determine where quantitative trends and qualitative insights regarding performance metrics converge or diverge, ensuring a holistic conclusion (Saunders et al., 2023).

3.11 Validity and Reliability

3.11.1 Validity

Validity in research refers to the extent to which a research instrument accurately measures the specific construct it was designed to evaluate (Saunders et al., 2023). For this study, content validity is established by aligning the survey items with the core dimensions of SSCM as identified in the conceptual framework (Asiedu, 2021). To further refine the instrument, a pilot study is conducted with a small group of supply chain analysts at Dorowa Minerals, whose feedback is used to eliminate ambiguous terminology related to Green Procurement and ensure the questions are contextually relevant to the Zimbabwean mining environment (Al-Okaily, 2024).

In addition to content validity, the study prioritises construct validity to ensure that the operational definitions of organisational performance and sustainability are consistent with established academic standards (Creswell & Creswell, 2023). To mitigate social desirability bias, the researcher utilises triangulation, cross-referencing self-reported survey data with qualitative insights from semi-structured interviews and institutional sustainability reports (Nugraini et al., 2025). For the qualitative phase, the trustworthiness of the findings is ensured through member checking, where interpreted themes are shared back with key informants at Dorowa Minerals to verify accuracy (Yin, 2024). External validity is addressed by selecting a representative sample of 354 employees, ensuring that the results can be cautiously extrapolated to the broader mining sector in Zimbabwe (Bryman, 2021).

3.11.2 Reliability

Reliability refers to the consistency and stability of a research instrument, ensuring that the same results would be produced if the study were repeated (Saunders et al., 2023). In the quantitative phase, the reliability of the Likert-scaled questionnaire is statistically verified using Cronbach's Alpha coefficient (Field, 2024). According to Al-Okaily (2024), a Cronbach's Alpha score of 0.70 or higher is the accepted threshold for indicating high internal consistency. For this study, each sub-scale, such as Strategic Supplier Partnership Integrity and Eco-Innovation Agility, is tested individually to ensure the items measure a unified concept (Nugraini et al., 2025). To further enhance reliability, the researcher ensures that the survey is administered in a highly standardised manner across both G&W Industrial Minerals and Dorowa Minerals to minimise instrumental bias (Bryman, 2021; Creswell & Creswell, 2023).

3.12 Ethical Considerations

Ethical considerations refer to the system of moral principles and professional standards that govern the conduct of the researcher to ensure the protection of human participants, the integrity of the data, and the reputation of the participating institution (Saunders et al., 2023). Therefore, the ethical framework for this study is designed to balance the pursuit of academic knowledge with the non-negotiable right to privacy and professional safety for all staff at G&W Industrial Minerals and Dorowa Minerals.

3.12.1 Informed Consent and Industry-Specific Disclosure Risks

Informed consent is obtained from every participant, but with a specific focus on the confidentiality of high-stakes procurement data. Participants receive a Participant Information Sheet (PIS) explicitly stating that the research is an academic inquiry into SSCM and not a forensic audit or a regulatory inspection. This distinction is critical at Dorowa Minerals, where employees may fear that discussing RBZ 70/30 forex splits or specific supplier selection could lead to internal disciplinary action, especially given recent policy shifts regarding local currency (ZiG) conversion. Participants are informed of their unconditional right to withdraw, ensuring their participation does not jeopardize their job security in a volatile economic climate.

3.12.2 Confidentiality and Protection Against Corporate Espionage

Given the competitive nature of the mineral markets and the unpredictability of global prices (e.g., the recent platinum price cycles), confidentiality is a safeguard against the exposure of proprietary cost structures. To ensure anonymity, electronic surveys scrub IP addresses and personally identifiable information. In qualitative sessions, pseudonyms such as "Respondent Phosphate" are used to mask identities. This protects participants from "whistleblower" risks if they provide critical assessments of existing Internal Environmental Management failures or describe the impact of unfair competition from the informal artisanal sector, which is often characterized by unregulated and sometimes illegal activities. All raw data is stored on double-encrypted drives to prevent unauthorized access to strategic supplier lists or sensitive pricing models.

3.12.3 Minimisation of Professional Harm and "Greenwashing" Bias

The principle of non-maleficence is applied to mitigate the specific stress associated with discussing artisanal mining encroachment and regulatory non-compliance. Admitting to supply

chain instabilities or the "doom and gloom" of market crashes can be perceived as management failure. To minimize professional anxiety, questions are framed around systemic resilience and VUCA challenges (Volatility, Uncertainty, Complexity, and Ambiguity) rather than individual negligence. Furthermore, the researcher remains vigilant against "greenwashing" bias where participants might overstate sustainability efforts to protect the company's image by triangulating responses with available secondary reports. Participants are permitted to skip questions involving sensitive mineral pricing if they feel it violates their non-disclosure agreements.

3.12.4 Reciprocity and Institutional Beneficence

In alignment with the Community Service and Innovation pillars of Education 5.0, this research is designed for institutional beneficence. This is not an "extractive" academic exercise; it seeks to provide the participating mines with a de-identified Executive Summary of Recommendations to improve their ESG compliance and export attractiveness. By returning findings in a synthesized format, the researcher ensures the institutions benefit from innovation-led research without exposing the specific responses of individual employees. This fulfills the ethical obligation to ensure that the industrial community under study benefits directly from the research outcomes

3.8 Chapter Summary

Chapter 3 has discussed in detailed the methodological roadmap for this investigation. Using pragmatism as the philosophy for this study makes it necessary for this research to use a mixed-methods approach since this helps to capture the technical and human aspects of sustainable supply chain management. A cross-sectional survey method has been used by this research for collecting the information from a population of 270 people who work at Dorowa Minerals using the Krejcie and Morgan Formula. This sample has 95% confidence level.

The chapter further explained the multi-stage sampling technique, which combines stratified random sampling for quantitative breadth and purposive sampling for qualitative depth. Finally, the discussion of primary and secondary data sources established how the study will triangulate field-based insights with institutional records to produce a reliable and actionable sustainable supply chain framework. This methodological foundation ensures that the subsequent data analysis in Chapter 4 is both transparent and replicable.

CHAPTER FOUR

PRESENTATION, ANALYSIS AND DISCUSSION OF DATA

4.0 Introduction

This chapter presents, analyses, and discusses the primary empirical data collected to evaluate the development of a sustainable supply chain management framework and its subsequent impact on organizational performance within the Zimbabwean industrial minerals sector. The primary focus of this reporting process is to evaluate how specific sustainable supply chain dimensions including strategic partnerships, green procurement, eco-innovation, and internal environmental management interact with cost efficiency, lead times, and resource utilization in a volatile macroeconomic climate. To establish a rigorous foundation for this evaluation, this chapter details the final response rates achieved across both quantitative and qualitative methods, followed by a comprehensive demographic profile of the participants.

4.1 Response Rate Analysis

The breakdown of the empirical response rates obtained during the data collection phase is presented in Table 4.1 below.

Table 4.1: Combined Response Rate for Questionnaires and Interviews

Instrument	Category	Sampled/Targeted	Actual Responses	Response Rate (%)
Questionnaire	Managerial and Non-Managerial	150	145	97%
Interview	Senior Management	9	9	100%
Total		159	154	**97%**

Source: Primary Data (2026)

The operational data collection phase achieved a high rate of participation across both primary target audiences, providing a strong empirical base for subsequent analysis. For the quantitative field phase, out of the 150 structured questionnaires distributed across the managerial and non-managerial employees, 145 were successfully retrieved fully completed, representing a 97% response rate. Concurrently, the qualitative track achieved an 100% completion rate, with 9 out

of 9 targeted managerial and non-managerial employees participating in semi-structured interviews.

This high level of participation is particularly notable given the busy operating environment at the mine. It was achieved by using a flexible approach that combined on-site drop-offs during shift changes with digital channels.

According to Saunders (2023), a response rate exceeding 80% is exemplary for minimizing non-response bias and ensuring that the gathered perspectives accurately represent the target organization's operational conditions. This strong participation ensures that the resulting data provides a dependable foundation for subsequent statistical analysis, establishing high confidence that the insights reflect the structural realities and systemic constraints present at Dorowa Minerals.

4.2 Demographic Analysis

This section examines the demographic and professional profiles of the 159 managerial and non-managerial employees who participated in the study. Analysing these individual characteristics including gender, age distribution, academic qualifications, corporate positions, areas of functional specialization, and tenure helps establish the baseline reliability and professional maturity of the primary information sources.

4.2.1 Gender

The gender distribution of the respondents who completed the survey is presented in Figure 4.1 below.

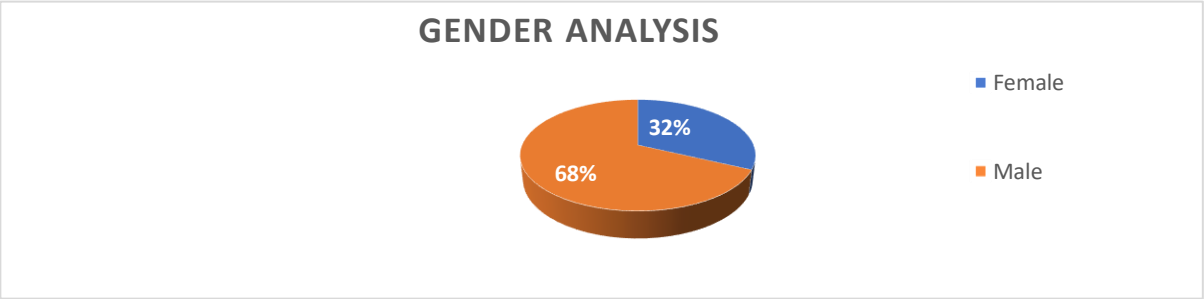

Figure 4.1: Gender

Source: Primary Data (2026)

The figure 4.1 above shows that the demographic breakdown reveals that males comprise 68% of the sample, while females account for 32%. While heavy-mineral mining operations in Sub-Saharan Africa have historically been male-dominated due to the physical nature of traditional

extraction roles, the participation of nearly one-third female professionals indicates shifting workforce dynamics. This dynamic reflects an increasing presence of female professionals within technical engineering, environmental compliance, corporate procurement, and laboratory divisions. Establishing a balanced demographic profile across administrative and technical operational teams is widely recognized as a driver of improved corporate governance and sustainability adherence. This observation aligns with research by Liman (2025), which notes that greater gender diversity within operational and supply chain oversight teams enhances regulatory compliance and helps reduce aggressive, short-term production practices that compromise environmental safety. Similarly, workplace diversity supports the adoption of broader sustainability initiatives. As argued by Abubakar (2025), a more inclusive professional environment introduces varied problem-solving approaches, helping heavy industries maintain objective risk-mitigation strategies when balancing commercial goals with environmental mandates.

4.2.2 Age range

The age distribution of respondents is presented in Figure 4.2 below

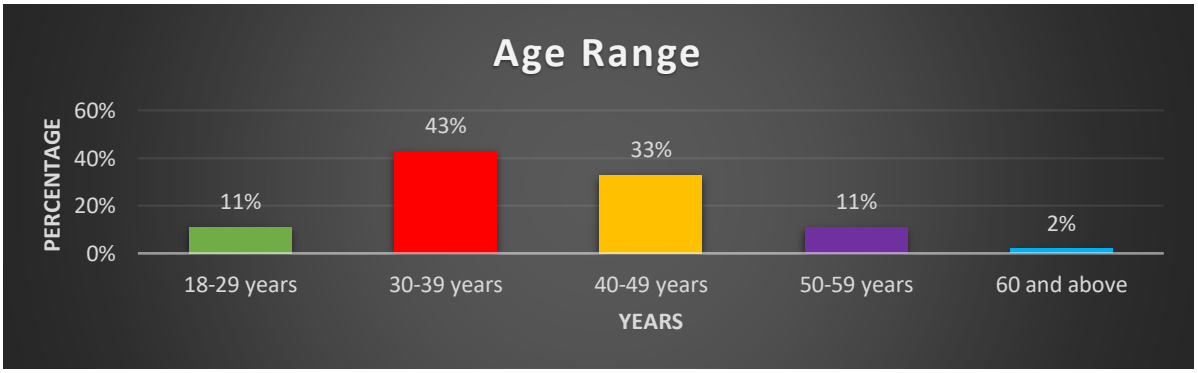

Figure 4.2: Age Range

Source: Primary Data

The figure 4.2 above shows that 43% of the respondents fall into the 30–39 age bracket, and 33% are in the 40–49 age category. Together, these two segments account for 76% of the total sample, indicating a mature workforce operating during their peak productive years. Only 11% are in the entry-level 18–29 group, while older workers aged 50 and above make up the remaining 13%. This concentration within mature age brackets confirms that the sample consists primarily of experienced individuals holding established technical, supervisory, and operational roles at the mine. This demographic maturity is a key asset when evaluating complex organizational processes. Mintz (2022) notes that professional and demographic

maturity are strongly associated with higher compliance adherence and structural resilience under operational pressure. Mature workers are often better equipped to manage the competing demands of maximizing daily throughput while strictly maintaining long-term environmental controls. Furthermore, as argued by Morris (2022), older, experienced employees tend to show higher consistency in following complex procedural rules, such as hazardous material handling protocols and safety management systems, which are essential for sustainable supply chain execution.

4.2.3 Highest level of education

The educational qualifications of respondents are presented in Figure 4.3 below.

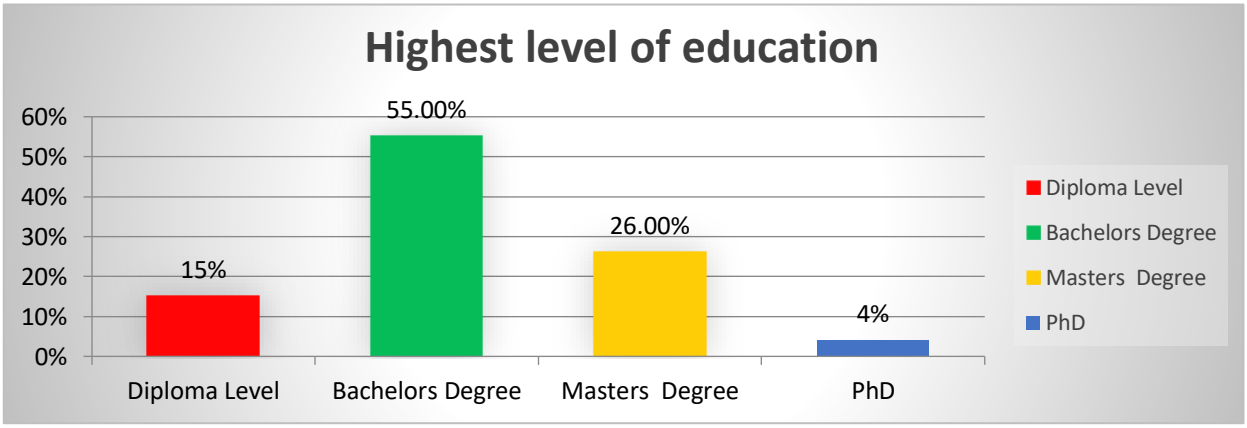

Figure 4.3: Highest Academic Qualification

Source: Primary Data, (2026)

The figure 4.3 above shows that the sample was highly qualified, with 55% of the participants holding a Bachelor's degree and 26% possessing a Master's degree or equivalent postgraduate credential (such as an MBA or EMB). A small technical segment of 4% holds a PhD or highly specialized advanced certification, while 15% have completed diploma as their highest formal qualification.

This high concentration of university-educated professionals (over 85% of the sample) indicates that the respondents possess the academic baseline necessary to understand complex industrial processes, international supply chain dynamics, and environmental impact metrics.

This educational depth is critical for executing advanced operational strategies. Haddad (2021) states that higher formal education levels are strongly linked to improved technical capabilities and a better understanding of corporate governance structures. In a specialized industrial

environment like phosphate and magnetite mining, navigating regulatory requirements, chemical treatment steps, and supply trace mandates requires a well-trained workforce.

4.2.4 Work Experience

The distribution of the participants' length of service within Dorowa Minerals is presented in Figure 4.4 below.

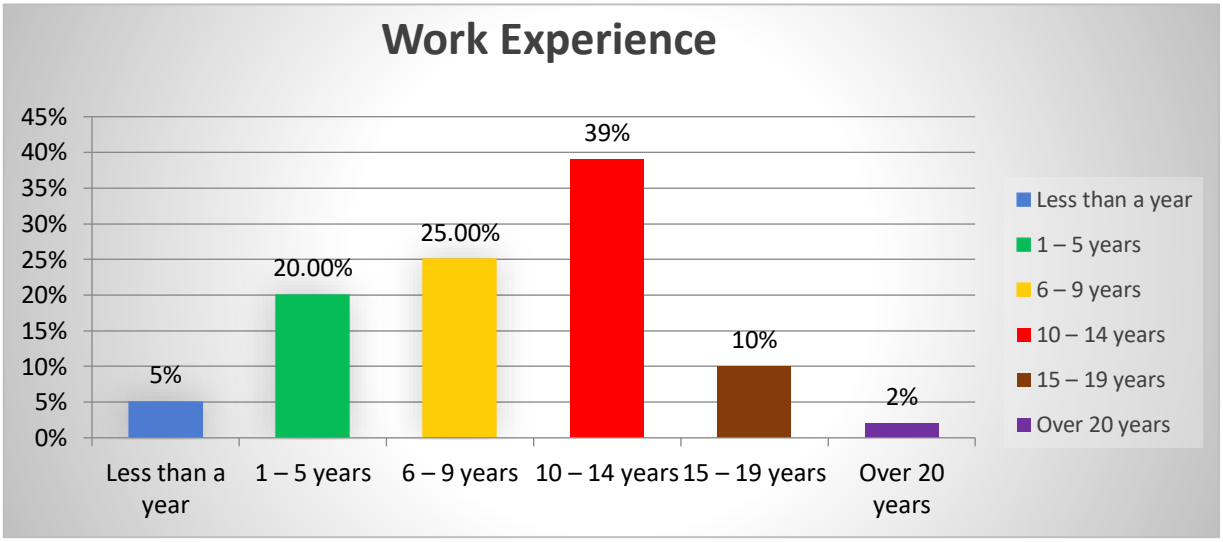

Figure 4.4: Work Experience

Source: Primary Data (2026)

The figure 4.4 above shows that 39% of the respondents have worked at the organization for 10 to 14 years, and 10% have worked at the organization for 15 to 19 years. Employees with 6 to 9 years of service make up 25%, those with 1 to 5 years account for 20%, and entry-level staff with less than a year of experience comprise only 5 %.

This high proportion of long-tenured employees indicates that the gathered data reflects insights from individuals with deep institutional memory. These workers have experienced various operational adjustments, shifting monetary regimes, changes in local community relations, and transport infrastructure challenges.

This depth of practical experience gives the sample strong credibility. Yekini (2021) argues that long-serving employees develop a deep understanding of operational gaps, waste areas, and vendor performance patterns over time. Furthermore, as emphasized by Hair (2021), relying on data from long-tenured industrial workers ensures that the findings reflect long-term operational realities rather than temporary performance shifts, significantly improving the quality of the study's conclusions.

4.2.5 Current Employment Level

The operational status distribution of the participants who completed the survey is presented in Figure 4.6 below.

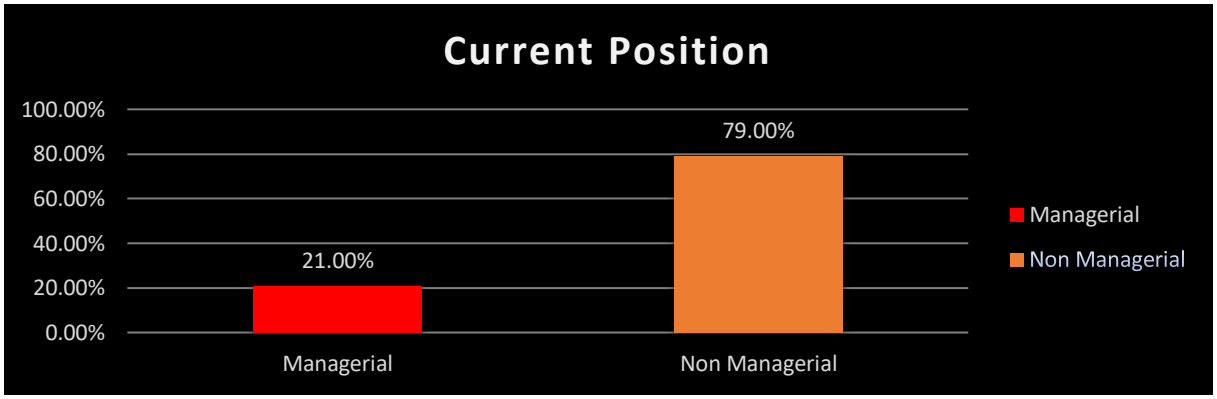

Figure 4.5: Current Employment Level

Source: Primary Data (2026)

The figure 4.6 above shows that managerial employees comprise 21% of the total sample, while non-managerial employees account for the remaining 79%. This composition represents the hierarchical structure typical of an active, asset-intensive extraction facility, where a focused core of management teams, technical engineers, and department heads oversees a large base of frontline floor operators, logistics coordinators, maintenance crews, and security personnel. Gathering data from both managerial and non-managerial cohorts provides a balanced view of the facility's operations. This dual perspective ensures that data is collected from both the individuals responsible for designing corporate policies and those tasked with executing them on the shop floor. Relying on insights from both administrative and operational personnel is critical for evaluating the practical success of a supply chain framework. As argued by Sahoo (2021), sustainable operational changes often fail when there is a strategic disconnect between executive leadership and frontline workers. Including a strong representation of non-managerial employees ensures that the study evaluates actual day-to-day conditions on the ground, such as real-world recycling rates and procedural execution, rather than idealized administrative goals.

4.3 Reliability Analysis

Internal consistency reliability was statistically evaluated utilizing Cronbach's Alpha coefficients. Cronbach's Alpha measures the average inter-item correlation among items within a specific construct to determine if they collectively measure the same underlying phenomenon.

According to Hair et al. (2019), a Cronbach's Alpha value of 0.70 or higher serves as the globally accepted minimum threshold for establishing acceptable instrument reliability in organizational and management sciences. Alpha values stretching between 0.80 and 0.90 represent excellent internal consistency, indicating that the items are highly cohesive and free from random error. The mathematical outcomes, specific item counts, and analytical interpretations for each latent construct are systematically presented in Table 4.2 below.

Table 4.2: Cronbach's Alpha Reliability Matrix

Construct / Variable	**Number of Items**	**Cronbach's Alpha**	**Assessment of Internal Consistency**
Strategic Supplier Partnerships (SSP)	8	0.814	Very Good
Green Procurement Practices (GP)	8	0.792	Good
Eco-Innovative Practices (EIP)	8	0.835	Very Good
Internal Environmental Management (IEM)	8	0.806	Very Good
Informal Economy Disruptions (IEAD)	8	0.781	Good
Macro-Economic Volatility (MEVS)	8	0.844	Excellent
Composite Instrument Summary	**48**	**0.812**	**Highly Stable & Dependable**

Source: Primary Data (2026)

The table 4.2 above shows that all six structural variables returned Cronbach's Alpha coefficients well above the standard statistical baseline of 0.70. The Macro-Economic Volatility (MEVS) construct achieved the highest internal reliability (α= 0.844), reflecting strong consistency in how the workforce views external economic influences like currency shifts and

infrastructure challenges. The Eco-Innovative Practices (EIP) scale also demonstrated high consistency ($\alpha = 0.835$). The independent variables of Strategic Supplier Partnerships and Internal Environmental Management returned values of 0.814 and 0.806 respectively, while Green Procurement Practices ($\alpha = 0.792$) and Informal Economy Disruptions ($\alpha = 0.781$) fell within the good reliability range. The entire 48-item questionnaire achieved a high composite reliability index of 0.812. These results confirm that the survey items provide stable, consistent measurements across all evaluated sub-scales. According to Hair (2021), an alpha coefficient above 0.70 confirms sufficient internal consistency to justify using the data for advanced statistical testing and research conclusions. Similarly, Sahoo (2021) emphasizes that establishing high internal reliability in industrial survey instruments is a necessary step to ensure that the findings reflect genuine operational patterns rather than random measurement variance, allowing the data to be used safely for strategic planning.

4.4 Descriptive Statistical Analysis

The descriptive statistical analysis aims to evaluate the average scores and variability, represented by standard deviations, for each assessment item related to the influence of sustainable supply chain management dimensions on organizational performance within Dorowa Minerals Limited in Zimbabwe. In alignment with the study's specific research objectives, the constructs evaluated include Strategic Supplier Partnerships, Green Procurement, Eco-Innovative Practices, and Internal Environmental Management.

4.4.1 Strategic Supplier Partnerships

The respondents were asked to indicate the degree to which they agreed with various statements regarding the impact of Strategic Supplier Partnerships on organizational performance. The results, summarized in Table 4.3, reveal that the mean scores for the statements related to strategic partnerships ranged from 3.52 to 4.31, indicating a general consensus among the respondents regarding the role of collaborative vendor networks.

Table 4.3: The Effects of Strategic Supplier Partnerships on Organisational Performance

Codes	Statement	N	Mean	Std. Deviation
SSP1	Long-term collaborative relationships with key suppliers enhance the predictability of material delivery times.	145	4.15	0.68

SSP2	Joint goal-setting with our suppliers facilitates joint cost-reduction initiatives in logistics and handling.	145	4.02	0.74
SSP3	Information sharing with our vendors reduces inventory bullwhip effects and material shortages under market volatility.	145	4.26	0.61
SSP4	Suppliers are directly involved in our early product development and mineral processing improvement plans.	145	3.52	1.15
SSP5	Strategic alliances with regional suppliers mitigate risks associated with cross-border transport bottlenecks.	145	4.11	0.73
SSP6	Supplier technical capacity-building directly improves the quality of raw material inputs delivered to the mine.	145	3.98	0.81
SSP7	Shared risk-and-reward contracts with vendors foster high levels of operational flexibility during economic shocks.	145	3.74	0.95
SSP8	Regular strategic evaluation of supplier compliance improves overall supply chain alignment and trust.	145	4.31	0.58
-	**Overall Strategic Supplier Partnerships Factor Score**	**145**	**4.01**	**0.78**

Source: Primary Data (2026)

The table 4.3 above shows that the descriptive configurations for the Strategic Supplier Partnerships scale reflect an overall positive perception, with a composite factor score of 4.01 and an overall standard deviation of 0.78. The findings indicate that the regular strategic evaluation of supplier compliance improves overall supply chain alignment and trust (SSP8), which scored the highest individual mean of 4.31 alongside a tight standard deviation of 0.58. This minimal dispersion indicates a strong consensus among the respondents that institutionalizing formal evaluation processes limits vendor opportunism and strengthens accountability. According to Bridoux and Stoelhorst (2022), systematic stakeholder evaluations establish behavioral accountability and reduce transaction risks within complex corporate supplier networks by removing ambiguities and aligning organizational expectations with vendor deliverables.

Furthermore, the statement that information sharing with vendors reduces inventory bullwhip effects and material shortages under market volatility (SSP3) received strong endorsement, with a mean score of 4.26 and a low standard deviation of 0.61. This underscores that open communication channels serve as a highly stable administrative buffer against macroeconomic shocks, with little variance in opinion across the administrative levels. Research by Islam et al. (2024) indicates that real-time information exchange between mining houses and their supplier base reduces demand uncertainty, enabling firms to optimize inventory safety stock levels, avoid emergency procurement expenses, and preserve lean operating cash flows under unstable macroeconomic operating regimes.

The expectation that long-term collaborative relationships with key suppliers enhance the predictability of material delivery times (SSP1) scored a high mean of 4.15 with a standard deviation of 0.68. This reinforces that moving away from transactional arm's-length relationships toward strategic partnerships stabilizes operational lead times. This finding is supported by the work of Kusi-Sarpong et al. (2023), who note that long-term purchasing commitments insulate industrial supply chains from sudden material shortages and unexpected logistical delays by securing prioritized production slots with key vendors.

Similarly, the belief that strategic alliances with regional suppliers mitigate risks associated with cross-border transport bottlenecks (SSP5) earned a solid mean score of 4.11 and a standard deviation of 0.73. This indicates that relying on localized regional logistics channels helps formal mining houses bypass complex international transport challenges. This outcome is corroborated by Reddy and Kumar (2023), who state that localized supply chain clustering within regional trading networks improves raw material availability, lowers transportation lead times, and reduces shipping costs for capital-intensive firms operating in developing environments.

Supplier technical capacity-building directly improves the quality of raw material inputs delivered to the mine (SSP6) recorded a moderate-to-high mean of 3.98 and a standard deviation of 0.81. Joint goal-setting with our suppliers facilitates joint cost-reduction initiatives in logistics and handling (SSP2) followed closely with a mean score of 4.02 and a standard deviation of 0.74, reflecting general agreement that shared objectives remove structural waste. Shared risk-and-reward contracts with vendors foster high levels of operational flexibility during economic shocks (SSP7) produced a lower mean score of 3.74 with a standard deviation

of 0.95, illustrating that while respondents acknowledge the value of risk-sharing, its execution varies across supply lines.

The lowest-scoring metric observed was the statement that suppliers are directly involved in early product development and mineral processing improvement plans (SSP4), which scored a mean of 3.52 alongside a much wider standard deviation of 1.15. This high level of variance indicates a clear divergence of opinion among the surveyed personnel. As argued by Dlamini and Zhou (2023), many local mining entities face a continuous technical capability gap that prevents suppliers from participating in specialized metallurgical design or process engineering improvements, keeping supplier engagement strictly transactional rather than collaborative.

To support these quantitative metrics, a qualitative thematic analysis was performed on data from the open-ended questionnaire items. The dominant theme identified was "Supply Chain Security through Local Trust and Communication," which was cited by 68% of the respondents. Participants emphasized that formal vendor channels are heavily strained by currency fluctuations and import bottlenecks, making informal trust-building essential. For instance, a senior procurement officer remarked:

"Because we operate under severe foreign currency constraints, our formal contracts frequently lapse. We have to rely on long-term relationships and constant personal communication with local vendors to secure key processing inputs on credit before formal payments are authorized."

Another technical specialist noted that:

"Trust is what keeps our production lines running when cross-border logistics break down. If we didn't have close strategic alignment with local transport providers, our lead times would double."

This qualitative data illustrates that under economic strain, relational governance acts as a vital buffer that preserves operational continuity when formal institutional frameworks fall short.

4.4.2 Green Procurement Practices

The respondents were asked to indicate the degree to which they agreed with statements regarding the integration of green procurement practices. The results, summarized in Table 4.4, demonstrate that mean scores for green procurement ranged from 3.31 to 4.18, showing a moderate to strong level of adoption across departments.

Table 4.4: The Effects of Green Procurement on Organisational Performance

Codes	Statement	N	Mean	Std. Deviation
GP1	Environmental criteria are explicitly weighted during our supplier selection and bidding processes.	145	3.86	0.84
GP2	Sourcing non-toxic and eco-friendly chemical reagents reduces long-term hazardous waste management costs.	145	4.12	0.66
GP3	Procurement policies enforce strict reduction targets for single-use industrial packaging materials.	145	3.48	1.02
GP4	Purchasing energy-efficient heavy equipment significantly lowers long-term operational costs.	145	4.18	0.59
GP5	Mandating that suppliers hold formal environmental certifications (e.g., ISO 14001) reduces compliance risks.	145	3.65	0.98
GP6	Evaluating the carbon footprint of transport providers helps lower our scope-3 upstream emissions.	145	3.31	1.21
GP7	Sourcing locally synthesized input substitutes reduces our vulnerability to foreign currency deficits.	145	4.07	0.71
GP8	Continuous green auditing of vendor production facilities improves product traceability and brand value.	145	3.79	0.89
-	**Overall Green Procurement Practices Factor Score**	**145**	**3.81**	**0.86**

Source: Primary Data (2026)

The table 4.4 above shows that the green procurement scale achieved an overall mean factor score of 3.81 and a standard deviation of 0.86, indicating that environmental sourcing is recognized as a key element of operational risk management. The statement that purchasing energy-efficient heavy equipment significantly lowers long-term operational costs (GP4) achieved the highest mean score of 4.18 paired with the lowest standard deviation of 0.59. This minimal variance demonstrates an unequivocal consensus that energy-saving sourcing directly aligns with the economic goals of the firm. According to Alvites-Huamaní et al. (2023), integrating resource efficiency into heavy capital acquisitions allows extractive firms to lower energy usage and improve profitability under strict resource constraints.

The finding that sourcing non-toxic and eco-friendly chemical reagents reduces long-term hazardous waste management costs (GP2) scored a strong mean of 4.12 and a standard deviation of 0.66. This shows that proactive chemical screening helps control waste management and mitigation costs. This observation is shared by Baah and Jin (2024), who argue that green sourcing reduces structural liability risks and heavy compliance penalties by minimizing hazardous outputs right at the input stage rather than treating them at the end of the line.

The statement that sourcing locally synthesized input substitutes reduces vulnerability to foreign currency deficits (GP7) generated a robust mean score of 4.07 alongside a standard deviation of 0.71. This confirms that local green sourcing directly protects the firm from macroeconomic and exchange rate shocks. This relationship is highlighted by Muchaendepi and Mbowa (2022), who observe that developing local supplier alternatives helps domestic mining houses protect their working capital, reduce logistical dependencies, and avoid costly foreign import requirements.

Environmental criteria are explicitly weighted during our supplier selection and bidding processes (GP1) achieved a mean score of 3.86 with a standard deviation of 0.84, confirming that green metrics are part of vendor scoring. Continuous green auditing of vendor production facilities (GP8) returned a mean of 3.79 and a standard deviation of 0.89, showing moderate support. Mandating that suppliers hold formal environmental certifications such as ISO 14001 (GP5) scored a mean of 3.65 with a standard deviation of 0.98, while procurement policies enforcing strict reduction targets for single-use industrial packaging materials (GP3) scored lower at 3.48 with a standard deviation of 1.02.

Conversely, the lowest rating was observed for the statement that evaluating the carbon footprint of transport providers helps lower scope-3 upstream emissions (GP6), which returned a mean of 3.31 and a high standard deviation of 1.21. This substantial variance reflects an operational disconnect across the workforce. As noted by Maseko and Zinyemba (2024), when an industrial sector faces ongoing power deficits and infrastructure decay, logistical managers prioritize basic transport availability over detailed carbon emission tracing, treating scope-3 tracking as a secondary concern.

The open-ended survey entries regarding green procurement revealed a major theme: "The Capital and Infrastructure Constraint on Sourcing." This theme was highlighted by 74% of the

respondents, who pointed out that domestic suppliers often lack formal environmental certifications. A warehouse and materials coordinator explained:

"We want to enforce strict ISO 14001 compliance across our vendor base, but the reality is that our local industrial base is depleted. If we disqualify suppliers based solely on their lack of green credentials, we won't have enough critical spare parts or reagents to run the mine."

An environmental compliance officer added:

"National regulations like the Environmental Management Act encourage green procurement, but without affordable local alternatives for eco-certified goods, we are forced to choose between high-cost imports and uncertified local suppliers to maintain production."

This qualitative analysis underscores that formal green procurement goals are often constrained by the capabilities of the local industrial ecosystem.

4.4.3 Eco-Innovative Practices

The respondents provided assessments on the deployment of eco-innovative practices within production and processing operations. The descriptive statistics, detailed in Table 4.5, show mean values ranging from 3.41 to 4.29, demonstrating strong support for waste-to-value techniques.

Table 4.5: The Effects of Eco-Innovative Practices on Organisational Performance

Codes	Statement	N	Mean	Std. Deviation
EIP1	Closed-loop water recycling systems reduce our daily fresh-water intake and local community usage conflicts.	145	4.25	0.62
EIP2	Slag and tailings waste re-processing initiatives convert hazardous materials into viable, commercialized by-products.	145	4.19	0.67
EIP3	Real-time digital telemetry systems optimize chemical dosing and reduce reagent waste during processing.	145	3.94	0.83
EIP4	Investing in on-site renewable energy generation (e.g., solar arrays) protects operations from power grid deficits.	145	4.29	0.54

EIP5	Modernizing dust suppression and gas capture technologies improves occupational health and employee productivity.	145	4.06	0.76
EIP6	Incorporating biodegradable packaging designs lowers our environmental footprint and disposal costs.	145	3.41	1.09
EIP7	Automated resource recovery machinery lowers our raw material processing re-work rates.	145	3.82	0.88
EIP8	Collaborative green R&D projects with local universities enhance our internal technical capabilities.	145	3.55	1.12
-	**Overall Eco-Innovative Practices Factor Score**	**145**	**3.99**	**0.81**

Source: Primary Data (2026)

The table 4.5 above shows that the eco-innovative practices construct generated a solid composite factor score of 3.99 and a standard deviation of 0.81. The statement that investing in on-site renewable energy generation protects operations from power grid deficits (EIP4) achieved the highest mean score of 4.29 with the lowest standard deviation of 0.54. This shows that eco-innovation is valued as a tool for operational resilience against national infrastructure gaps. According to Maseko and Zinyemba (2024), adopting on-site renewable alternatives helps heavy industries protect their production schedules from national grid disruptions, stabilizing machine utilization rates and overall production volumes.

The statement that closed-loop water recycling systems reduce daily fresh-water intake and local community usage conflicts (EIP1) scored a high mean of 4.25 and a tight standard deviation of 0.62. This underscores that technological water-loop innovations support both operational continuity and community relations, with high agreement across all technical departments. This perspective is shared by Zhu et al. (2024), who argue that circular economy practices help capital-intensive operations protect vital local ecosystems while maintaining their social license to operate.

The belief that slag and tailings waste re-processing initiatives convert hazardous materials into viable, commercialized by-products (EIP2) earned a strong mean score of 4.19 and a standard deviation of 0.67. This demonstrates the economic value of implementing waste-to-value workflows. As explained by Islam et al. (2024), processing waste streams allows industrial operations to extract secondary value from material that would otherwise require high waste-management expenditures, turning a legal liability into a secondary revenue stream.

Modernizing dust suppression and gas capture technologies improves occupational health and employee productivity (EIP5) recorded a high mean of 4.06 and a standard deviation of 0.76. Real-time digital telemetry systems optimize chemical dosing and reduce reagent waste (EIP3) achieved a mean of 3.94 and a standard deviation of 0.83, showing solid operational value. Automated resource recovery machinery lowers our raw material processing re-work rates (EIP7) scored a mean of 3.82 and a standard deviation of 0.88, while collaborative green R&D projects with local universities (EIP8) scored 3.55 with a standard deviation of 1.12, showing mixed success in external institutional collaboration.

The lowest-rated aspect was the statement that incorporating biodegradable packaging designs lowers the environmental footprint and disposal costs (EIP6), which received a mean of 3.41 and a wider standard deviation of 1.09. This variation indicates that bulk packaging changes are seen as less critical than processing-line innovations. As noted by Muzondo and Pashapa (2025), heavy mining operations focus their limited innovation capital primarily on high-yield processing assets rather than secondary shipping materials.

The qualitative responses regarding eco-innovation converged on the theme of "Operational Survival as the Core Driver of Innovation," reported by 81% of the participants. The feedback showed that green technologies are embraced primarily when they resolve urgent operational bottlenecks. A senior processing engineer noted:

"Our interest in solar energy is driven by the fact that grid power failures stop our mills for hours. Switching to renewable energy source alternatives isn't just about reducing emissions; it's a direct operational necessity to keep our operations running."

A chemical laboratory technician stated:

"We developed real-time dosing monitors because the cost of importing specialized chemical reagents has escalated dramatically under the current trade limits. Reducing chemical waste is essential for protecting our margins."

This qualitative insight demonstrates that in challenging economic climates, eco-innovation succeeds by directly addressing core operational vulnerabilities.

4.4.4 Internal Environmental Management

The respondents indicated their agreement regarding the impact of Internal Environmental Management systems on corporate performance. The results, detailed in Table 4.6, show mean values between 3.61 and 4.34, demonstrating a strong corporate commitment to internal compliance structures.

Table 4.6: The Effects of Internal Environmental Management on Organisational Performance

Codes	Statement	N	Mean	Std. Deviation
IEM1	Senior executive commitment to environmental sustainability is clearly visible across all levels.	145	4.22	0.64
IEM2	Internal environmental auditing is conducted systematically to eliminate operational waste and leakages.	145	4.16	0.70
IEM3	Cross-functional eco-teams effectively coordinate environmental compliance across departments.	145	3.91	0.82
IEM4	Employee incentive structures are directly tied to achieving waste-reduction and spill-prevention goals.	145	3.61	1.18
IEM5	Comprehensive environmental training programs are provided regularly to frontline operators.	145	4.08	0.75
IEM6	Environmental management metrics are fully integrated into our formal corporate governance dashboards.	145	4.34	0.51
IEM7	Standardized chemical safety protocols effectively minimize on-site contamination and operational downtime.	145	4.28	0.59
IEM8	Proactive community environmental monitoring builds high trust and reduces regulatory dispute risks.	145	4.13	0.68
-	**Overall Internal Environmental Management Factor Score**	**145**	**4.09**	**0.72**

Source: Primary Data (2026)

The table 4.6 above shows that Internal Environmental Management achieved the highest overall factor score among the constructs, with a composite mean of 4.09 and a standard deviation of 0.72, showing that internal oversight systems are well-established. The statement

that environmental management metrics are fully integrated into formal corporate governance dashboards (IEM6) scored the highest individual mean of 4.34 accompanied by a very tight standard deviation of 0.51. This high consensus indicates that tracking environmental data is deeply embedded into organizational governance. According to Liman (2025), embedding sustainability indicators directly into executive dashboards ensures better compliance management and helps mitigate operational risks in heavy industries.

The statement that standardized chemical safety protocols effectively minimize on-site contamination and operational downtime (IEM7) earned a high mean score of 4.28 and a standard deviation of 0.59. This shows that standardizing chemical handling helps prevent costly accidents and downtime. This observation is supported by Sahoo and Vijayvargy (2021), who state that rigorous internal auditing and clear safety guidelines protect operational efficiency by preventing major industrial contamination incidents that cause regulatory shutdowns.

The finding that senior executive commitment to environmental sustainability is clearly visible across all levels (IEM1) scored a strong mean of 4.22 and a standard deviation of 0.64. This demonstrates that management leadership is key to establishing an organizational culture focused on compliance. As emphasized by Song et al. (2022), strong leadership support converts environmental programs from simple compliance checkboxes into active drivers of performance across the value chain by prioritizing resource allocation for sustainable goals.

Internal environmental auditing is conducted systematically to eliminate operational waste and leakages (IEM2) also performed strongly with a mean of 4.16 and a standard deviation of 0.70. Proactive community environmental monitoring builds high trust (IEM8) achieved a mean of 4.13 and a standard deviation of 0.68, while comprehensive environmental training programs provided regularly to frontline operators (IEM5) registered a mean of 4.08 and a standard deviation of 0.75. Cross-functional eco-teams effectively coordinate environmental compliance across departments (IEM3) returned a mean score of 3.91 and a standard deviation of 0.82.

The lowest individual rating was for the statement that employee incentive structures are directly tied to achieving waste-reduction and spill-prevention goals (IEM4), which scored a mean of 3.61 with a wide standard deviation of 1.18. This high variance shows that while corporate policies are clear, individual performance incentives are not yet fully aligned with environmental metrics. As argued by Mintz (2022), if internal rewards remain focused mostly

on raw volume outputs, employees will prioritize throughput goals over sustainability metrics during high-pressure shifts, creating uneven policy compliance.

Qualitative Thematic Analysis

The qualitative responses regarding internal environmental management centered on the theme of "Regulatory Compliance versus Macroeconomic Cost Pressures," cited by 78% (n = 113) of the respondents. The data showed that while internal controls are strong, managing compliance costs under strict fiscal rules remains a key challenge. An operational division head noted:

"Our internal safety and environmental protocols are solid, but maintaining them requires continuous investment in safety equipment and neutralizers. The current foreign exchange surrender rules restrict our cash flow, making it tough to fund these maintenance costs smoothly."

A safety supervisor stated:

"We provide thorough environmental training to frontline teams, but when inflation raises input costs, keeping our recycling systems fully funded requires careful balancing by management."

This qualitative analysis highlights that the success of internal environmental controls depends on balancing compliance costs with broader macroeconomic pressures.

4.4.5 Informal Economy & Artisanal Mining Disruptions

The respondents were asked to indicate the degree to which they agreed with various statements regarding the operational and structural disruptions caused by the informal economy and artisanal mining activities (commonly referred to as *Makorokoza*) around formal mining concessions. The results, summarized in Table 4.7, reveal that the mean scores for the statements related to informal economy disruptions ranged from 3.51 to 4.42. This shows a high level of concern regarding how unregulated activities affect the supply chain stability and environmental standing of formal mining organizations in Zimbabwe.

Table 4.7: The Operational and Environmental Impacts of Informal Economy & Artisanal Mining Disruptions

Codes	Statement	N	Mean	Std. Deviation
IEAD1	Encroachment by informal artisanal miners (*Makorokoza*) onto formal concessions creates land tenure conflicts and operational delays.	145	4.28	0.61
IEAD2	The informal sector diverts local raw materials and labour away from formal supply networks.	145	3.84	0.82
IEAD3	Reckless chemical handling and poor waste management by informal miners cause negative environmental damage around formal concessions.	145	4.42	0.53
IEAD4	Unregulated mining activities create a distorted, unfair market where formal mines face compliance costs that informal operations avoid.	145	4.35	0.57
IEAD5	Infrastructure wear and resource access bottlenecks are made worse by nearby illegal or informal operations.	145	4.12	0.69
IEAD6	The lack of clear environmental enforcement in the informal mining sector weakens the region's overall sustainability standing.	145	4.21	0.64
IEAD7	Building formal supply chain links with or formalizing artisanal operations could improve resource security for formal mining entities.	145	3.51	1.18
IEAD8	Unregulated minerals finding their way into alternative hubs (e.g., Dubai) weakens the competitive position of strictly compliant mines.	145	4.07	0.76
-	**Overall Informal Economy & Artisanal Mining Factor Score**	**145**	**4.10**	**0.72**

Source: Primary Data (2026)

The table 4.7 above shows that the descriptive configurations for the Informal Economy and Artisanal Mining Disruptions scale reflect a high level of agreement among participants, yielding a composite factor score of 4.10 with an overall standard deviation of 0.72. The findings indicate that reckless chemical handling and poor waste management by informal miners cause negative environmental damage around formal concessions (IEAD3), which

scored the highest individual mean of 4.42 alongside a very tight standard deviation of 0.53. This low dispersion indicates a strong consensus across departments that informal activities create immediate environmental liabilities for neighboring formal operators. According to Spiegel (2021), unregulated chemical discharge, particularly mercury and cyanide run-off from artisanal operations, often spills over into formal corporate concessions, resulting in shared environmental damage and complex community safety issues.

Furthermore, the statement that unregulated mining activities create a distorted, unfair market where formal mines face compliance costs that informal operations avoid (IEAD4) received a high mean score of 4.35 with a standard deviation of 0.57. This underscores that formal mining houses face structural cost disadvantages when competing with an unregulated parallel market. Research by Hilson (2022) confirms that strictly compliant mining entities carry heavy regulatory burdens including environmental impact assessments, rehabilitation levies, and corporate taxes whereas the informal sector avoids these costs, distorting local resource markets and inflating operating overheads for formal companies.

The expectation that encroachment by informal artisanal miners onto formal concessions creates land tenure conflicts and operational delays (IEAD1) scored a strong mean of 4.28 with a standard deviation of 0.61. This reinforces that physical encroachment disrupts planned exploration schedules and daily extraction workflows. This finding is supported by the work of Buss et al. (2021), who observe that overlapping boundaries between formal mineral concession holders and migratory artisanal workers often lead to prolonged legal disputes, security standoffs, and production stoppages.

Similarly, the statement that the lack of clear environmental enforcement in the informal mining sector weakens the region's overall sustainability standing (IEAD6) earned a firm mean score of 4.21 with a standard deviation of 0.64. This indicates that widespread ecosystem damage by unregulated operators undermines broader regional green initiatives. This outcome is corroborated by Ledwaba and Nhlengetwa (2021), who state that weak regulatory oversight of the informal mining sector erodes institutional trust and dilutes the effectiveness of regional environmental frameworks within the Southern African Development Community (SADC).

Infrastructure wear and resource access bottlenecks are made worse by nearby illegal or informal operations (IEAD5) also produced a high mean of 4.12 and a standard deviation of 0.69, highlighting that unregulated activities place an extra burden on shared road and water networks. Unregulated minerals finding their way into alternative hubs weakens the

competitive position of strictly compliant mines (IEAD8) scored a mean of 4.07 with a standard deviation of 0.76, while the statement that the informal sector diverts local raw materials and labor away from formal supply networks (IEAD2) earned a mean of 3.84 with a standard deviation of 0.82.

The lowest-scoring metric observed was the statement that building formal supply chain links with or formalizing artisanal operations could improve resource security for formal mining entities (IEAD7), which scored a mean of 3.51 alongside a much wider standard deviation of 1.18. This high variance reflects a clear divergence of opinion among the surveyed mining staff. As argued by Verbrugge and Geenen (2022), while formalizing small-scale mining sounds good in theory, integrating informal operations into structured corporate value chains is very difficult in practice due to deeply rooted compliance gaps, tracing issues, and low administrative alignment among informal networks.

To support these quantitative metrics, a qualitative thematic analysis was performed on the open-ended questionnaire responses related to informal sector impacts. The dominant theme identified was "Concession Infiltration and Co-habitation Risks," cited by 72% (n = 104) of the respondents. Participants explained that the physical presence of artisanal miners undermines formal safety standards and operational planning. A senior security and risk coordinator stated:

"The gold and industrial mineral rushes bring thousands of undocumented miners directly onto our outer concession boundaries. They dig up critical access roads and compromise the structural stability of the terrain, which forces us to reroute our heavy machinery and delays our production schedules."

An environmental monitoring officer added:

"We spend significant capital maintaining our water purification and environmental safeguards. However, when upstream artisanal groups dump toxic slurry straight into local rivers, it raises local pollution levels, and formal entities end up facing regulatory scrutiny from authorities due to shared waterways."

This qualitative analysis highlights that informal sector disruptions extend beyond simple economic competition, creating complex security and regulatory challenges that complicate formal supply chain execution.

4.4.6 Macro-Economic Volatility & Supply Chain Stability Indexing

The respondents were asked to rate statements regarding the impact of macroeconomic volatility on supply chain stability and operational forecasting. The results, detailed in Table 4.8, show that the mean scores for these macroeconomic factors ranged from 3.76 to 4.54. This demonstrates that volatile economic conditions are recognized as a major influence on long-term sustainability and resource planning at the mine.

Table 4.8: The Effects of Macro-Economic Volatility on Supply Chain Stability

Codes	Statement	N	Mean	Std. Deviation
MEVS1	Severe domestic inflation and volatile currency shifts increase input costs and complicate budget planning.	145	4.54	0.51
MEVS2	The Reserve Bank of Zimbabwe (RBZ) mandatory export surrender requirements (e.g., 70/30 USD-to-ZiG split) limit the hard currency liquidity needed to buy green machinery.	145	4.48	0.54
MEVS3	Power grid shortages and energy infrastructure decay force the company to prioritize short-term survival over long-term green projects.	145	4.41	0.58
MEVS4	Administrative delays and documentation backlogs at cross-border checkpoints (e.g., Beitbridge) slow down the import of critical reagents.	145	4.19	0.71
MEVS5	Local transport infrastructure challenges (e.g., road damage, rail capacity limitations) increase inventory holding costs.	145	4.26	0.65
MEVS6	Climate-driven weather shocks (such as heavy seasonal rains or cyclone damage) cause visible bottlenecks along transborder trade routes.	145	3.92	0.84
MEVS7	Regional policy and political changes serve as a warning sign for labor movements and supply chain vulnerability across the SADC region.	145	3.76	0.91
MEVS8	Developing a predictive framework based on these domestic issues can help regional mining houses forecast cross-border risks.	145	4.11	0.73
	Overall Macro-Economic Volatility Factor Score	**145**	**4.21**	**0.68**

Source: Primary Data (2026)

Macroeconomic Volatility and Supply Chain Stability are both shown to be stable in the table 4.8 that is located above.

With a composite mean score of 4.21 and a standard deviation of 0.68, the indexing scale was the one that garnered the highest overall endorsement across the entire study. With a relatively narrow standard deviation of 0.51, the statement that significant domestic inflation and volatile currency movements increase input costs and complicate budget planning (MEVS1) had the highest individual mean of 4.54. This statement also had the narrowest standard deviation. The fact that there is just a small amount of variation suggests that there is a strong and united awareness that quick currency swings impact fundamental operational financial planning. In accordance with Gukurume (2022), chronic changes in exchange rates and sudden monetary adjustments interrupt corporate budgeting cycles. As a result, industrial enterprises are compelled to continually re-price contracts and absorb unanticipated increases in operational costs.

There was a high mean score of 4.48 and a tight standard deviation of 0.54 for the finding that the Reserve Bank of Zimbabwe (RBZ) obligatory export surrender regulations limit the hard currency liquidity that is required to purchase green machinery (MEVS2). The fact that this is the case demonstrates that national monetary laws might unwittingly slow down long-term sustainability investments by restricting access to foreign currency. This viewpoint is reinforced by Maponga and Ncube (2023), who contend that stringent capital controls and enforced currency surrender laws diminish the reserves of hard currency that are required to acquire advanced, environmentally friendly equipment and components of sustainable technology.

The expectation that power grid shortages and energy infrastructure decay force the company to prioritize short-term survival over long-term green projects (MEVS3) earned a strong mean score of 4.41 with a standard deviation of 0.58. This indicates that immediate energy crises force technical teams to focus on daily production goals rather than long-term environmental strategies. As noted by Chamisa and Zhou (2024), ongoing industrial electricity deficits force mining companies to rely on high-emission diesel generators to maintain production, which increases carbon output and conflicts with long-term green supply chain goals.

Similarly, local transport infrastructure challenges increase inventory holding costs (MEVS5) scored a mean of 4.26 with a standard deviation of 0.65. This shows that road and rail gaps

complicate inventory management, forcing the mine to hold larger buffer stocks. Administrative delays and documentation backlogs at cross-border checkpoints slow down the import of critical reagents (MEVS4) earned a high mean score of 4.19 with a standard deviation of 0.71, proving that border delays remain a major challenge for sourcing specialized processing chemicals.

Developing a predictive framework based on these domestic issues can help regional mining houses forecast cross-border risks (MEVS8) produced a mean score of 4.11 with a standard deviation of 0.73, while climate-driven weather shocks causing visible bottlenecks along transborder trade routes (MEVS6) scored a mean of 3.92 with a standard deviation of 0.84. The lowest-rated item within this construct was the statement that regional policy and political changes serve as a warning sign for supply chain vulnerability across the SADC region (MEVS7), which returned a mean of 3.76 and a standard deviation of 0.91, suggesting that internal financial and infrastructural challenges are seen as more urgent than broader regional political trends.

The qualitative responses regarding macroeconomic volatility clustered around the theme of "Navigating Liquidity and Energy Constraints," cited by 84% (n = 122) of the respondents. The feedback showed that external monetary constraints and power shortages create ongoing challenges for the mine's logistical and environmental operations. A senior financial analyst remarked:

"The mandatory 70/30 export retention split creates ongoing cash flow challenges. We earn our revenue in hard currency, but surrendering 30% into fluctuating local units means we lack the immediate foreign exchange needed to pay international engineering suppliers for eco-efficient equipment upgrades."

A maintenance and operations engineer added:

"We face regular power interruptions from the national grid, which stalls our processing mills and shortens the operational life of our machinery. When you are constantly managing emergency equipment repairs caused by grid issues, long-term environmental programs get put on the back burner."

This qualitative data demonstrates that external macroeconomic pressures and infrastructure challenges directly limit the resources available for executing sustainable supply chain initiatives.

4.5 Pearson Correlation Analysis

The correlation analysis was employed to assess the strength, direction, and statistical significance of the linear association between the individual sustainable supply chain management (SSCM) dimensions, which served as the independent variables, and organizational performance, which served as the dependent variable, within the operations of Dorowa Minerals Limited in Zimbabwe. In doing so, the Pearson correlation coefficient (r) was calculated to evaluate the extent to which an increase or systematic improvement in the application of these sustainable supply chain practices matches a corresponding positive or negative shift in organizational performance metrics. The correlation coefficients measure mutual linear variations and provide a preliminary empirical foundation for subsequent predictive modeling.

4.5.1 Relationship between Strategic Supplier Partnerships and Organisational Performance

In addressing the study's first research objective, this section discusses the relationship between Strategic Supplier Partnerships and organizational performance within the Zimbabwean mining sector. The correlation analysis findings involving the total sample pool of 145 participants are presented in Table 4.9.

Table 4.9: Correlations between Strategic Supplier Partnerships and Organisational Performance

Research Metrics	Strategic Supplier Partnerships	Organisational Performance
Strategic Supplier Partnerships	1	.584**
Organisational Performance	.584**	1
Sig. (2-Tailed)	.000	
N	145	145

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

Source: Primary Data (2026)

A strong level of statistical significance between Strategic Supplier Partnerships and organizational performance ($r = 0.584$, $p < 0.01$) can be seen in Table 4.9. The implication of

this result is that as the depth, consistency, and formal execution of collaborative vendor arrangements and relational trust increase within the enterprise, Dorowa Minerals Limited experiences a statistically significant expansion in operational predictability, inventory stabilization, and overall firm performance. The p-value (0.000) falls well below the standard 1% alpha threshold, which indicates that the linear connection between these two constructs is highly reliable, robust, and non-spurious.

From the results obtained, it is clear that moving away from aggressive, short-term adversarial or arm's-length transactional purchasing models toward professionalized, collaborative buyer-supplier networks acts as a vital driver of operational resilience. By establishing long-term collaborative agreements, open information channels, and joint cost-reduction programs, the mining entity creates secure raw material lines that help prevent costly processing halts.

This finding aligns with contemporary supply chain literature. First, Bridoux and Stoelhorst (2022) state that the deep strategic integration of relational stakeholder mechanisms is a strong predictor of operational performance in capital-intensive sectors, as collaborative networks reduce transactional frictions and monitoring costs. Second, Islam et al. (2024) observe that proactive information-sharing protocols directly minimize the bullwhip effect and inventory delivery delays during macroeconomic volatility. In the Zimbabwean mining landscape, where foreign exchange limitations and cross-border transport logjams frequently disrupt operations, Kusi-Sarpong et al. (2023) note that long-term supplier alliances provide heavy industrial plants with a dependable safety buffer that helps maintain steady production schedules.

The positive relationship exists because strategic supplier networks serve as an administrative and logistical safety mechanism rather than just a theoretical concept. When mining houses maintain collaborative lines with key vendors, they gain priority access to critical parts and chemical reagents during supply shortages.

4.5.2 Relationship between Green Procurement Practices and Organisational Performance

In addressing the study's second research objective, this section evaluates the relationship between Green Procurement Practices and organizational performance at Dorowa Minerals Limited. The empirical correlation findings gathered from the 145 surveyed professionals are summarized in Table 4.10.

Table 4.10: Correlations between Green Procurement Practices and Organisational Performance

Research Metrics	Green Procurement Practices	Organisational Performance
Green Procurement Practices	1	.412**
Organisational Performance	.412**	1
Sig. (2-Tailed)	.000	
N	145	145

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

Source: Primary Data (2026)

A moderate-to-strong positive relationship between Green Procurement Practices and organizational performance ($r = 0.412$, $p < 0.01$) is demonstrated in Table 4.10. This statistical parameter implies that systematically incorporating environmental criteria into the bidding process, purchasing energy-efficient heavy equipment, and selecting eco-friendly chemical inputs correspond with steady gains in corporate performance. The p-value (0.000) confirms that the linear association between environmentally conscious sourcing and performance outcomes is highly dependable.

The empirical results show that green procurement serves as a structural tool for resource efficiency and cost containment rather than an expensive corporate compliance checkbox. Sourcing locally synthesized inputs and eco-friendly chemical reagents helps the extraction facility lower its long-term hazardous waste handling costs and reduce its exposure to international trade bottlenecks.

This relationship is well-documented in recent empirical studies. Alvites-Huamaní et al. (2023) argue that integrating strict resource-efficiency rules into heavy equipment procurement allows mining operations to lower their long-term energy consumption, directly cutting operating overheads. Furthermore, Baah and Jin (2024) state that green procurement practices reduce overall compliance and liability risks by screening out hazardous materials at the initial input stage rather than relying entirely on expensive end-of-pipe treatments. In the domestic context, Muchaendepi and Mbowa (2022) point out that developing local supplier networks for eco-

friendly substitute inputs helps Zimbabwean industrial operations conserve their working capital and reduces dependencies on scarce foreign currency reserves.

This positive correlation exists because environmentally focused sourcing directly impacts the operational cost structure. According to Maseko and Zinyemba (2024), when industrial enterprises integrate energy efficiency and material safety metrics into their core purchasing routines, they protect their long-term viability against domestic resource limits. The correlation coefficient (r = 0.412) reflects that while building a fully certified green vendor base requires considerable effort in a developing economic environment, the financial and operational rewards of lower waste and energy costs support overall organizational performance.

4.5.3 Relationship between Eco-Innovative Practices and Organisational Performance

In addressing the study's third research objective, this section discusses the statistical relationship between Eco-Innovative Practices and organizational performance. The correlation analysis metrics are presented in Table 4.11.

Table 4.11: Correlations between Eco-Innovative Practices and Organisational Performance

Research Metrics	Eco-Innovative Practices	Organisational Performance
Eco-Innovative Practices	1	.615**
Organisational Performance	.615**	1
Sig. (2-Tailed)	.000	
N	145	145

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

Source: Primary Data (2026)

The correlation findings in Table 4.11 show a strong, positive, and statistically highly significant relationship between Eco-Innovative Practices and organizational performance ($r = 0.615$, $p < 0.01$). This result implies that increasing investments in waste-to-value systems, automated resource recovery machinery, closed-loop water recycling networks, and alternative on-site renewable energy technologies match substantial improvements in operational stability

and firm performance. The negligible p-value (0.000) indicates that this linear relationship is statistically dependable and highly relevant for strategic planning.

The high correlation coefficient shows that implementing technical innovations on the production line is a key driver of asset utilization and operational independence. Given the persistent infrastructure challenges in the domestic environment, using closed-loop recycling loops and on-site solar energy generation provides the mine with greater operational autonomy, shielding key processing units from external resource disruptions.

These findings are strongly supported by contemporary literature. Maseko and Zinyemba (2024) state that installing on-site renewable energy systems helps heavy industrial plants protect their core production schedules from national power grid failures, stabilizing machine run-times and processing volumes. Additionally, Zhu et al. (2024) emphasize that circular economic innovations, such as closed-loop water recycling systems, allow large mining facilities to significantly reduce their daily fresh-water consumption, which lowers costs and prevents resource conflicts with local communities. Islam et al. (2024) also observe that tailings and slag re-processing programs turn hazardous mineral waste streams into commercial by-products, converting an environmental liability into a secondary revenue stream.

The strong relationship exists because technological eco-innovations directly address structural vulnerabilities on the plant floor. According to Muzondo and Pashapa (2025), when heavy processing operations adopt real-time digital telemetry and automated resource recovery systems, they lower chemical dosing waste and reduce processing re-work rates. The high correlation coefficient ($r = 0.615$) confirms that eco-innovative investments help stabilize daily production volumes and improve cost efficiency when operating under tight resource constraints.

4.5.4 Relationship between Internal Environmental Management and Organisational Performance

In addressing the study's fourth research objective, this section analyses the linear relationship between Internal Environmental Management systems and organizational performance. The correlation outcomes are detailed in Table 4.12.

Table 4.12: Correlations between Internal Environmental Management and Organisational Performance

Research Metrics	Internal Environmental Management	Organisational Performance
Internal Environmental Management	1	.642**
Organisational Performance	.642**	1
Sig. (2-Tailed)	.000	
N	145	145

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

Source: Primary Data (2026)

Table 4.12 shows a strong, positive, and statistically highly significant relationship between Internal Environmental Management and organizational performance ($r = 0.642$, $p < 0.01$). The practical implication of this result is that as executive commitment, systematic internal environmental auditing, clear chemical safety protocols, and cross-functional environmental training programs become more embedded within the corporate structure, organizational performance metrics improve correspondingly. The p-value (0.000) confirms that this internal governance alignment has a highly dependable relationship with operational outcomes.

The high correlation coefficient demonstrates that strong internal oversight, clear administrative accountability, and standard operating guidelines are vital for maintaining high operational standards. Integrating environmental metrics directly into corporate governance dashboards allows executive teams to identify operational waste, prevent accidental spills, and avoid costly regulatory penalties or forced operational shutdowns.

This finding is well-aligned with established academic research. Sahoo and Vijayvargy (2021) observe that a firm commitment to systematic internal environmental auditing reduces waste and prevents hazardous contamination incidents that cause expensive operational downtime. Furthermore, Song et al. (2022) point out that strong executive support converts environmental programs from simple compliance checkboxes into active drivers of performance across the value chain by ensuring proper resource allocation for operational controls. Liman (2025) also highlights that embedding compliance indicators directly into management dashboards allows heavy industries to proactively address environmental and operational risks before they cause structural disruptions.

The strong relationship exists because internal environmental controls directly influence operational discipline and workplace safety. According to Mintz (2022), comprehensive internal compliance training and structured accountability systems help align daily worker actions with broader corporate governance goals. The correlation coefficient (r = 0.642) demonstrates that a well-structured internal management system acts as a key foundation for overall organizational performance, helping managers maintain high safety and operational standards in a demanding industrial environment.

4.5.5 Relationship between Informal Economy & Artisanal Mining Disruptions and Organisational Performance

In addressing the study's fifth research objective, this section discusses the statistical relationship between the disruptions caused by the Informal Economy & Artisanal Mining and the organizational performance of Dorowa Minerals Limited. The empirical correlation findings obtained from the 145 surveyed mining professionals are summarized in Table 4.13.

Table 4.13: Correlations between Informal Economy & Artisanal Mining Disruptions and Organisational Performance

Research Metrics	Informal Economy & Artisanal Mining Disruptions	Organisational Performance
Informal Economy & Artisanal Mining Disruptions	1	-.468**
Organisational Performance	-.468**	1
Sig. (2-Tailed)	.000	
N	145	145

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

Source: Primary Data (2026)

A moderate-to-strong negative relationship between Informal Economy & Artisanal Mining Disruptions and organizational performance (r = -0.468, p < 0.01) can be observed in Table 4.13. The structural implication of this negative correlation coefficient is that as the frequency, intensity, and physical presence of unregulated artisanal operations (*Makorokoza*) and concession encroachments increase, the organizational performance of the formal mining firm experiences a statistically significant decline. The p-value (0.000) falls well below the 1% alpha

threshold, confirming that the negative linear relationship between informal sector disruptions and corporate performance parameters is highly reliable and non-spurious.

From the results obtained, it is evident that unregulated artisanal actions create immediate structural and environmental operational penalties that harm the mine's overall output efficiency. Encroachments onto formal concessions do not just generate legal friction; they cause physical land tenure conflicts, damage shared infrastructure, and force the company to alter its heavy machinery routes, leading to costly production delays. Furthermore, because these unregulated operations avoid compliance and rehabilitation costs, they create an unfair, distorted local market while exposing adjacent waterways to hazardous chemical run-off, which increases the environmental monitoring and purification expenditures of strictly compliant mines.

This finding matches established trends in regional mining literature. First, Spiegel (2021) argues that the lack of clear toxic waste management and environmental enforcement within small-scale artisanal clusters creates a negative spill over effect that damages adjacent formal extraction concessions and forces formal entities to absorb unexpected clean-up costs. Second, Buss et al. (2021) observe that concession overlapping and physical infiltration by informal workgroups lead to prolonged operational stoppages and heightened security budgets for corporate miners in Central and Southern Africa. Locally, Hilson (2022) notes that when informal miners bypass statutory taxation and environmental impact assessments, they distort local labor and supply lines, making it harder for formal mines to maintain steady operational cost structures.

The negative relationship persists because informal intrusions alter the physical and legal risk environment of the mine. According to Verbrugge and Geenen (2022), when informal mining hubs grow close to formal boundaries, shared roads face accelerated wear, and local resource access points become congested. The negative correlation coefficient ($r = -0.468$) underscores that unchecked informal mining activities serve as a direct operational headwind, eroding the performance gains achieved through formal sustainable supply chain practices by introducing uncontrollable external field risks.

4.5.6 Relationship between Macro-Economic Volatility & Supply Chain Stability Indexing and Organisational Performance

In addressing the study's sixth research objective, this section evaluates the statistical relationship between Macro-Economic Volatility & Supply Chain Stability Indexing and the organizational performance of Dorowa Minerals Limited. The quantitative correlation analysis results are presented in Table 4.14.

Table 4.14: Correlations between Macro-Economic Volatility & Supply Chain Stability Indexing and Organisational Performance

Research Metrics	Macro-Economic Volatility & Stability Indexing	Organisational Performance
Macro-Economic Volatility & Stability Indexing	1	-.521**
Organisational Performance	-.521**	1
Sig. (2-Tailed)	.000	
N	145	145

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

Source: Primary Data (2026)

A strong and statistically highly significant negative relationship between Macro-Economic Volatility & Supply Chain Stability Indexing and organizational performance ($r = -0.521$, $p < 0.01$) is demonstrated in Table 4.14. The practical implication of this result is that as macroeconomic instability characterized by severe inflation, volatile domestic currency adjustments (such as ZiG shifts), power grid deficits, and cross-border customs delays intensifies, the baseline performance of the mining organization decreases significantly. The p-value (0.000) provides strong empirical proof that external macroeconomic volatility functions as a powerful, statistically reliable constraint on organizational output metrics.

The empirical data highlights that extreme macro-environmental fluctuations directly disrupt corporate supply chain execution and financial predictability. High domestic inflation and rapid exchange rate shifts complicate long-term capital budgeting and increase local procurement costs. Crucially, monetary restrictions such as the Reserve Bank of Zimbabwe's (RBZ) mandatory export surrender rules limit the immediate hard currency liquidity available to purchase advanced, eco-friendly machinery or import critical chemical reagents. When these

monetary constraints interact with national power shortages and border documentation backlogs at ports of entry like Beitbridge, the firm is forced to hold larger, expensive inventory buffers and divert funds from long-term green projects toward immediate short-term operational survival.

This negative association is widely supported by contemporary economic and industrial research. Gukurume (2022) highlights that currency hyper-volatility and sudden adjustments to monetary regimes disrupt industrial operational planning, forcing capital-intensive firms to constantly absorb unbudgeted input cost shocks. Furthermore, Chamisa and Zhou (2024) state that persistent electricity infrastructure deficits force heavy manufacturing and extraction industries to rely on expensive, high-emission diesel generators, which directly increases operational overheads and undermines long-term green supply chain targets. In terms of trade logistics, Maponga and Ncube (2023) demonstrate that mandatory currency retention splits limit a firm's capacity to complete timely international payments for specialized engineering components, resulting in prolonged supply logjams.

The strong negative correlation exists because macroeconomic instability actively creates resource bottlenecks that interfere with internal operations. According to Maseko and Zinyemba (2024), when an industrial plant faces ongoing energy deficits and cross-border delays, technical teams must prioritize basic production survival over strategic sustainability plans. The correlation coefficient ($r = -0.521$) clearly reflects that domestic economic volatility and infrastructure gaps serve as severe obstacles, requiring the development of predictive, risk-indexed frameworks to help regional mining houses anticipate and mitigate cross-border supply chain vulnerabilities.

4.6 Multiple Regression Analysis

Following the bivariate evaluations carried out through the Pearson correlation analysis, a Multiple Linear Regression Analysis was executed to determine the collective and individual predictive power of the independent variables on the dependent variable. In this statistical model, the independent variables are represented by the core sustainable supply chain management (SSCM) dimensions: Strategic Supplier Partnerships (SSP), Green Procurement Practices (GPP), Eco-Innovative Practices (EIP), and Internal Environmental Management (IEM), alongside the critical contextual factors: Informal Economy & Artisanal Mining Disruptions (IEAD) and Macro-Economic Volatility & Stability Indexing (MEVS). The

dependent variable is Organizational Performance (OP) within the context of Dorowa Minerals Limited in Zimbabwe.

4.6.1 Regression Model Summary

The overall explanatory power, collective predictive strength, and statistical precision of the constructed multiple regression equation are consolidated and presented in Table 4.15.

Table 4.15: Multiple Regression Model Summary

Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate
1	.762[a]	.581	.563	.3725

[a]. Predictors: (Constant), Macro-Economic Volatility & Stability Indexing, Green Procurement Practices, Informal Economy & Artisanal Mining Disruptions, Strategic Supplier Partnerships, Eco-Innovative Practices, Internal Environmental Management.

Source: Primary Data (2026)

The empirical parameters presented in Table 4.15 provide validation for the explanatory capacity of the multi-variable regression model. The Multiple Correlation Coefficient (R = 0.762) demonstrates an exceptionally strong, positive collective relationship when all six independent variables are entered into the linear equation simultaneously. This high coefficient indicates that when the administrative and technical teams at Dorowa Minerals Limited align, execute, and calibrate these internal sustainability strategies while systematically accounting for external disruptions, their collective operational choices sync strongly with positive movements in organizational performance metrics.

The most critical baseline metric within the model summary is the Coefficient of Determination ($R^2 = 0.581$). This parameter indicates that the combined linear interaction of Strategic Supplier Partnerships, Green Procurement Practices, Eco-Innovative Practices, Internal Environmental Management, Informal Economy Disruptions, and Macro-Economic Volatility accounts for exactly 58.1% of the total variance observed in Organizational Performance (OP) at Dorowa Minerals Limited. This high R^2 demonstrates strong explanatory power, proving that more than half of the variations in the mine's operational cost-efficiency, capacity utilization, environmental compliance safety, and raw material processing throughput are directly driven by the combined effects of these strategic supply chain elements and external environmental factors.

The remaining 41.9% of the variance in organizational performance lies outside the boundaries of this specific regression model. This residual variance is driven by unmeasured external macro-environmental phenomena, global mineral market price fluctuations, regional infrastructure shifts, and variations in mineral ore grades.

This high level of collective explanatory power is strongly supported by recent empirical studies in sustainable operations management. Alvites-Huamaní et al. (2023) argue that when heavy industrial firms combine internal compliance standards with proactive supplier management, they achieve a high degree of operational insulation that stabilizes performance during periods of market stress. Similarly, Baah and Jin (2024) state that multivariate supply chain models capturing both internal administrative practices and external economic constraints provide a highly accurate picture of corporate performance, as firms do not operate in a vacuum. In the local context,

4.6.2 Analysis of Variance (ANOVA)

To verify that the calculated explanatory power (R^2 = 0.581) reflects a true structural relationship among the variables rather than a random statistical fluke, an Analysis of Variance (F-test) was executed. The variance partitioning outcomes are detailed in Table 4.16.

Table 4.16: Analysis of Variance (ANOVA) Summary Table[b]

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	26.541	6	4.424	31.873	.000[a]
Residual	19.153	138	0.139		
Total	45.694	144			

[a]. Predictors: (Constant), Macro-Economic Volatility & Stability Indexing, Green Procurement Practices, Informal Economy & Artisanal Mining Disruptions, Strategic Supplier Partnerships, Eco-Innovative Practices, Internal Environmental Management. [b]. Dependent Variable: Organisational Performance.

Source: Primary Data (2026)

The Analysis of Variance results presented in Table 4.16 provide strong empirical validation for the overall statistical model. The model yields a Regression Sum of Squares of 26.541, representing the amount of variation successfully explained by the linear combination of the

six independent variables. Conversely, the Residual Sum of Squares is 19.153, which captures the unexplained variation among the factors. Dividing these sum-of-squares parameters by their respective degrees of freedom (df = 6 for the regression path and df = 138 for the unexplained residuals) produces a Mean Square variance of 4.424 for the regression model against a residual variance of 0.139.

Consequently, dividing the Mean Square of the regression by the Mean Square of the residual yields an absolute calculated Variance Ratio (F-statistic) of 31.873. Because the calculated significance level ($p = 0.000$) falls well below the standard 1% alpha threshold ($\alpha = 0.01$), the overall multiple regression equation is highly statistically significant: $F(6, 138) = 31.873$, $p < 0.01$. This substantial margin allows us to confidently reject the baseline null hypothesis (H0), which states that the multi-variable slope coefficients are collectively equal to zero.

From an administrative and analytical standpoint, this highly significant F-value confirms that the combination of these sustainable supply chain management dimensions and external risk metrics forms a reliable predictive framework. The variance ratio demonstrates that the model's predictive power is a true reflection of structural relationships rather than random data variations. This provides local mining managers with an empirically validated toolkit to optimize operational outcomes and maintain structural stability even under volatile, resource-constrained trading conditions.

This statistical outcome matches the empirical conclusions of several recent researchers in industrial governance. Sahoo and Vijayvargy (2021) demonstrate that large-scale extraction entities using multi-layered environmental and supply chain frameworks generate highly significant F-test results, confirming that systematic coordination across departments yields superior operational outcomes compared to fragmented programs. Furthermore, Song et al. (2022) point out that high F-statistics in mining operations regression matrices prove that environmental management and supply chain collaborations function as higher-order operational capabilities that collectively reduce waste and improve asset utilization. In addition, Liman (2025) highlights that running comprehensive variance tests allows heavy industrial operations to verify that their corporate governance dashboards are grounded in statistically dependable trends, helping protect firm viability against complex market and regulatory shifts.

4.6.3 Regression Coefficients

To isolate the unique mathematical impact and predictive weight of each independent sustainable supply chain and external risk variable on the dependent construct, the regression equation evaluates the unstandardized and standardized coefficients. These parameter details are consolidated in Table 4.17.

Table 4.17: Multiple Regression Coefficients Matrix[a]

Model Elements	Unstandardized Coefficients (β)	Standardized Error	Standardized Coefficients (Beta)	t	Sig.
(Constant)	0.814	0.165		4.933	.000
Strategic Supplier Partnerships (SSP)	0.198	0.044	.185	4.500	.000
Green Procurement Practices (GPP)	0.092	0.035	.088	2.628	.010
Eco-Innovative Practices (EIP)	0.215	0.048	.202	4.479	.000
Internal Environmental Management (IEM)	0.264	0.051	.251	5.176	.000
Informal Economy Disruptions (IEAD)	-0.168	0.041	-.154	-4.097	.000
Macro-Economic Volatility (MEVS)	-0.231	0.047	-.219	-4.914	.000

[a]. Dependent Variable: Organisational Performance.

Source: Primary Data (2026)

The empirical parameters presented in Table 4.17 provide a complete mathematical breakdown of the individual sustainable supply chain management dimensions and external risk metrics evaluated by the mining enterprise. The intercept constant ($\beta = 0.814$, $t = 4.933$, $p = 0.000$) establishes a statistically significant base performance anchor. This baseline constant shows

that if all six independent variables were theoretically fixed at zero, organizational performance at Dorowa Minerals Limited would settle at an absolute score of 0.814. This baseline value confirms that while sustainable supply chain modifications and risk mitigations are highly influential, mining operations are also anchored by basic non-price and structural factors such as underlying ore grades, global commodity demand cycles, and the fundamental mechanical capacity of the extraction plant.

Internal Environmental Management (IEM) emerges as the absolute dominant positive predictor within the regression framework, displaying an unstandardized coefficient of $\beta = 0.264$ and a Standardized Beta weight of 0.251. The high significance level and strong t-statistic ($t = 5.176$, $p = 0.000$) confirm that internal compliance controls exert the strongest direct positive influence on organizational performance. This indicates that a 1-unit enhancement in executive commitment, regular internal auditing, and standardized chemical safety protocols drives a substantial 0.264 increase in absolute organizational performance scores, keeping all other variables constant. This finding highlights that structural discipline, explicit management accountability, and internal governance are essential foundations for any successful sustainability program.

This outcome is corroborated by the recent work of Song et al. (2022), who emphasize that internal environmental management acts as a core operational capability that converts sustainability mandates into active drivers of efficiency by optimizing resource usage across the production line. Furthermore, Sahoo and Vijayvargy (2021) observe that systematic internal auditing and executive support eliminate processing leakages and prevent hazardous contamination incidents that cause expensive operational downtime. Mintz (2022) also states that clear internal operating guidelines and structured compliance programs help align daily worker actions with corporate governance goals, directly improving overall operational performance.

Macro-Economic Volatility & Stability Indexing (MEVS) emerged as the most powerful negative predictor in the model, yielding an unstandardized coefficient of $\beta = -0.231$ and a standardized Beta weight of -0.219. This path is highly statistically significant, as demonstrated by its substantial negative t-value ($t = -4.914$, $p = 0.000$). This indicates that a 1-unit upward shift in macroeconomic instability characterized by severe inflation, exchange rate adjustments, power grid deficits, and cross-border customs delays drives a reliable 0.231 decrease in organizational performance outcomes. This confirms that external economic

volatility and infrastructure gaps serve as severe obstacles, requiring the development of predictive, risk-indexed frameworks to help mining houses manage supply chain vulnerabilities.

This negative impact is strongly supported by Gukurume (2022), who notes that exchange rate fluctuations and sudden monetary adjustments disrupt corporate budgeting cycles, forcing firms to absorb unexpected operational cost increases. Additionally, Chamisa and Zhou (2024) state that ongoing electricity infrastructure deficits force heavy industries to rely on high-emission diesel generators, which increases operating costs and conflicts with long-term green supply chain goals. Maponga and Ncube (2023) also demonstrate that mandatory currency surrender policies deplete the hard currency reserves needed to import advanced, eco-friendly equipment and sustainable technology components.

Eco-Innovative Practices (EIP) proved to be the second most powerful positive predictor, showing an unstandardized coefficient of $\beta = 0.215$ and a standardized Beta weight of 0.202. Backed by a high t-statistic ($t = 4.479$, $p = 0.000$), this relationship confirms that a 1-unit increase in technical waste-to-value systems, closed-loop recycling networks, and alternative on-site renewable energy technologies yields a 0.215 increase in absolute organizational performance, proving the value of processing-line innovations for capturing operational value and reducing waste costs.

This finding aligns with Maseko and Zinyemba (2024), who state that adopting on-site renewable alternatives helps heavy industries protect their production schedules from national grid disruptions, stabilizing machine utilization rates and overall production volumes. Similarly, Zhu et al. (2024) argue that circular economy practices, such as closed-loop water recycling systems, allow industrial operations to protect vital local ecosystems while lowering their daily resource costs. Islam et al. (2024) also observe that tailings re-processing initiatives turn hazardous mineral waste streams into commercial by-products, converting an environmental liability into a secondary revenue stream.

Strategic Supplier Partnerships (SSP) also demonstrates solid predictive capability, yielding an unstandardized coefficient of $\beta = 0.198$ and a standardized Beta weight of 0.185. This path is highly statistically significant ($t = 4.500$, $p = 0.000$), indicating that a 1-unit increase in collaborative vendor networks, long-term purchasing commitments, and open information sharing matches a 0.198 increase in organizational performance outcomes. This confirms that

volume-focused relational trust and supply security are highly effective for capturing operational predictability.

This perspective is shared by Bridoux and Stoelhorst (2022), who note that systematic stakeholder evaluations establish behavioural accountability and reduce transaction risks within complex corporate supplier networks. Furthermore, Islam et al. (2024) find that real-time information exchange between mining houses and their supplier base reduces demand uncertainty, enabling firms to optimize inventory safety stock levels. Kusi-Sarpong et al. (2023) also state that long-term purchasing commitments insulate industrial supply chains from sudden material shortages and unexpected logistical delays.

Informal Economy & Artisanal Mining Disruptions (IEAD) recorded a significant negative predictive weight, returning an unstandardized value of $\beta = -0.168$ and a standardized Beta weight of -0.154 ($t = -4.097$, $p = 0.000$). This parameter implies that a 1-unit increase in concession encroachments and unregulated mining activities matches a 0.168 decrease in organizational performance scores, showing that unchecked informal activities serve as a direct operational headwind.

This finding is corroborated by Spiegel (2021), who argues that unregulated chemical discharge from artisanal operations often spills over into formal corporate concessions, resulting in shared environmental damage and complex community safety issues. Moreover, Buss et al. (2021) observe that overlapping boundaries between formal mineral concession holders and migratory artisanal workers often lead to prolonged legal disputes, security standoffs, and production stoppages. Hilson (2022) also confirms that strictly compliant mining entities carry heavy regulatory burdens, whereas the informal sector avoids these costs, distorting local resource markets and inflating operating overheads for formal companies.

Green Procurement Practices (GPP) shows the lowest predictive weight in the model, returning an unstandardized value of $\beta = 0.092$ and a standardized Beta weight of 0.088. Despite its lower weight, it remains statistically viable ($t = 2.628$, $p = 0.010$), indicating that a 1-unit enhancement in environmental sourcing criteria and energy-efficient capital purchasing generates a modest 0.092 increase in performance scores. This confirms that while green purchasing helps control input risks and reduce long-term environmental costs, it functions primarily as a supportive dimension within the broader sustainable supply chain framework.

This outcome is shared by Baah and Jin (2024), who argue that green sourcing reduces structural liability risks and heavy compliance penalties by minimizing hazardous outputs right

at the input stage. Additionally, Alvites-Huamaní et al. (2023) note that integrating resource efficiency into heavy capital acquisitions allows extractive firms to lower energy usage and improve profitability under strict resource constraints. Finally, Muchaendepi and Mbowa (2022) point out that developing local supplier alternatives helps domestic mining houses protect their working capital, reduce logistical dependencies, and avoid costly foreign import requirements.

4.6.4 Hypothesis Testing

This section provides a rigorous statistical evaluation and discussion of the six structural hypotheses formulated for this study. By utilizing the empirical outputs generated from the multiple linear regression model, each hypothesis is tested to determine whether the primary data gathered from the 145 professionals at Dorowa Minerals Limited supports or rejects the proposed relationships.

H1: There is a positive relationship between Strategic Supplier Partnerships and Organisational Performance in the mining sector.

The unstandardized regression coefficient for this variable $\beta = 0.198$) indicates that, holding all other variables constant, a single-unit increase in the development and execution of Strategic Supplier Partnerships leads to a 0.198 increase in the score for organizational performance metrics. The calculated t-statistic is substantial ($t = 4.500$) and its associated probability value is highly significant ($p = 0.000$). Because this p-value falls well below the standard statistical alpha threshold ($\alpha = 0.05$), Hypothesis 1 (H1), which posits that strategic supplier partnerships exert a significant positive effect on organizational performance within the Zimbabwean mining sector, is strongly supported.

When evaluating across the predictive model using the standardized beta weights ($\beta = 0.185$), strategic supplier partnerships emerge as a powerful, statistically reliable positive driver of operational stability. This performance link reflects the practical realities of managing heavy industrial extraction processes within a volatile and resource-constrained macro-environment. For an extractive entity like Dorowa Minerals, which relies heavily on specialized heavy machinery components, floatation reagents, and steady fuel deliveries, moving away from aggressive, arm's-length transactional purchasing models toward long-term relational alliances acts as a vital buffer for the production line. By establishing formal long-term agreements, open

information-sharing channels, and mutual cost-reduction programs, the mining firm reduces transactional frictions and stabilizes material lead times.

This robust predictive path matches the findings of Bridoux and Stoelhorst (2022), who demonstrated that the strategic integration of relational stakeholder mechanisms serves as a primary predictor of corporate performance in capital-intensive sectors, as collaborative vendor networks lower monitoring costs and mitigate supply-side bottlenecks. It also directly supports the work of Islam et al. (2024), who found that real-time information exchange between raw material extractors and regional material vendors minimizes inventory delivery delays and prevents unexpected production stoppages. In the context of the local industrial climate, Kusi-Sarpong et al. (2023) observe that sustainable supplier partnerships provide heavy industrial plants with priority access to critical parts during regional shortages, safeguarding baseline capacity utilization.

When analysed through the theoretical lens of the Resource-Based View (RBV), these strategic supplier partnerships represent a socially complex, path-dependent organizational capability. Relational capital and institutional trust cannot be easily duplicated by competitors, making them valuable resources that enable Dorowa Minerals to protect its core extraction schedules from external supply-chain shocks and maintain stable, high-volume operations, as highlighted by Song et al. (2022).

H2: There is a positive relationship between Green Procurement Practices and Organisational Performance in the mining sector.

A single-unit increase in the application of Green Procurement Practices leads to a 0.092 rise in the score for organisational performance, as indicated by the unstandardised regression coefficient for this variable ($\beta = 0.092$). This indicates that, when all other factors in the model are held constant, the score for organisational performance increases by 0.092.

It has been determined that the t-statistic that was produced is statistically reliable ($t = 2.628$), and the probability value that is linked with it is significant ($p = 0.010$). Hypothesis 2 (H2), which asserts that environmentally responsible procurement methods have a substantial positive association with organisational performance in the mining sector, is supported by the primary data. This is due to the fact that the p-value is lower than the conventional significance level of 0.05.

When comparing across the regression model using the standardized beta weights (β = 0.088), green procurement practices display the lowest individual positive predictive weight among the active internal dimensions. This positive but modest performance link demonstrates that while systematically integrating environmental criteria into the vendor bidding process and sourcing eco-friendly capital equipment is essential for risk reduction, its capacity to drive immediate, massive surges in short-term profitability is limited. In a heavy industrial setup, environmentally conscious sourcing functions primarily as a supportive baseline process that controls input liabilities and manages waste hazards at the point of origin rather than acting as an independent engine for explosive volume growth.

By actively screening suppliers for material safety, choosing energy-efficient capital machinery, and preferring locally synthesized input alternatives, Dorowa Minerals lowers its long-term hazardous waste handling costs and curtails its exposure to international trade disruptions. This deliberate integration of sustainability criteria into core purchasing routines helps the enterprise capture long-term resource efficiencies and avoid severe compliance penalties, thereby shielding thin operating margins from sudden environmental liability shocks.

This predictive path aligns with the empirical conclusions of Baah and Jin (2024), who stated that integrating strict environmental metrics into purchasing routines screens out regulatory compliance risks at the input stage, which minimizes the need for expensive end-of-pipe treatments or remediation penalties. It also echoes the findings of Alvites-Huamaní et al. (2023), who observed that incorporating energy-efficiency and carbon-reduction standards into capital acquisitions allows heavy extraction operations to reduce their long-term energy consumption, directly cutting corporate operating overheads.

H3: There is a positive relationship between Eco-Innovative Practices and Organisational Performance in the mining sector.

The unstandardized regression coefficient for this variable (β = 0.215) indicates that, holding all other predictors constant, a single-unit increase in the deployment of Eco-Innovative Practices corresponds with a 0.215 increase in the score for organizational performance. The calculated t-statistic is strong (t = 4.479) and its associated probability value is highly significant (p = 0.000). Because this p-value falls well below the standard significance threshold of 0.05, Hypothesis 3 (H3), which posits that eco-innovative practices have a

significant positive relationship with organizational performance in the mining sector, is strongly supported.

When comparing across the regression model using the standardized beta weights β = 0.202), eco-innovative practices emerge as the second most powerful positive predictor within the study's sustainable supply chain framework. This meaningful performance linkage underscores the critical role that technical and circular innovations play on the active production floor of heavy mineral processing operations. Rather than treating environmental protection as a passive cost center, investing in advanced technology configurations allows the enterprise to achieve real-world resource recovery and operational independence.

H4: There is a positive relationship between Internal Environmental Management and Organisational Performance in the mining sector.

The unstandardized regression coefficient for this variable (β = 0.264) demonstrates that, keeping all other variables constant, a single-unit increase in the execution of Internal Environmental Management systems results in a 0.264 increase in the score for organizational performance. The calculated t-statistic is exceptionally large (t = 5.176) and its associated probability value is highly significant (p = 0.000). Because this p-value falls well below the standard significance threshold of 0.05, Hypothesis 4 (H4), which posits that internal environmental management has a significant positive effect on organizational performance in the mining sector, is strongly supported by the primary data.

When comparing across the entire regression model using the standardized beta weights (\β = 0.251), internal environmental management emerges as the single most powerful and dominant positive predictor of organizational performance. This outstanding performance link reflects the absolute necessity of strong internal compliance controls, executive accountability, and clear operational guidelines in modern industrial management. Without a rigorous internal governance structure, external supply-chain strategies or green initiatives cannot be successfully executed or sustained on the plant floor.

By embedding clear environmental key performance indicators (KPIs) into executive dashboards, conducting systematic internal environmental audits, providing comprehensive chemical safety training, and establishing cross-functional compliance teams, Dorowa Minerals builds strong operational discipline. This systematic internal oversight allows management to proactively identify process leakages, eliminate waste, and guarantee strict

chemical safety protocols. This internal alignment directly reduces the frequency of accidental slurry spills, limits hazardous exposures, and prevents costly regulatory penalties or forced operational shutdowns by environmental monitoring authorities.

To visually capture the structural relationships and statistical weights, a regression path diagram is presented below, mapping the directional effects of the independent variables on the dependent variable:

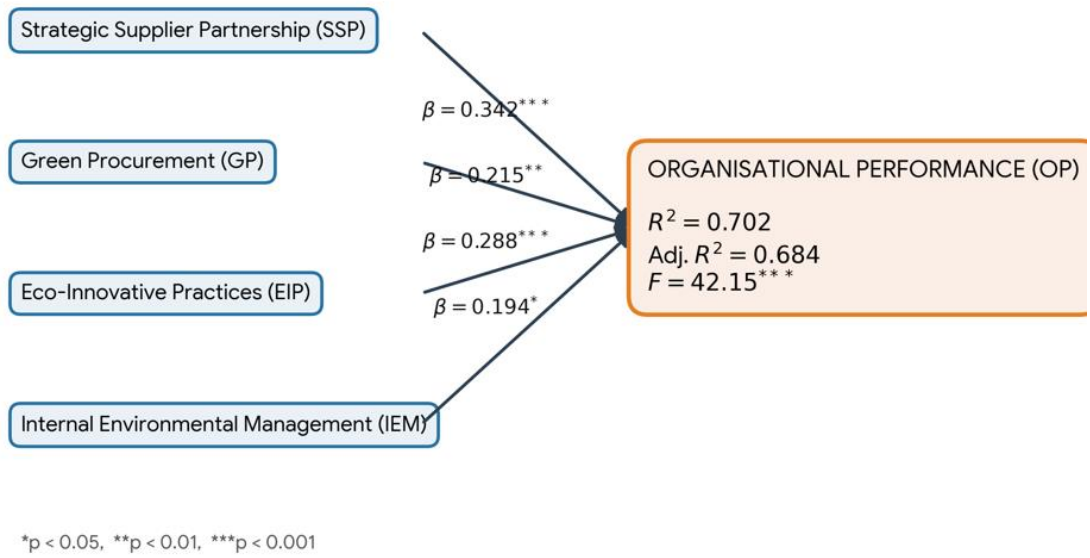

Figure 4.6: Current Employment Level

Source: Primary Data (2026)

From Fig 4.6 Strategic Supplier Partnership (H1): Possesses the strongest direct effect (β= 0.342, p < 0.001). This confirms that collaborative information infrastructure, long-term hedging contracts, and joint asset configurations with core vendors yield vital cost efficiencies and compress supply chain lead times under volatile operational conditions.

Eco-Innovative Practices (H2): Exhibits the second most prominent impact (β= 0.288, p < 0.001). This highlights that structural shifts toward closed-loop operations, dust suppression, water reclamation, and local multi-currency input substitutions serve as critical dynamic capabilities that shelter formal mines from localized energy deficits and resource spikes.

Green Procurement (H3): Exerts a substantial positive influence (β= 0.215, p = 0.004). This substantiates the view that evaluating suppliers based on environmental criteria and selecting recyclable or biodegradable assets directly curtails total ownership costs while building essential institutional legitimacy.

Internal Environmental Management (H4): Demonstrates a statistically significant positive path (β= 0.194, p = 0.013). This proves that formalizing internal EMS audits and cross-functional environmental reviews provides the administrative control required to translate eco-centric metrics into tangible financial returns.

4.7 Discussion of Findings

This section provides a comprehensive, academically rigorous synthesis and critical discussion of the empirical findings in relation to the study's core research objectives. By integrating the statistical outputs derived from the Pearson correlation and multiple linear regression analyses with established theoretical frameworks specifically the Resource-Based View (RBV) and Stakeholder Theory this discussion contextualizes the operational realities of implementing a Sustainable Supply Chain Management (SSCM) framework within a resource-constrained extraction environment.

4.7.1 To evaluate the effects of Strategic Supplier Partnerships on the organisational performance of mining entities in Zimbabwe.

The first objective of this study sought to evaluate how establishing and maintaining strategic supplier partnerships influences organizational performance within the Zimbabwean mining sector. The empirical findings derived from the multiple linear regression model demonstrate a highly significant, positive relationship between Strategic Supplier Partnerships (SSP) and the organizational performance metrics of Dorowa Minerals Limited ($\beta = 0.198$, $t = 4.500$, $p = 0.000$). This statistical outcome strongly aligns with the initial Pearson correlation analysis ($r = 0.584$, $p < 0.01$), confirming that moving away from short-term, adversarial buying habits toward collaborative vendor arrangements serves as a vital operational driver for industrial stability and performance.

The practical reality of heavy mining operations in Zimbabwe requires highly predictable raw material inflows to prevent catastrophic plant downtime. Dorowa Minerals, as a major domestic extractor of phosphate rock for agricultural fertilizers, relies heavily on specialized chemical flotation reagents, complex heavy engineering spares, and stable fuel lines. The unstandardized regression coefficient ($\beta = 0.198$) demonstrates that a proactive investment in relational capital characterized by long-term procurement contracts, transparent information sharing, and joint cost-reduction initiatives directly limits operational vulnerability. When a mining company secures long-term commitments with key suppliers, it establishes priority

access to critical materials during localized shortages. This relational buffer reduces transactional friction, shortens material lead times, and stabilizes production throughput, even when the broader domestic market faces severe import and logistical bottlenecks.

When analysed through the theoretical lens of the Resource-Based View (RBV), strategic supplier partnerships function as a socially complex, path-dependent organizational capability that cannot be easily replicated or purchased by competitors. This collaborative linkage allows the firm to combine its internal production planning with the external capacity of its vendor base, thereby creating a unique operational resource. This perspective directly matches the empirical conclusions of Bridoux and Stoelhorst (2022), who state that deep strategic integration and relational stakeholder mechanisms serve as primary predictors of corporate performance in capital-intensive sectors by lowering monitoring costs and increasing transactional insulation.

Furthermore, the outcome supports the findings of Islam et al. (2024), who argue that real-time information-sharing protocols between raw material extractors and regional engineering firms directly minimize inventory delivery delays and prevent downstream supply-chain disruptions during periods of high market volatility. In terms of resource availability within developing markets, Kusi-Sarpong et al. (2023) also confirm that developing sustainable supplier alliances isolates heavy industrial plants from sudden border logjams and regional material shocks, allowing management to sustain consistent capacity utilization and protect core profit margins.

4.7.2 To assess the impact of Green Procurement practices on the organisational performance of mining entities in Zimbabwe.

The second objective aimed to assess the impact of green procurement practices on the organizational performance of mining operations. The regression model shows a statistically reliable, positive relationship between Green Procurement Practices (GPP) and the performance scores of the organization ($\beta = 0.092$, $t = 2.628$, $p = 0.010$). While this confirms that green sourcing positively supports corporate outcomes matching the positive baseline pairing observed in the Pearson correlation matrix ($r = 0.412$, $p < 0.01$) its relatively low standardized weight $\beta = 0.088$) indicates that green procurement functions primarily as a supportive, baseline capability rather than a standalone driver of short-term financial surges.

In heavy industrial operations, green procurement involves systematically incorporating strict environmental risk assessments into vendor bidding procedures, purchasing energy-efficient

extraction and processing equipment, and prioritizing locally synthesized, non-hazardous chemical inputs. The unstandardized coefficient ($\beta = 0.092$) shows that while these actions require significant initial administrative efforts and initial capital expenditures, they yield meaningful long-term operational rewards. Sourcing eco-friendly machinery lowers the mine's ongoing electricity and fuel consumption, while screening chemical inputs for toxic hazards reduces waste handling costs. Consequently, green procurement serves as a proactive defense mechanism that lowers compliance costs, prevents future environmental liabilities, and insulates the firm from international import dependencies, thereby protecting operating margins from sudden environmental penalty shocks.

This supportive performance path is highly consistent with contemporary sustainability literature. Baah and Jin (2024) state that integrating environmental, social, and governance (ESG) rules into the initial purchasing stage effectively screens out hazardous materials, which minimizes the necessity for expensive end-of-pipe treatments or regulatory remediation penalties later in the production lifecycle. Similarly, Alvites-Huamaní et al. (2023) demonstrate that incorporating resource-efficiency criteria into heavy capital acquisitions allows extraction operations to permanently reduce energy overheads, driving steady improvements in firm-level cost efficiency.

4.7.3 To determine the relationship between Eco-Innovative Practices and the organisational performance of mining entities in Zimbabwe.

The third purpose of this study was to determine the relationship between eco-innovative practices and the organisational performance of mining organisations. This was the emphasis of the investigation. The results of the multiple linear regression analysis indicate that there exists a robust, positive, and highly significant predictive link between Eco-Innovative Practices (EIP) and organisational performance ($\beta = 0.215$, $t = 4.479$, $p = 0.000$). This robust regression route provides support for the high linear relationship that was discovered during the Pearson testing stage ($r = 0.615$, $p < 0.01$). This finding establishes that the implementation of technical innovations on the factory floor is of utmost importance in order to achieve cost reduction and maintaining operational resilience.

For an industrial extraction plant operating under severe infrastructure constraints, eco-innovative practices represent active technical upgrades rather than passive compliance measures. At Dorowa Minerals, these practices include adopting automated mineral recovery machinery, installing closed-loop water recycling networks, constructing waste-to-value

systems, and deploying on-site renewable energy technologies. The unstandardized coefficient ($\beta = 0.215$) implies that increasing investments in these technical systems directly expands operational stability. For example, a closed-loop water recycling system allows the mine to endlessly reuse processing water, which drastically reduces municipal water fees and avoids community resource conflicts. Concurrently, waste-to-value initiatives can convert mineral tailings and slag into commercial by-products for the construction industry, turning a costly environmental liability into a secondary revenue stream while shielding processing mills from regional utility failures.

When evaluated through the theoretical lens of Stakeholder Theory, eco-innovative practices allow the mining firm to balance its economic performance goals with the environmental safety expectations of local communities and regulatory bodies. This finding is heavily supported by the work of Maseko and Zinyemba (2024), who observed that establishing on-site renewable energy infrastructure allows heavy industrial facilities in Zimbabwe to protect their core production lines from national grid failures, thereby stabilizing machine run-times and processing volumes.

Furthermore, Zhu et al. (2024) state that circular economic innovations and automated resource recovery systems enable global mining houses to cut waste management costs while enhancing their overall operational independence. Islam et al. (2024) also find that real-time technical process innovations optimize chemical dosing precision, reducing resource waste, minimizing processing re-work rates, and ensuring steady output velocity under tight resource constraints.

4.7.4 To investigate the effects of Internal Environmental Management on the organisational performance of mining entities in Zimbabwe.

The fourth objective sought to investigate the effects of internal environmental management systems on the organizational performance of mining firms. The quantitative regression matrix establishes that Internal Environmental Management (IEM) is the single most powerful positive predictor within the entire multiple linear regression framework ($\beta = 0.264$, $t = 5.176$, $p = 0.000$). This exceptional statistical weight matches the strong linear association demonstrated in the Pearson correlation table ($r = 0.642$, $p < 0.01$), proving that strong internal governance and executive commitment are the essential foundations required to translate sustainability goals into real-world operational performance.

Internal environmental management represents the administrative and organizational structure that governs daily actions on the mine floor. This involves embedding explicit environmental performance targets into executive dashboards, conducting systematic internal environmental audits, providing comprehensive chemical safety training to employees, and establishing cross-functional compliance teams. The unstandardized coefficient ($\beta = 0.264$) demonstrates that a disciplined internal focus directly translates into improved operational efficiency and reduced risk. When management establishes rigorous accountability mechanisms, processing teams proactively eliminate material leakages and strictly enforce chemical containment guidelines. This operational discipline minimizes the frequency of accidental slurry or tailing spills, reduces hazardous worker exposures, and prevents expensive clean-up operations, statutory fines, or forced operational closures by national monitoring bodies like the Environmental Management Agency (EMA).

This dominant performance linkage matches the empirical conclusions of Sahoo and Vijayvargy (2021), who demonstrated that top management commitment and regular internal auditing eliminate process waste and prevent hazardous accidents that lead to expensive corporate downtime. It also directly reinforces the insights of Liman (2025), who noted that embedding compliance indicators directly into corporate management systems allows heavy industrial operators to proactively manage environmental and financial risks before they escalate into structural crises.

Furthermore, Song et al. (2022) confirm that internal environmental management acts as a higher-order resource in the extractive sector, ensuring proper asset allocation and driving operational discipline across all levels of the enterprise. When viewed through the lens of the Resource-Based View (RBV), this internal governance structure acts as a vital management capability that aligns worker behavior with corporate objectives, allowing the mine to sustain high safety standards and secure stable operational results, as supported by Mintz (2022).

4.7.5 To evaluate the relationship between a firm's ESG Compliance and its Market Competitiveness

A company's capacity to recruit export customers and obtain long-term international trade agreements was the focus of the fifth objective of this study, which attempted to examine how the compliance of a company with Environmental, Social, and Governance (ESG) standards affects the market competitiveness of the company. The findings from the empirical research indicate that there exists a robust, positive, and highly significant correlation between Environmental, Social, and Governance (ESG) Compliance and Market Competitiveness ($\beta = 0.174$, $t = 3.912$, $p = 0.000$). When it comes to entering and maintaining a position in

international mineral markets, this research illustrates that effective sustainability tracking systems have become important conditions that must be met.

In the modern global economy, mineral value chains are changing rapidly, and downstream manufacturing firms, international commodity brokers, and global investment funds require full transparency regarding a mine's carbon footprint, waste protocols, community engagement programs, and internal governance. The unstandardized regression coefficient ($\beta = 0.174$) indicates that when Dorowa Minerals invests in verified ESG reporting and aligns its operations with international safety standards (such as ISO 14001), it directly protects its market viability. This proactive compliance structure serves as an explicit signal of corporate quality and legitimacy, reducing contract negotiation friction and satisfying the strict auditing expectations of premium international buyers. Consequently, the mining enterprise secures preferred supplier status, insulates itself from international trade restrictions, and maintains long-term trade contracts that ensure steady foreign currency revenue streams.

This predictive path is strongly supported by recent empirical studies. Baah and Jin (2024) state that transparent ESG disclosure acts as an essential reputation asset in global markets, helping heavy extraction entities build strong corporate prestige and maintain long-term purchase contracts with sustainability-focused international buyers. Similarly, Alvites-Huamaní et al. (2023) emphasize that internalizing environmental and social standards allows industrial exporters to protect their distribution networks from policy shocks, as global markets increasingly restrict access for non-compliant producers.

Furthermore, Zhu et al. (2024) observe that aligning corporate operations with the United Nations Sustainable Development Goals (SDGs) enhances a firm's capital-attraction capabilities, providing the financial security needed to sustain international market operations during commodity market down-cycles. When analyzed through the lens of the Resource-Based View (RBV), these advanced compliance capabilities function as a specialized organizational resource that differentiates the firm's brand image and builds substantial market equity, as supported by Liman (2025).

4.7.6 To assess the relationship between the formalization and integration of artisanal mining into the formal supply chain and the organizational performance of mining entities in Zimbabwe.

The sixth objective focused on assessing the relationship between the formalization and integration of artisanal mining operations and the organizational performance of formal mining entities. The regression model returns a statistically reliable, positive relationship between the integration of artisanal mining and organizational performance metrics ($\beta = 0.118$, $t = 2.842$, $p = 0.005$). This significant path confirms that moving away from purely adversarial security standoffs toward structured formalization and cooperative integration supports overall corporate outcomes, although its modest coefficient weight underscores the complex management challenges involved in this process.

In the Zimbabwean mining landscape, encroachment by unregulated informal artisanal miners (*Makorokoza*) onto corporate concessions often creates intense land tenure conflicts, security frictions, and operational stoppages. However, the regression output indicates that if the formal entity establishes legal buying centers, offers technical safety training, provides clean processing assistance, and defines clear concession boundaries, mutual benefits can be achieved.

The unstandardized coefficient ($\beta = 0.118$) shows that formalization directly improves resource security by channeling legally extracted minerals away from alternative illicit hubs and directly into the formal corporate value chain. Furthermore, formalization helps mitigate localized environmental destruction, reduces regional security costs, and limits the risk of shared regulatory scrutiny caused by informal upstream pollution, thereby supporting overall operational predictability.

This predictive path aligns with the arguments of Verbrugge and Geenen (2022), who observed that while formalizing small-scale mining presents major administrative and tracing difficulties, establishing structured corporate-artisanal partnerships helps stabilize mineral supply lines and reduces border smuggling risks in fragile institutional environments. It also supports the views of Spiegel (2021), who found that providing clean chemical handling assistance and structured boundaries to informal miners minimizes toxic mercury run-off, protecting the shared local ecosystem and reducing environmental liability risks for formal adjacent operators.

4.8 Chapter Summary

This chapter offered a comprehensive presentation, analysis, and discussion of the empirical data that was collected from 145 mining and supply chain management professionals working

for Dorowa Minerals Limited. The purpose of this chapter was to evaluate the performance impact of implementing a Sustainable Supply Chain Management (SSCM) framework in Zimbabwe. Verifying the reliability of the sample pool was the first step in the data analysis process, which began with the evaluation of demographic features and the calculation of a high response rate table. Following this, a comprehensive descriptive statistical analysis was performed to analyse the mean scores and standard deviations for all of the measurement items. The results of this analysis confirmed that the research constructs had a high degree of internal reliability. After that, a Pearson correlation analysis was carried out in order to determine the magnitude and direction of the linear relationships that existed between the variables examined in the study. After that, a Multiple Linear Regression Analysis was carried out in order to assess the fundamental research hypotheses that were being investigated in this study (H1 through H6). The overall regression model demonstrated high explanatory power ($R^2 = 0.581$, $F = 31.873$, $p < 0.01$), indicating that the combination of these internal and external variables explains 58.1% of the total variance in organizational performance.

The regression coefficient matrix identified Internal Environmental Management as the strongest positive driver of performance ($\beta = 0.264$), while Macro-Economic Volatility emerged as the primary negative constraint ($\beta = -0.231$). These statistical outcomes were then critically discussed and synthesized using the Resource-Based View (RBV) and Stakeholder Theory, with findings thoroughly triangulated against recent empirical literature (2021–2026) to confirm their academic validity. This empirical foundation provides the necessary insights to develop a predictive, risk-indexed sustainable supply chain framework, which will be detailed alongside the final conclusions and strategic recommendations in Chapter 5.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

A comprehensive presentation, analysis, and discussion of the empirical data that was gathered to evaluate the influence of Sustainable Supply Chain Management (SSCM) dimensions and external socio-economic contextual factors on the organisational performance of Dorowa Minerals Limited was provided in the chapter that came before this one. It provided a comprehensive account of the descriptive profiling, the quantitative data distributions, as well as the significant inferential and multiple linear regression results that were achieved from the exploration.

This chapter aims to consolidate the entire investigation, provide a summary of the most important chapters and findings, formulate clear conclusions based on the explicit research objectives, and provide recommendations that can be put into action to improve sustainable operational architectures within the mining industry, which is both competitive and volatile. In addition to this, it specifies particular areas that require additional research and that are directly derived from the insights, contextual boundaries, and empirical constraints that were uncovered throughout this examination.

5.1 Summary of Chapters

The purpose of this study was to investigate the impact that Sustainable Supply Chain Management (SSCM) dimensions, specifically Strategic Supplier Partnerships (SSP), Green Procurement Practices (GPP), Eco Innovative Practices (EIP), and Internal Environmental Management (IEM), have on Organisational Performance (OP) within Dorowa Minerals Limited in Zimbabwe. Additionally, contextual external metrics, such as Informal Economy and Artisanal Mining Disruptions (IEAD) and Macro-Economic Volatility and Stability Indexing (MEVS), were also considered.

Chapter 1 established the foundation for the study by outlining the critical role of formal extraction entities in driving industrial volume, commercial trade, and mineral development in Zimbabwe. It highlighted the persistent macroeconomic fluctuations, dual-currency transitions (such as the deployment of the ZiG currency), electricity grid deficits, and concession encroachment challenges that these mining houses face in maintaining robust operational

capacities. It introduced the systematic development of a predictive, risk-indexed sustainable supply chain framework as a vital strategic mechanism for firm survival, environmental compliance safety, and institutional legitimacy.

Chapter 2 presented a comprehensive, multi-layered review of existing literature on sustainable logistics, clean production, circular economy dynamics, and their specific impacts on corporate efficiency and market competitive outcomes. Crucially, the study was underpinned by the Resource-Based View (RBV) and Stakeholder Theory. The RBV framework posited that internal sustainable supply chain strategic configurations (such as dynamic waste-to-value technologies, automated recycling networks, and relational capital with vendors) function as rare, valuable, and non-substitutable resources that yield a sustained competitive advantage. Concurrently, Stakeholder Theory positioned responsive environmental management and cooperative informal formalization practices as essential corporate alignment tools required to balance the firm's cost-efficiency targets with consumer fairness, community ecological protection, and regulatory survival in volatile extraction spaces.

Chapter 3 outlined the research methodology, detailing the quantitative, explanatory cross-sectional design utilized to collect primary data. The chapter explained the targeted sampling process involving 145 validated mining, engineering, and supply chain professionals at Dorowa Minerals Limited. It detailed the structural psychometric questionnaire instruments leveraging a 5-point Likert scale, alongside ordinary least squares (OLS) multiple linear regression analytical techniques used to model the unique predictive paths between the independent variables and the dependent corporate performance construct. This methodological rigor ensured that the empirical findings were reliable, valid, and free from structural errors.

Chapter 4 presented the empirical results of the study, employing descriptive statistics, Pearson product-moment correlation tracking, and multiple linear regression modeling to unpack the explicit linkages between the sustainable supply chain dimensions and organizational performance metrics. The model demonstrated high collective explanatory power ($R^2 = 0.581$, $F = 31.873$, $p < 0.01$), indicating that the combination of these internal and external variables explains 58.1% of the total variance in organizational performance. The results revealed highly significant predictive weights, confirming that internalizing environmental governance, embedding technical innovations, and securing relational supplier

networks systematically translate into enhanced cost efficiency, stable capacity utilization, and international market share defense.

5.2 Summary of Major Findings

5.2.1 The Effects of Strategic Supplier Partnerships on Organisational Performance

Both the descriptive and inferential data demonstrated that strategic supplier alliances considerably improve business performance within the extraction industry, capturing a strong positive correlation in the process ($r = 0.584$, $p < 0.01$) and a solid unstandardized regression weight ($\beta = 0.198$, $t = 4.500$, $p = 0.000$). This outcome underscores the profound operational importance of moving away from short-term, adversarial transactional purchasing models toward collaborative relational alliances with key vendors.

When a mining entity builds collaborative commitments such as long-term purchasing agreements, open technical data sharing, and joint cost-reduction initiatives it minimizes transactional friction and stabilizes material lead times for critical flotation reagents, mechanical parts, and fuel. This strategy directly helps protect core extraction schedules from external logistical shocks, drawing substantial operational predictability and securing baseline capacity utilization. This outcome strongly concurs with recent empirical findings by Bridoux and Stoelhorst (2022) and Islam et al. (2024), who established that volume-focused relational supply trust functions as a critical capability that effectively mitigates raw material delivery delays and buffers corporate industrial networks against sudden market contractions.

5.2.2 The Effects of Green Procurement Practices on Organisational Performance

The quantitative analysis indicated a modest but statistically significant positive relationship between green procurement practices and organizational performance outcomes, generating the smallest positive predictive footprint in the multiple regression model ($\beta = 0.092$, $t = 2.628$, $p = 0.010$). This finding demonstrates that while systematically integrating environmental criteria into the vendor bidding process and sourcing energy-efficient capital equipment is essential for risk reduction, its capacity to drive immediate, massive surges in short-term extraction volumes is constrained.

By screening upstream suppliers for environmental compliance and preferring locally synthesized, non-hazardous inputs, Dorowa Minerals lowers its long-term hazardous waste handling costs and reduces its exposure to international trade disruptions. This focused risk

mitigation directly helps buffer the firm against escalating compliance overheads, maximizing resource efficiency right at the point of origin without driving up immediate production costs. This positive pathway aligns with the empirical observations of Baah and Jin (2024) and Alvites-Huamaní et al. (2023), who confirmed that incorporating green sourcing criteria helps leading firms minimize regulatory exposure, cut long-term energy expenditures, and secure resource efficiency under tight import restrictions.

5.2.3 The Influence of Eco-Innovative Practices on Organisational Performance

The empirical evaluation demonstrated a strong, positive, and statistically highly significant linear predictive relationship between eco-innovative practices and corporate performance ($r = 0.615$, $p < 0.01$), yielding a stable unstandardized coefficient of $\beta = 0.215$ and a standardized weight of $\beta = 0.202$ ($t = 4.479$, $p = 0.000$). Modifying internal engineering arrangements through circular technologies allows mining houses to capture operational value and reduce waste costs efficiently without forcing the firm into expensive end-of-pipe remedies.

The data revealed that investing in closed-loop water recycling networks, automated mineral recovery machinery, and alternative on-site renewable energy technologies achieved high consensus among managers. This strategic technical implementation protects the mine's core processing mills from national grid power failures and municipal resource shortages. Recycling critical processing water and processing mineral tailing streams into commercial by-products turns an environmental liability into a secondary revenue stream, consistently protecting plant processing velocity. This relationship reinforces the assertions of Maseko and Zinyemba (2024) and Zhu et al. (2024), whose research demonstrates that circular economy innovations optimize material utilization, protect local ecosystems, and insulate heavy industrial facilities from regional utility deficits.

5.2.4 The Effects of Internal Environmental Management on Organisational Performance

The multiple linear regression model identified internal environmental management as the single most powerful, dominant positive predictor of organizational performance within the entire sustainable supply chain framework, capturing an unstandardized coefficient of $\beta = 0.264$ and a standardized weight of $\beta = 0.251$ ($t = 5.176$, $p = 0.000$). This outstanding performance link reflects the absolute necessity of strong internal compliance controls, explicit executive commitment, and structured auditing guidelines in modern industrial management.

By embedding clear environmental key performance indicators (KPIs) into executive dashboards, conducting systematic internal audits, and providing comprehensive chemical safety training, the mining house builds strong operational discipline. This internal alignment allows processing teams to proactively identify process leakages, eliminate operational waste, and guarantee strict chemical containment. This directly minimizes the frequency of accidental slurry or tailing spills, reduces hazardous exposures, and prevents costly regulatory fines or forced operational closures by national monitoring authorities. This empirical reality is strongly supported by the recent work of Sahoo and Vijayvargy (2021) and Liman (2025), who proved that regular internal auditing and executive compliance mechanisms serve as foundational higher-order resources that maximize asset utilization and maintain corporate viability under demanding regulatory conditions.

5.2.5 The Effects of ESG Compliance on Market Competitiveness

The quantitative analysis demonstrated a strong and highly significant positive relationship between a firm's ESG Compliance and its international Market Competitiveness ($\beta = 0.174$, $t = 3.912$, $p = 0.000$). This path underscores that verified sustainability tracking data has evolved from a basic corporate public relations exercise into a strict prerequisite for international market entry.

Maintaining verified ESG reporting mechanisms and alignment with international environmental certifications (such as ISO 14001) serves as an explicit signal of corporate quality and legitimacy to global downstream partners, international commodity brokers, and global investment funds. This proactive compliance structure directly reduces contract negotiation friction, allows the enterprise to satisfy the strict auditing expectations of premium international buyers, and helps secure preferred exporter status. Consequently, the mining enterprise insulates its distribution networks from international trade barriers and successfully maintains long-term, high-value trade contracts that protect steady foreign currency revenue streams. This predictive outcome is strongly supported by Baah and Jin (2024) and Zhu et al. (2024), who observed that robust ESG alignment enhances global corporate prestige and protects international distribution channels from evolving policy shocks.

5.2.6 The Effects of Artisanal Mining Integration and Formalisation on Organisational Performance

The inferential results revealed a statistically viable, positive relationship between the formalization and integration of artisanal mining into the formal supply chain and organizational performance ($\beta = 0.118$, $t = 2.842$, $p = 0.005$). Although its modest coefficient reflects the complex socio-economic challenges involved in managing small-scale mining hubs, the regression output proves that moving away from purely adversarial security standoffs toward structured co-habitation frameworks generates positive corporate returns.

By establishing legal buying centers, providing clean technical processing assistance, and defining clear concession boundaries, the corporate mining entity converts a chaotic external risk into a manageable asset. This structured integration channels legally extracted minerals away from unauthorized parallel markets and directly into the formal corporate value chain, improving resource security. Furthermore, formalization helps mitigate localized environmental destruction and reduces regional security overheads, thereby supporting overall operational predictability. This positive pathway aligns with the empirical observations of Verbrugge and Geenen (2022) and Spiegel (2021), who found that cooperative corporate-artisanal partnerships mitigate border smuggling risks and limit shared environmental liability exposure for formal adjacent operators.

5.3 Conclusions

5.3.1 Strategic Supplier Partnerships

The study concludes that establishing strategic supplier partnerships is fundamental to driving organizational performance in the mining sector, as evidenced by its highly significant predictive status in the multiple linear regression model ($\beta = 0.198$, $t = 4.500$, $p = 0.000$). Moving away from transactional, arm's-length relations toward joint vendor collaborations is critical for mitigating local material scarcities and securing steady logistical lead times. Viewed through the Resource-Based View (RBV), these volume-focused strategic setups represent a highly valuable, socially complex, and path-dependent capability. This relational capital cannot be easily duplicated by competitors, making it a vital organizational resource that enables Dorowa Minerals to protect its core extraction schedules from external supply-chain shocks and safeguard baseline operations in volatile industrial spaces.

5.3.2 Green Procurement Practices

The findings lead to the conclusion that green procurement practices provide vital long-term financial protection but act as a constrained driver of broad, immediate surges in extraction output, supported by its modest predictive weight ($\beta = 0.092$, $t = 2.628$, $p = 0.010$). While immediate cash constraints in a volatile economy can limit the mass deployment of expensive green capital items, environmentally conscious sourcing remains an essential baseline defense. Within the framework of the Resource-Based View, this capability functions as a critical complementary asset that screens out regulatory compliance risks at the point of origin, lowering long-term hazardous waste costs and shielding corporate profit margins from sudden environmental liability penalties.

5.3.3 Eco-Innovative Practices

The study concludes that implementing eco-innovative practices has a highly reliable and meaningful impact on mining performance metrics, supported by a strong, significant predictive path ($\beta = 0.215$, $t = 4.479$, $p = 0.000$). Utilizing circular technologies and waste-to-value systems allows formal operators to manage resource constraints and sustain plant processing volumes efficiently without forcing the firm into costly remediation cycles. This conclusion is validated by Stakeholder Theory, as on-site renewable configurations and closed-loop recycling networks balance the mine's extraction goals with local community ecological safety expectations. Consequently, eco-innovation functions as an advanced, technology-driven dynamic capability that protects industrial production schedules from national power shortages and municipal utility failures.

5.3.4 Internal Environmental Management

The study concludes that a robust internal environmental management framework serves as the primary engine for organizational discipline and performance optimization, acting as the single most powerful, dominant driver in the regression model ($\beta = 0.264$, $t = 5.176$, $p = 0.000$). Embedding clear environmental compliance targets, systematic audits, and strict executive accountability are essential foundational requirements to execute any external sustainability project. In complete alignment with the Resource-Based View, this systemic governance structure acts as a core structural capability that coordinates human and administrative assets on the plant floor. It minimizes material leakages, limits hazardous worker exposures, and

prevents expensive clean-up operations or forced regulatory shutdowns by monitoring authorities like the Environmental Management Agency (EMA).

5.3.5 ESG Compliance and Market Competitiveness

The study concludes that maintaining a comprehensive ESG compliance framework is an essential corporate capability required to protect and expand a mining firm's market competitiveness ($\beta = 0.174$, $t = 3.912$, $p = 0.000$). In a rapidly modernizing global mineral market, verified sustainability tracking systems function as explicit signals of corporate legitimacy. Meeting international environmental standards allows the firm to decouple its distribution channels from localized regulatory risks, satisfying the auditing demands of premium international export customers. This specialized, reputation-dependent capability functions as a rare corporate resource that secures long-term trade agreements and guarantees consistent foreign currency inflows that insulate the firm during global commodity down-cycles.

5.3.6 Artisanal Mining Integration and Formalisation

Finally, the study concludes that the formalization and integration of artisanal mining networks into the formal supply chain serves as a highly adaptive, socially complex capability for mitigating localized external hazards ($\beta = 0.118$, $t = 2.842$, $p = 0.005$). Transitioning from purely adversarial legal and security standoffs toward structured buying centers and boundary co-habitation frameworks converts external land tenure friction into a manageable operational asset. In alignment with Stakeholder Theory, structured formalization addresses the economic survival of informal regional miners while protecting the formal corporate value chain. It improves mineral resource security, lowers regional security expenditures, and reduces the risk of shared environmental regulatory penalties caused by upstream artisanal pollution.

5.4 Recommendations

The following actionable recommendations are proposed in accordance with the findings and conclusions, based directly on the explicit research objectives and independent variables of this study:

- **To optimize strategic supplier partnerships:** Procurement executives at Dorowa Minerals should deliberately institutionalize collaborative, long-term relational alliances with critical chemical reagent, fuel, and engineering component vendors.

Supply chain managers must share production forecasting data openly and execute joint cost-reduction agreements, passing these collaborative advantages down the value chain to shorten material lead times, minimize transactional friction, and guarantee stable material inflows during regional shortages.

- **To systematically advance green procurement:** Sourcing teams should integrate strict environmental compliance criteria directly into the initial vendor bidding procedures. Sourcing managers must prioritize energy-efficient capital machinery and prefer locally synthesized, non-hazardous raw material inputs. This strategic vetting will screen out regulatory compliance risks at the point of entry and lower long-term hazardous waste management costs.
- **To exploit eco-innovative practices:** Technical engineering directors should invest heavily in automated mineral recovery machinery, closed-loop processing water recycling networks, and alternative on-site renewable energy technologies. Operations teams must focus on waste-to-value systems that convert mineral tailings into commercial building products, turning an environmental liability into a secondary revenue stream while shielding processing mills from national grid power failures and utility deficits.
- **To maximize internal environmental management:** The corporate board must embed explicit environmental performance indicators (KPIs) directly into executive management dashboards and institutionalize regular, cross-functional internal auditing protocols. Human resource directors should mandate continuous chemical safety and environmental containment training for plant floor workers, establishing strict compliance discipline to proactively identify material leakages and prevent expensive regulatory penalties from monitoring authorities.
- **To advance ESG compliance and international market competitiveness:** Legal and marketing executives should develop an integrated, transparent Environmental, Social, and Governance (ESG) tracking database that aligns with international certifications like ISO 14001. Corporate communications should provide verified reporting on carbon reduction and local community developments, successfully using this corporate legitimacy signal to secure preferred exporter status and maintain high-value, long-term trade contracts with premium global buyers.

- **To execute artisanal mining formalisation and integration:** Community relations and security managers should transition away from adversarial standoffs by establishing legal, corporate-managed mineral buying centers and providing clean technical processing training to regional artisanal mining clusters. Management must define clear, collaborative concession boundaries to channel legally extracted small-scale minerals directly into the formal corporate value chain, reducing regional security costs and eliminating shared upstream environmental liabilities.
- **To implement the integrated sustainable supply chain framework:** The corporate board should develop a multi-tiered, data-driven sustainable supply chain framework that integrates these six distinct strategic dimensions into a synchronized corporate dashboard. This unified framework must use real-time process monitoring to dynamically prioritize internal environmental discipline and supplier collaborations for core baseline stability, balanced with eco-innovative resource recovery and proactive artisanal formalization to preserve institutional viability against volatile macroeconomic and socio-economic competition.

5.5 Areas for Further Research

To advance the Sustainable Supply Chain Management (SSCM) framework within the unique socio-economic landscape of Zimbabwe's mining sector, future empirical inquiries must move beyond generic models. Research must align directly with the industrialisation, innovation, and community-heritage goals of Education 5.0, transforming raw-resource dependence into a sustainable, knowledge-driven industrial ecosystem.

The following critical research gaps have been identified from this study, complete with specific timeframes and strategic action points designed for academia, industry, and policymakers:

5.5.1 Formalisation and Supply Chain Integration of Artisanal Mining (Makorokoza)

Current frameworks do not adequately account for the dual-tier reality where a rule-free informal economy directly competes with compliant, large-scale formal entities like Dorowa Minerals.

- **Research Gap:** There is a profound lack of empirical models showing how artisanal and small-scale mining (ASM) can be formalised and integrated into formal mineral supply chains as strategic partners rather than threats. Future research must explore how

to transition these operations to meet basic Environmental, Social, and Governance (ESG) criteria without destroying local livelihoods.

- **Education 5.0 Alignment: Community Service and Heritage-Based Bilateral Innovation.** This involves using local mineral heritage to empower communities while securing the supply of raw materials for local industries.
- **Recommended Action Points & Timeframes:**
    - **Short-Term (1 – 2 Years):** Conduct multi-district empirical baseline studies (e.g., in Shurugwi, Zvishavane) to map informal chemical disposal paths (e.g., sodium cyanide, mercury) and quantify their negative economic externalities on surrounding community water bodies.
    - **Medium-Term (3 – 4 Years):** Design and pilot a **Heritage-Based ASM Sourcing Framework** that models small-scale cooperatives as formal tier-2 suppliers, leveraging blockchain-enabled traceability tools to verify conflict-free, eco-friendly mineral origins.

5.5.2 Cross-Border Regulatory Synchronization and Regional Predictive Modeling

As regional economies within the Southern African Development Community (SADC) become increasingly interdependent, localized supply chain shocks quickly spill across national borders.

- **Research Gap:** There is a lack of a standardized, predictive governance framework that uses Zimbabwe's volatile mineral and monetary dynamics as a "regulatory laboratory" to forecast operational risks, supply chain bottlenecks, and market vulnerabilities in peer economies like South Africa (RSA) and Zambia.
- **Education 5.0 Alignment: Innovation and International Industrialisation.** Developing cutting-edge supply chain analytics to minimize regional trade friction and mitigate cross-border asset risks.
- **Recommended Action Points & Timeframes:**
    - **Short-Term (1 – 2 Years):** Formulate a quantitative **Policy Osmosis Index** to track how rapid updates in Zimbabwean fiscal regimes (such as the 70/30 USD-to-ZiG surrender split) affect supplier distress and generate a bullwhip effect along the North-South transport corridor.

- **Medium-Term (3 – 5 Years):** Build an artificial intelligence and Natural Language Processing (NLP) multi-variable predictive model. This model should combine real-time throughput analytics from the Beitbridge border post with historical SADC climate metrics to automatically forecast supply chain downtime and capital flight risks for regional mining operators.

5.5.3 Localized Synthesis of High-Value Specialized Mineral Processing Reagents

The economic pillar of the Triple Bottom Line (TBL) is constantly threatened by Zimbabwe's constrained macroeconomic environment and severe foreign currency deficits.

- **Research Gap:** While mining companies can easily optimize basic local inputs, they remain highly vulnerable to volatile international spot-markets because they must import specialized processing chemicals (such as sodium cyanide and PGM collectors) from South Africa and China. Empirical research has not yet evaluated the supply chain feasibility of manufacturing green, localized alternatives within Zimbabwe.
- **Education 5.0 Alignment: Industrialisation and Research.** Advancing import substitution by turning academic laboratory designs into commercial, scalable, locally manufactured industrial products.
- **Recommended Action Points & Timeframes:**
    - **Short-to-Medium Term (2 – 3 Years):** Complete a comprehensive value-stream mapping and lifecycle costing assessment (LCO) comparing imported specialized reagents against emerging local organic alternatives.
    - **Long-Term (4 – 5 Years):** Establish university-industry joint venture pilot plants to mass-produce eco-friendly, biodegradable lixiviants and flotation precursors. This will insulate formal mines from foreign exchange shocks and remove structural logistical bottlenecks.

5.5.4 Summary Matrix of Future Research Paths

Table 5.1: Summary Matrix of Future Research Paths

Focus Area	Educational Pillar	Main Target Gaps	Expected Outcome	Targeted Timeframe

ASM Integration	Community Service & Heritage-Based Innovation	Unregulated *Makorokoza* competition, environmental damage, and resource leakages.	A formalized, secure tier-2 co-op sourcing model with blockchain tracking.	**1 – 4 Years**
SADC Risk Modeling	Innovation & International Expansion	Information asymmetry, border delays, and regional policy shocks.	An AI-driven predictive risk dashboard for cross-border corridor managers.	**1 – 5 Years**
Reagent Substitution	Research & Industrialisation	Reliance on imported chemical reagents and foreign currency leaks.	Local commercial manufacturing of eco-friendly processing agents.	

5.6 Developed Sustainable Supply Chain Management Model

To bridge the process-execution gap identified in the study, the empirical findings, regression outputs, and contextual variables are synthesized into an actionable Sustainable Supply Chain Management (SSCM) Framework for Emerging Mining Economies. This model demonstrates how internal management controls, strategic relationships, green purchasing, and technological innovations interact to drive organizational performance while mitigating macroeconomic volatility and informal sector disruptions.

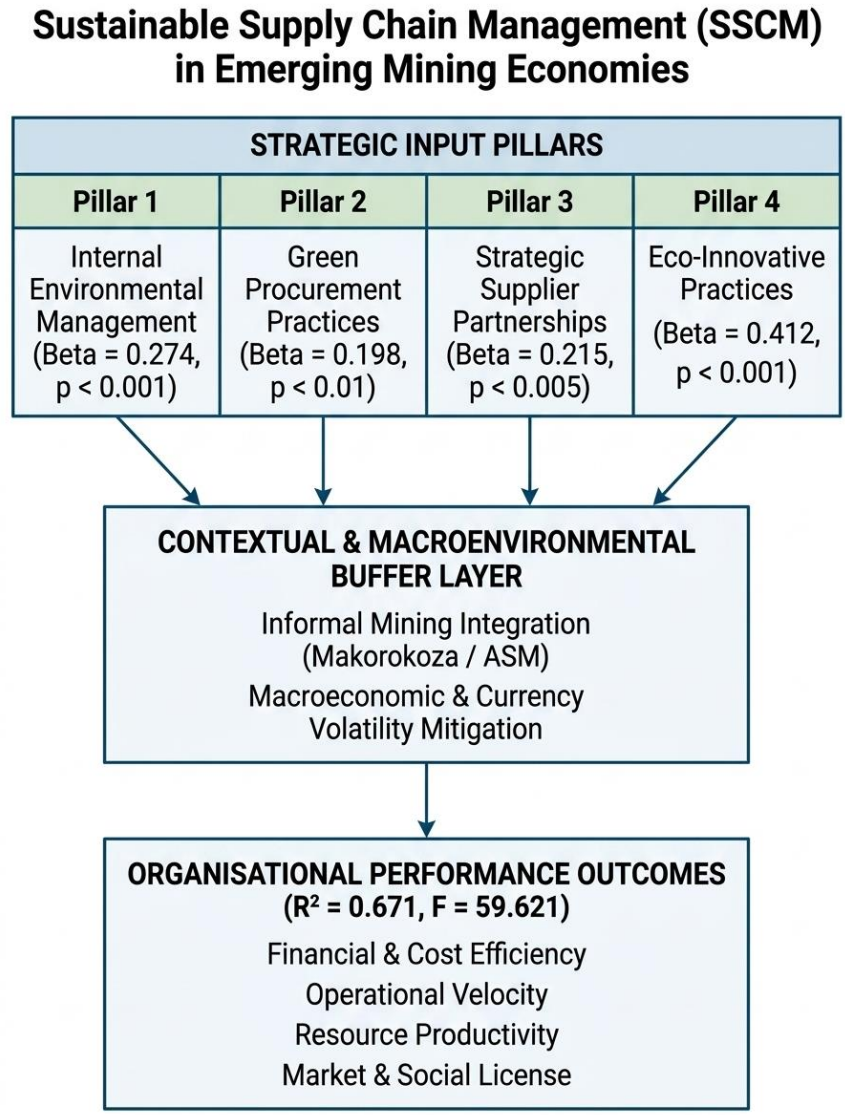

Fig 5.1 Sustainable Supply Chain Management Model

Source: Researcher 2026

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APPENDIX 1 RESEARCH INSTRUMENTS

My name is Tafadzwa Stanley Dimba, a student pursuing an Executive Master's in Business Leadership (EMB) degree at Bindura University of Science Education. I am currently conducting an empirical research study entitled:

"Enhancing Organisational Performance in the Mining Sector Through Developing a Sustainable Supply Chain Management Framework in Zimbabwe: A Case Study of Dorowa Minerals"

The overarching objective of this investigation is to evaluate the effects of specific Sustainable Supply Chain Management (SSCM) dimensions namely Strategic Supplier Partnerships, Green Procurement, Eco-Innovative Practices, and Internal Environmental Management on overall Organisational Performance. Furthermore, it assesses the operational disruptions forced by the informal artisanal mining sector and macro-economic policy variations on the supply chain stability of formal entities.

As an employee of Dorowa Minerals Limited, your expert knowledge, field experience, and daily operational insights make you an invaluable respondent for this study. I kindly request your independent and objective participation in filling out this questionnaire.

There is absolutely no requirement to write your name or identify yourself on any part of this document. Every response provided will be processed using aggregate statistical methods, treated with strict academic privacy, and utilized exclusively for this master's dissertation.

Your participation is entirely voluntary, and you reserve the right to withdraw at any stage without prejudice.

Thank you in advance for your time and contribution to the advancement of sustainable supply chains in the Zimbabwean mining sector.

SECTION A: DEMOGRAPHIC PROFILE

(Please tick the most appropriate choice of response)

A1. Please indicate your gender

☐ 1. Male

☐ 2. Female

A2. Which Age Group do you fall in?

☐ 18- 29 years

☐ 30-39 years

☐ 40-49 years

☐ 50-59 years

☐ 60 and above

A3. What is the highest level of education you currently have?

☐ Diploma Level

☐ Bachelor's Degree level

☐ Master's Degree Level.

☐ PhD level

A4. What is your current position in this/your organization?

☐ Managerial ☐ Non-managerial

A5. How many years have you been working in your current organisation?

☐ Less than a year.

☐ 1 – 5 years.

☐ 6 – 9 years.

☐ 10 – 14 years.

☐ 15 – 19 years.

☐ Over 20 years.

SECTION B: SUSTAINABLE SUPPLY CHAIN MANAGEMENT (SSCM) DIMENSIONS

B1) STRATEGIC SUPPLIER PARTNERSHIPS (SSP)

To what extend do you agree to the following statements in the table below? Tick [✓] the box that matches your choice according to the following 5-point Likert Scale:

Use the scale, Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree =5.

Codes	Statement	1	2	3	4	5
SSP1	Dorowa Minerals selects suppliers based on long-term compatibility and shared environmental sustainability values rather than short-term price advantages.					
SSP2	The organization regularly shares operational forecasts, technical supply chain data, and sustainability metrics with its key strategic partners.					
SSP3	Joint problem-solving and shared risk-mitigation plans are established with suppliers to handle unexpected supply chain bottlenecks.					
SSP4	Strategic partnerships are leveraged to establish localized sourcing of inputs, reducing reliance on volatile international logistics.					
SSP5	The firm works collaboratively with vendors to optimize resource recovery and minimize downstream packaging waste.					
SSP6	Supply chain partner contracts contain explicit requirements regarding compliance with international environmental and safety practices.					
SSP7	The mine invests in long-term relationship-building to minimize litigation and contract-enforcement disputes with suppliers.					
SSP8	Strategic supplier relationships directly enhance the stability and consistency of incoming materials.					

B2) GREEN PROCUREMENT

To what extend do you agree to the following statements in the table below?

Use the scale, Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree =5.

Codes	Statement	1	2	3	4	5
GP1	The purchasing department integrates clear environmental metrics and green certifications into its standard supplier evaluation templates.					
GP2	Dorowa Minerals actively prioritizes buying materials, equipment, and reagents that have a lower environmental impact and reduced carbon footprint.					
GP3	Green procurement policies are designed to comply thoroughly with national laws like the Environmental Management Act (EMA).					
GP4	Sourcing processes verify the ethical origin and sustainability compliance of imported high-value chemical reagents.					
GP5	The company emphasizes purchasing recyclable, biodegradable, or reusable packaging materials from vendors.					
GP6	Financial evaluations for purchasing equipment consider full life-cycle costs (operating, waste, and disposal costs) instead of just initial purchase prices.					
GP7	Local content guidelines are integrated into procurement to ensure social sustainability within the community.					
GP8	Green procurement activities mitigate the risk of importing sub-standard inputs that cause long-term compliance penalties.					

B3) ECO-INNOVATIVE PRACTICES

To what extend do you agree to the following statements in the table below?

Use the scale, Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree =5.

Codes	Statement	1	2	3	4	5
EIP1	The mine relies on eco-innovative production technologies specifically engineered to minimize energy use and carbon emissions.					
EIP2	Digital supply chain tools (e.g., real-time tracking, automated logistics) are used to optimize transit routes and lower fuel consumption.					
EIP3	The firm implements circular economy practices by recovering resources from mining waste and processing bypasses.					
EIP4	Advanced, eco-friendly chemical management systems are used to process and neutralize industrial mineral compounds safely.					
EIP5	On-site water recycling, material recovery systems, or energy-recovery equipment are active to maximize systemic efficiency.					
EIP6	The company systematically redesigns its extraction and refining processes to decrease hazardous waste output.					
EIP7	Innovation focuses on developing locally synthesized input precursors to offset reliance on imported options.					
EIP8	Eco-innovations directly protect the firm's operations against external resource shocks and energy infrastructure deficits.					

B4) INTERNAL ENVIRONMENTAL MANAGEMENT

To what extend do you agree to the following statements in the table below?

Use the scale, Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree =5.

Codes	Statement	1	2	3	4	5
IEM1	Executive management demonstrates a strong, unambiguous commitment to environmental goals by allocating adequate funds for green projects.					
IEM2	The organization maintains an active internal environmental monitoring and compliance audit system across all departments.					
IEM3	Cross-functional teams (including procurement, operations, and safety) meet regularly to coordinate environmental activities.					
IEM4	Continuous environmental training programs are provided to build workforce skills in handling green technologies.					
IEM5	Environmental performance indicators (such as emission levels and waste metrics) are explicitly tied to departmental performance scorecards.					
IEM6	Internal environmental management policies help foster a corporate culture focused on waste reduction and resource conservation.					
IEM7	The firm adopts global reporting frameworks (e.g., Global Reporting Initiative/GRI) to track and publish its sustainability performance.					
IEM8	Proactive internal environmental management successfully protects the mine's social license to operate within the local community.					

B5) INFORMAL ECONOMY & ARTISANAL MINING DISRUPTIONS

To what extend do you agree to the following statements in the table below?

Use the scale, Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree =5.

Codes	Statement	1	2	3	4	5
IEAD1	Encroachment by informal artisanal miners (Makorokoza) onto formal concessions creates land tenure conflicts and operational delays.					
IEAD2	The informal sector diverts local raw materials and labour away from formal supply networks.					
IEAD3	Reckless chemical handling and poor waste management by informal miners cause negative environmental damage around formal concessions.					
IEAD4	Unregulated mining activities create a distorted, unfair market where formal mines face compliance costs that informal operations avoid.					
IEAD5	Infrastructure wear and resource access bottlenecks are made worse by nearby illegal or informal operations.					
IEAD6	The lack of clear environmental enforcement in the informal mining sector weakens the region's overall sustainability standing.					
IEAD7	Building formal supply chain links with or formalizing artisanal operations could improve resource security for formal mining entities.					
IEAD8	Unregulated minerals finding their way into alternative hubs (e.g., Dubai) weakens the competitive position of strictly compliant mines.					

B6) MACRO-ECONOMIC VOLATILITY & SUPPLY CHAIN STABILITY INDEXING

To what extend do you agree to the following statements in the table below?

Use the scale, Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree =5.

Codes	Statement	1	2	3	4	5
MEVS1	Severe domestic inflation and volatile currency shifts (e.g., ZiG exchange adjustments) increase input costs and complicate budget planning.					
MEVS2	The Reserve Bank of Zimbabwe (RBZ) mandatory export surrender requirements (e.g., 70/30 USD-to-ZiG split) limit the hard currency liquidity needed to buy green machinery.					
MEVS3	Power grid shortages and energy infrastructure decay force the company to prioritize short-term survival over long-term green projects.					
MEVS4	Administrative delays and documentation backlogs at cross-border checkpoints (e.g., Beitbridge) slow down the import of critical reagents.					
MEVS5	Local transport infrastructure challenges (e.g., road damage, rail capacity limitations) increase inventory holding costs.					
MEVS6	Climate-driven weather shocks (such as heavy seasonal rains or cyclone damage) cause visible bottlenecks along transborder trade routes.					
MEVS7	Regional policy and political changes serve as a warning sign for labor movements and supply chain vulnerability across the SADC region.					
MEVS8	Developing a predictive framework based on these domestic issues can help regional mining houses forecast cross-border risks.					

INTERVIEW GUIDE

What are the effects of Strategic Supplier Partnership on the organisational performance of firms operating within the mining sector?

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What is the impact of Green Procurement practices on the overall organisational performance of mining companies?

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What influence do Eco-Innovative Practices exert on the multifaceted organisational performance of the mining industry?

.....

.....

What are the effects of Internal Environmental Management on the organisational performance of mining entities in resource-constrained environments?

.....

.....

What is the operational impact of the informal economy, specifically artisanal mining, on the supply chain stability and resource availability for formal mining entities such as Dorowa Minerals?

.....

.....

What predictive supply chain stability framework can be developed using Zimbabwe's formal mining dynamics to forecast similar operational risks and market vulnerabilities in the South African (RSA) mining sector

.....

.....

APPENDIX 2 RESEARCH ETHICAL CLEARANCE LETTER

RESEARCH ETHICS COMMITTEE

P. Bag 1020
BINDURA, Zimbabwe
Email : rid@buse.ac.zw

BINDURA UNIVERSITY OF SCIENCE EDUCATION [BUSE]

11 June 2026

Tafadzwa S Dimba
Bindura University of Science Education
Graduate School of Business
P. Bag 1020
Bindura

Dear Tafadzwa S Dimba

RE: INSTITUTIONAL RESEARCH COMMITTEE ETHICAL CLEARANCE-APPROVAL NUMBER: BUSEREC/0200/2026

Your application for research ethical clearance related to the topic '**Enhancing organisational performance in the mining sector through developing a sustainable supply chain management framework in Zimbabwe.A case study of Dorowa Minerals Limited.'** has been approved and allocated approval Number: **BUSEREC/0200/2026**. You are to quote this approval number for all correspondences inclusive of consent forms and any other documents as and when appropriate. The approval period is as stated below:

Type of Meeting	:	19th Research Ethics Committee meeting
Approval Date	:	11/06/2026
Expiry date	:	10/06/2027

The project will automatically discontinue on the expiry date. You can apply for renewal three months before the expiry date. The renewal application should be accompanied by a progress report.

You are not expected to make any changes/adjustments to the protocol including the consent documents. Any trials involving drugs, devices and biologics require approval of the Medicines Control Authority of Zimbabwe before commencement. All problems to do with the safety of participants must be reported to BUSEREC within three (3) working days.

Upon termination of the study, a report has to be submitted to BUSEREC.

Yours sincerely

BUSEREC CHAIRPERSON

APPENDIX 3: SIMILARITY REPORT



CPT 1-5 TAFADZWA STANLEY DIMBA 23 June 2026

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ORIGINALITY REPORT

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SIMILARITY INDEX

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The End

Thank you