An environmental performance evaluation framework for sustainable operations of Zimbabwean small-scale miners: Evidence from Mashonaland Central province

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DECLARATION

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ABSTRACT

There is a lack of Environmental Performance Evaluation (EPE) frameworks in the literature specifically addressing the unique EPE needs of Zimbabwean small-scale miners, despite the unsustainable development footprints observed in their operations. This study proposes an environmental performance evaluation framework to promote sustainable operations of Zimbabwean small-scale miners. The environmental performance evaluation framework may enhance the sustainability of Zimbabwean small-scale mining operations by providing a basis for measuring environmental performance and guiding managerial decision-making processes. Data collection was done in two ways. First, questionnaires were administered to 315 small-scale miners from Mashonaland Central Province, Zimbabwe. The questionnaire data were employed to develop the EPE framework. Second, interviews were conducted with 16 small-scale miners sampled from Mashonaland Central Province to gather data for the validation of the framework. IBM SPSS 29 software was employed to analyse quantitative data, complemented with the Fuzzy Analytic Hierarchical Process (FAHP). ATLAS.ti 25 software was used to analyse the qualitative data. The final proposed framework comprised EPE indicators grouped into three categories: Environmental Management Control (EMC), Environmental Quality and Degradation Control (EQDC), and Environmental Compliance and Monitoring (ECM) that Zimbabwean small-scale miners can monitor to promote sustainable operations. The study recommends that Zimbabwean small-scale miners adopt and implement the framework and prioritise monitoring of the indicators following the priority order presented by the framework to promote sustainable operations. The study also recommends that training programmes be put in place at the organisational level to support the adoption and implementation of the framework. The study contributes to the management accounting literature, EPE in particular, by proposing a sector-specific EPE framework for the Zimbabwean context.

Key Terms: economic sustainability; environmental performance evaluation; environmental sustainability; institutional isomorphism theory; social sustainability; stakeholder theory; sustainability; tragedy of the commons theory; triple bottom line

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DEDICATION

I dedicate this study to my family and my mother, Grace Kuradu, for their unconditional love.

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ABBREVIATIONS AND ACRONYMS

CDP	Carbon Disclosure Project
CSRD	Corporate Sustainability Reporting Directive
DJSI	Dow Jones Sustainability Indices
DPSIR	Drivers, Pressures, State, Impacts, Responses
EA	Environmental Accounting
ECI	Environmental Condition Indicator
EEA	European Environmental Agency
EIA	Environmental Impact Assessment
EITI	Extractive Industries Transparency Initiative
EMA	Environmental Management Accounting
EMAS	Eco-Management and Audit Scheme
EMEP	Environmental Monitoring and Evaluation Programme
EMS	Environmental Management System
EPA	Environmental Protection Agency
EPE	Environmental Performance Evaluation
EPEI	Environmental Performance Evaluation Indicators
EPI	Environmental Performance Index
EPI	Environmental Performance Indicator
ESG	Environmental, Social, and Governance
EU	European Union
FAHP	Fuzzy Analytic Hierarchical Process
GDP	Gross Domestic Product
GEO	Global Environment Outlook
GHG	Greenhouse Gas
GRESB	Global Real Estate Sustainability Benchmark
GRI	Global Reporting Initiative
ICMM	International Council on Small Scale Mining and Metals
IFAC	International Federation of Accountants
IFC	International Finance Cooperation
IISD	International Institute for Sustainable Development
ILO	International Labour Organization
IPIS	International Peace Information Service

IR	Integrated Reporting
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
MCDM	Multi-Criteria Decision Making
MEMA	Monetary Environmental Management Accounting
MFA	Material Flow Analysis
MFCA	Material Flow Cost Accounting
MPI	Management Performance Indicator
NGO	Non-Governmental Organisation
OPI	Operational Performance Indicator
PEMA	Physical Environmental Management Accounting
SASB	Sustainability Accounting Standards Board
SBTI	Science-Based Targets Initiative
SDGs	Sustainable Development Goals
SFA	Substance Flow Analysis
SSM	Small-Scale Miners
TBL	Triple Bottom Line
TFNs	Triangular fuzzy numbers
UN DSD	United Nations Division for Sustainable Development
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNGC	United Nations Global Compact Local Network
UNIDO	United Nations Industrial Development Organization
UNISA	University of South Africa
WARS	Water Accounting and Reporting Standards
WBCSD	World Business Council for Sustainable Development
WCED	World Commission on Environment and Development
WEF	World Economic Forum
WFA	Water Footprint Assessment
WFN	Water Footprint Network
WRI	World Resources Institute
ZELA	Zimbabwe Environmental Law Association

CHAPTER 1: BACKGROUND TO THE STUDY

1.1 INTRODUCTION

Environmental Performance Evaluation (EPE) is a contemporary management accounting research topic pursued by researchers worldwide. EPE is considered an enabler of the sustainable operations of small-scale miners (Mas-Machuca & Marimon, 2019). EPE entails the collection and analysis of environmental information to establish the environmental performance of organisations (ISO 14031, 2021). Through EPE, inefficiencies in resource consumption, waste management, and emission reduction are minimised (ISO 14031, 2021). Like any other discipline, EPE has its unique challenges. From a global perspective, small-scale miners have been generally pursuing EPE with reluctance (Ndiweni & Seif, 2024; Moyo et al., 2023; Singo et al., 2022; Mambrey et al., 2020). This study sought to develop an EPE framework that guides small-scale miners in conducting sustainable business operations.

This introductory chapter sets the foundation for the study. Section 1.2 provides the background and context for the research problem. Sections 1.3 and 1.4 discuss and outline the problem statement and research objectives, respectively. Section1.5 outlines the research questions. Sections 1.6, 1.7, and 1.8 outline and discuss the thesis statement, delineation, and limitations of the study. Section 1.9 provides operational definitions of key terms. Underlying assumptions of the study are discussed in Section 1.10. The theoretical framework is discussed under Section 1.11. The research methodology and significance of the study are discussed in Sections 1.12 and 1.13, respectively. The chapter overview is presented under Section 1.14. The chapter concludes with a summary in Section1.15.

1.2 BACKGROUND TO THE PROBLEM

Extant literature emphasises the need for small-scale miners to follow a sustainable development path in their operations (Ndiweni & Seif, 2024; Moyo et al., 2023; Singo et al., 2022; Mambrey et al., 2020). In one way or another, the operations of the small-scale miners may harm the environment. Small-scale miners should therefore strive to manage their environmental impacts through effective EPE to achieve sustainable operations (Ndiweni & Seif, 2024; Mubonderi, 2023; Zimbabwe Auditor-General, 2015).

1.2.1 Environmental performance evaluation towards sustainable development

The necessity for small-scale miners to undertake sustainable development initiatives in their operations, given their significant negative environmental impacts, was indicated by Ndiweni and Seif (2024), Moyo et al. (2023) and Mubonderi (2023), to mention only a few. To mitigate adverse environmental impacts, the deployment of effective EPE initiatives has been widely suggested in management accounting literature as a significant measure (Bosetti, 2023; ISO 14031, 2021). EPE, as a systematic process for collecting and analysing environmental information and data within the management accounting domain, facilitates organisations to have deep insights into the understanding of their environmental performance (ISO 14031, 2021). EPE is a valuable tool for the identification of environmental impacts, monitoring them, and informing the decision-making process concerning environmental sustainability (ISO 14031, 2021). A critical pillar of the EPE process is the use of environmental performance indicators (EPIs), which integrate diverse environmental data to promote holistic evaluations of environmental performance (United Nations [UN], 2001).

ISO 14031 (2021) classifies EPIs into management performance indicators (MPIs), operational performance indicators (OPIs), and environmental condition indicators (ECIs), each providing unique insights into an organisation's environmental management accounting perspectives. EPE is increasingly pivotal to sustainable operations, with scholarly consensus on the crucial link existing between EPE and sustainable development (Halkos & Argyropoulou, 2021).

1.2.2 Association between environmental performance evaluation and sustainable development

Despite a lack of a universally agreed-upon definition of sustainable development (Oghenekohwo & Frank-Oputu, 2017; Adejumo & Adejumo, 2014), the seminal definition provided in the Brundtland report views sustainable development as development that satisfies the needs of the present without undermining the potential for future generations to satisfy their own (Brundtland Commission, 1987). This view of sustainable development emphasises the need to exploit current resources with future generations in mind. EPE is an enabler of sustainable development, as it sets benchmarks and objectives for achieving environmental management accounting goals (Halkos & Argyropoulou, 2021).

Through EPE, inefficiencies in resource consumption, waste treatment, and emissions are reduced, thereby promoting sustainable operations (ISO 14031, 2021). Furthermore, public

disclosure of environmental performance information, through EPE reporting frameworks, enhances organisational transparency and accountability to stakeholders, including investors, regulators, and communities, thereby promoting environmental responsibility and sustainable development (Jackson, 2021). More broadly, EPE information alerts policymakers to environmental trends and the performance of existing legislation, thereby informing evidence-based policy to guide progress toward the Sustainable Development Goals (SDGs) (Jackson, 2021). EPE specifically addresses some of the United Nations Sustainable Development Goals (UN SDGs) like clean water and sanitation (SDG 6), affordable and clean energy (SDG 7), responsible consumption and production (SDG 12), climate action (SDG 13), life below water (SDG 14), and life on land (SDG 15) (Pedersen, 2018; Jackson, 2021).

1.2.3 Global and regional perspectives on environmental performance evaluation implementation

Globally, EPE implementation and performance vary considerably across industries and geographic locations (Kevser et al., 2025), potentially creating a complex and dynamic landscape. Industrialised countries are likely to have better controls and more advanced EPE practices, whereas developing countries are often affected by capacity and resource shortages (Mubonderi, 2023; van der Poll, 2022; Shahabadi, Samari & Nemati, 2017). Although EPE has improved recently, significant challenges remain in evaluating the environmental effects of small-scale mining (Ndiweni & Seif, 2024; Mubonderi, 2023). Similarly, the implementation of EPE in Africa is characterised by uneven uptake, owing to varying stages of environmental regulations and enforcement on the continent. Although there is a global movement towards more integrated EPE strategies, low-income countries continue to face insufficient technical capacity and financial resources for effective implementation of EPE (Kevser et al., 2025; Shahabadi et al., 2017). This may constrain data collection, analysis, and dissemination, and consequently, transparency and accountability.

1.2.4 Zimbabwean perspective on environmental performance evaluation implementation

In Zimbabwe, small-scale miners face the complex task of balancing economic development and environmental management accounting (Ndiweni & Seif, 2024), and most are not in a position to conduct EPE due to a lack of necessary expertise and financial capacity (Ndiweni & Seif, 2024). As a step towards EPE implementation, Zimbabwe adopted the Environmental

Management Act [Chapter 20:27] of 2002, which mandates EPE for all developmental projects, including mining, through environmental impact assessments (EIAs) (Zimbabwe Auditor-General, 2015). Despite the adoption of the Environmental Management Act, unsustainable operations persist in the mining sector (Zimbabwe Auditor-General, 2015).

The Zimbabwe Auditor-General (2015) reveals that constrained resources and technical expertise within government agencies often compromise the implementation of EPE on developmental projects. Such a scenario can potentially compromise EPE, especially in the small-scale mining sector. As revealed by the Zimbabwe Auditor-General (2015), the Environmental Management Agency and the local environmental regulatory authority are failing to properly execute their environmental management mandate. The regulatory authority has been criticised for conducting irregular and inadequate environmental audits in the mining sector.

The Zimbabwe Environmental Management Agency has also been criticised for its failure to effectively enforce environmental impact assessment (EIA) controls. Many miners have been found operating without or with expired EIA certifications (Zimbabwe Auditor-General, 2015). The Environmental Management Agency has also been found to maintain incomplete environmental management records, thereby further compromising its capacity to fulfil its mandate. However, the regulatory authority has also attributed the anomalies to inadequate staffing. The report also revealed that environmental regulation non-compliance penalties are ineffective as deterrents, as there is a concerning trend where the same offenders commit similar offences repeatedly (Zimbabwe Auditor-General, 2015).

Similarly, the African Minerals Development Centre (2017) reported that the Zimbabwean mining code contained no provisions for regulating small-scale mining operations. The code was last updated in 1961(African Minerals Development Centre, 2017). This may explain why substantial environmental harm is increasing in Zimbabwe's small-scale mining sector (Singo et al., 2022). The country's less regulated operations contribute significantly to deforestation, biodiversity loss and ecological disturbance (Nitschke et al., 2025). Spontaneous resource exploitation activities exacerbate environmental impacts. In addition, dust emissions contribute to air pollution and respiratory illnesses, as well as substantial greenhouse gas (GHG) emissions (Nitschke et al., 2025).

The environmental impacts have disproportionate hazardous effects on local communities (Kwang & Blagogie, 2025). The Zimbabwean small-scale miners have often experienced mine

collapses resulting in injuries and deaths. Mine explosions and respiratory diseases, due to inadequate safety protocols, have been the order of the day (Singo et al., 2022).

It is clear that the sector needs to be regulated. Most of the small-scale miners operate informally. The adoption and implementation of effective EPE frameworks may constitute a critical pillar of the formalisation required for the sustainable operations of small-scale miners.

1.2.5 The way forward: Environmental performance evaluation frameworks implementation

The adoption and implementation of effective EPE frameworks may help regulate small-scale mining operations to achieve sustainability. However, like most developing nations, Zimbabwe is evidently behind with the adoption and implementation of EPE frameworks due to limited expertise and resources. On the contrary, developed countries have more active EPE systems in place due to pressure from increasingly stringent regulations (Kevser et al., 2025; van der Poll, 2022; Shahabadi et al., 2017). Limited availability of easily accessible environmental impact data constrains comprehensive global EPE and targeted improvement initiatives. While technological advancement may offer opportunities for greater sustainability in advanced economies (Yu et al., 2025), the small-scale mining sector, in developing countries, seems to be struggling in this regard (Jackson, 2021). Often, developing countries lack the technical and economic capacity to implement the EPE frameworks (Jackson, 2021).

Several EPE frameworks and guidelines have been presented in the literature. These include the ISO 14031 guideline, Extractive Industries Transparency Initiative, Global Reporting Initiative (GRI) standards and material flow analysis, to mention a few (Obi, 2025; Bosetti, 2023; ISO 14031, 2021). However, their technical sophistication or generality has the tendency of demanding high technical capacity and sums of money, rendering them inaccessible to small-scale miners who have limited financial capacity (Kevser et al., 2025; Yu et al., 2025; Shahabadi et al., 2017). Additionally, some frameworks, such as the European Environment Agency (EEA) core set of indicators and the Eco-management and Audit Scheme (EMAS), may have limited applicability to the Zimbabwean context, as they primarily focus on the European context (Gurvitsh, 2017; Wenk, 2005). The generic frameworks may not apply to the unique EPE needs of Zimbabwean small-scale miners as they require considerable tailoring to suit their contexts. The required tailoring requires higher-level technical expertise and financial investments that are generally beyond the reach of the small-scale miners. It is within this

context that this research study proposes a simplified, cost-effective baseline EPE framework tailored to the EPE needs of Zimbabwean small-scale miners to support sustainable operations.

1.3 PROBLEM STATEMENT

There is a lack of EPE frameworks in the literature which specifically address the unique environmental performance evaluation needs of Zimbabwean small-scale miners, despite them having evidently shown an unsustainable development path in their operations (Ndiweni & Seif, 2024; Moyo et al., 2023; Singo et al., 2022; Mambrey et al., 2020). Such unsustainable mining practices confirm the tragedy of the commons theory which clarifies that shared resources tend to be over-exploited if not well managed (Hardins, 1968). The scenario is further worsened as the small-scale miners face little pressure from environmental regulators as explained by the stakeholder theory (Ndiweni & Seif, 2024; Singo et al., 2022; Freeman, 1984). The current problem is likely a result of the miners copying informal, environmental non-compliant mining practices from their peers as explained by the institutional isomorphism theory (DiMaggio & Powell, 1983).

Although it is acknowledged that multi-faceted EPE frameworks exist, most of them are generic in nature and require considerable tailoring to meet the unique EPE needs of the Zimbabwean small-scale miners (Bosetti, 2023; ISO 14031, 2021; Gurvitsh, 2017). This situation primarily results in a context adaptation gap which needs to be addressed. The required tailoring may only be possible with higher-order technical EPE skills, which are often lacking among the small-scale miners (Kevser et al., 2025; Yu et al., 2025; ISO 14031, 2021; Shahabadi et al., 2017). Moreover, most of the small-scale miners are financially constrained when hiring the required technical expertise for the necessary tailoring (Kevser et al., 2025; Yu et al., 2025; Ndiweni & Seif, 2024). Zimbabwean small-scale miners operate in a unique economic, social and political context, which also requires a context-specific EPE framework to curb the escalation of the ongoing environmental harm to preserve natural capital. This mismatch between existing EPE framework designs and Zimbabwe small-scale miners' realities creates a secondary implementation gap which complicates implementation efforts due to high cost and operational complexity (Bansah, Yalley & Dumakor-Dupey, 2021). This research study, therefore, proposes a baseline environmental performance evaluation framework to promote sustainable operations of Zimbabwean small-scale miners.

1.4 AIM AND RESEARCH OBJECTIVES

This study aims to develop an environmental performance evaluation framework for the sustainable operations of Zimbabwean small-scale miners.

The research objectives of this study are to:

- **RO1:** Determine the environmental performance evaluation indicators being monitored by Zimbabwean small-scale miners.
- **RO2:** Assess the extent to which small-scale miners in Zimbabwe balance economic, environmental, and social sustainability in their operations.
- **RO3:** Establish environmental performance evaluation indicators that can promote sustainable operations of Zimbabwean small-scale miners.
- **RO4:** Identify factors affecting the monitoring of environmental performance evaluation indicators by Zimbabwean small-scale miners.
- **RO5:** Develop an environmental performance evaluation framework to promote sustainable operations of Zimbabwean small-scale miners.

1.5 RESEARCH QUESTIONS

The study seeks to answer the following research questions:

- **RQ1:** Which environmental performance evaluation indicators are being monitored by Zimbabwean small-scale miners?
- **RQ2:** To what extent do Zimbabwean small-scale miners balance economic, environmental, and social sustainability in their operations?
- **RQ3:** Which environmental performance evaluation indicators can promote sustainable operations of Zimbabwean small-scale miners?
- **RQ4:** What factors are affecting the monitoring of environmental performance evaluation indicators by Zimbabwean small-scale miners?

1.6 THESIS STATEMENT

An environmental performance evaluation framework can improve the sustainability of Zimbabwean small-scale mining operations by providing a basis for measuring environmental performance and guiding managerial decision-making.

1.7 DELINEATION

The study focuses on developing an EPE framework to promote sustainable operations of Zimbabwean small-scale miners. The small-scale mining sector is chosen based on its perceived significant operational impact on the environment. The study adopts a mixed-methods approach as both qualitative and quantitative data are collected. Primary data were gathered through questionnaires and interviews from small-scale miners operating in the Mashonaland Central province, Zimbabwe. The study excluded all other small-scale miners from other provinces other than the Mashonaland Central Province because of proximity reasons and the significance of mining operations in the province. The study only targeted small-scale miners perceived to be knowledgeable in environmental management accounting. The study only focused on small-scale miners who accepted study invitations. The sample for the main study was selected using simple random sampling, whilst the sample for the pilot study was conveniently selected. The study is anchored on the tragedy of the commons, institutional isomorphism and stakeholder theories.

1.8 LIMITATIONS

The study is limited because the data were gathered from only one (1) out of the 10 provinces of Zimbabwe. This might affect the generalisation of results and findings. However, future studies may incorporate the remaining provinces and extend or confirm current results and findings. Data on sensitive EPE issues might have been affected by greenwashing tendencies of research participants, in that they might deliberately give inaccurate responses to questions probing their EPE and sustainability practices. The participants might do so to portray a favourable picture, which may contradict their current EPE positions. This might compromise data credibility, results and findings of the study. However, to minimise the potential adverse effects of such tendencies, the potential benefits of participating honestly in the study were clearly explained to the participants so that they would understand the need to give accurate responses. Moreover, the respondents were assured that their responses would be treated with confidentiality, as their identities would not be published in the research reports. Assurance was given that no personal identification details were to be shown on questionnaires.

Moreso, the study relied exclusively on self-reported questionnaire data and did not triangulate with environmental records, physical site observations, community perspectives or objective environmental measurement. This might create potential for recall bias and social desirability bias as respondents might over-report environmentally favorable EPE practices. To reduce

bias, the questionnaire ensured respondent anonymity, used neutrally worded questions, and was pilot tested. Also, findings were interpreted as perceptions rather than objective measurements, as future research should triangulate these findings with field observations and environmental data to validate ground realities.

1.9 DEFINITION OF KEY TERMS

Environmental performance evaluation (EPE): An organised process of collecting and analysing environmental data to establish an informed position about an organisation's environmental performance (Own definition).

Sustainable Operations: Capacity to last longer in business conducted in an environmentally and socially conscious manner (Own definition).

Sustainable Development: Development that lasts (Own definition).

Small-Scale Miner: For this study, this term refers to any small-scale mining establishment registered as such under Zimbabwean legislation (Own Definition).

1.10 UNDERLYING ASSUMPTIONS

It was assumed that small-scale miners in Zimbabwe generally understood the EPE concept and the need to operate sustainably, and that they would embrace developments in EPE if the process were conducted formally and well-organised.

1.11 SIGNIFICANCE OF THE STUDY

This study is important to several parties.

Zimbabwean small-scale miners: The proposed EPE framework can potentially guide and motivate the small-scale miners in EPE and promote sustainable operations. The need for small-scale miners to conduct their operations sustainably is well documented in the literature (Ndiweni & Seif, 2024; Moyo et al., 2023; Singo et al., 2022; Mambrey et al., 2020). This may help in safeguarding natural capital, thereby promoting sustainable development. Natural capital is the critical pillar for economic development (Barker, 2021).

National policymakers: Human life may be placed at risk when businesses disregard environmental and social obligations in their operations. Negligent environmental conduct may have serious effects, including global warming (climate change) and biodiversity loss (depletion of plant and animal species). Unprecedented changes in temperature and

precipitation patterns have been recorded globally in recent decades, and further change is predicted to occur in the near future, mainly because of human activity (Jeppesen et al., 2015). From this perspective, the proposed EPE framework may help national policy makers to regulate the operational conduct of small-scale miners to reduce their environmental burdens, thereby saving lives.

Academics/Researchers: The study is expected to make a valuable contribution to the EPE literature by developing an EPE framework specific to the environmental needs of Zimbabwean small-scale miners. The literature generally lacks such baseline EPE frameworks specific to the needs of Zimbabwean small-scale miners. Therefore, the study addressed a gap in the literature.

1.12 CHAPTER SUMMARY

This introductory chapter aims to define the tone for the entire study. The need for the study has been articulated in the background section, with the research problem concisely articulated in the problem statement. The need for the small-scale miners to conduct their operations sustainably has been highlighted. The importance of developing a sector-specific EPE framework has also been emphasised. The chapter also outlined the research objectives to be addressed within the specified assumptions, delimitations and limitations. Key terms have been defined in the context of the study. The next chapter presents the theoretical perspectives.

CHAPTER 2: LITERATURE REVIEW-THEORETICAL PERSPECTIVES

2.1 INTRODUCTION

This chapter positions the study within relevant theoretical lenses by discussing the theoretical frameworks that underpin it. Section 2.2 presents the theoretical framework, which discusses in detail the theories underpinning the study. The study is anchored in the tragedy of the commons, stakeholder, and institutional isomorphism theories. The chapter concludes with a summary in Section 2.3.

2.2 THEORETICAL FRAMEWORK

A theory is a well-structured explanation of a given phenomenon (Hofstee, 2006). To gain a clearer understanding of organisations' EPE responsibilities and their actual behavioural positions concerning EPE, attention is drawn to the tragedy of the commons, stakeholder, and institutional isomorphism theories. These theories are discussed below.

2.2.1 Tragedy of the Commons Theory

Hardin (1968) put forth the groundbreaking economic theory known as the Tragedy of the Commons in 1968. It explains the difficulties of overseeing collective resources, sometimes referred to as the commons (Hardin, 1968). The theory posits that a shared resource, such as forests, fishing areas, or grazing land, available to numerous users, should be well-regulated. The theory further clarifies that when the shared resource is poorly regulated, users tend to act in their self-interest, typically maximising their gains from the resource without considering the long-term impact on others. Over time, the shared resource may be exhausted or deteriorated as each user seeks to maximise personal gains. The tragedy results from this, as everyone who depends on the shared resource suffers when the resource's sustainability and long-term value are degraded (Hardin, 1968).

In the context of small-scale mining, the environment can be framed as the commons. The theory works as follows: Communities and small-scale miners frequently share environmental resources, including land, water, forests, and air quality. Small-scale miners may prioritise short-term financial gains over environmental preservation when regulations and enforcement are lax. Self-serving, uncontrolled mining can lead to soil erosion, deforestation, water pollution, and biodiversity loss, all of which can harm the natural commons (Nitschke et al., 2025; Mas-Machuca & Marimon, 2019). As clean water supplies, fertile land, and ecosystem

health are compromised, long-term environmental degradation resulting from collective negligence can affect the broader community and the miners themselves.

Small-scale miners may also generate uncontrolled waste, contaminated water sources with hazardous chemicals, or clear forests for small-scale mining operations, subsequently destroying the environment (Mas-Machuca & Marimon, 2019). These practices, motivated by personal financial gain, may affect the environment as a whole. It can be assumed that within the framework of the tragedy of the commons, effective environmental protection strategies should be implemented to conserve the commons (the environment) for the benefit of all. This study, therefore, seeks to develop an EPE framework anchored on the Tragedy of the Commons Theory, thereby promoting the sustainable operations of small-scale miners in Zimbabwe.

2.2.2 Stakeholder Theory

The Stakeholder Theory was developed by Edward Freeman in 1984. In this context, it is necessary to explain the term stakeholder. According to Freeman (1984) the word stakeholder gained prominence in management literature in 1963. Initially, the term was meant to describe a special group of parties special to the operations of a business, whose absence would mean the extinction of the business (Freeman 1984). Freeman states that initially, this exclusive group consisted only of shareholders, employees, customers, suppliers, lenders, and society. Freeman insists that the term stakeholder can refer to any group or individual who can influence or be influenced by a business' operations. He further states that there is a reciprocal relationship between the organisation and its stakeholders. This implies that the organisation can affect, or be affected by, its stakeholders. However, Freeman (1984) notes that stakeholder theory presents an oversimplified view of stakeholder groups, as each can be further broken down into sub-stakeholders.

Environmentalists are among the stakeholder groups vital to ensuring environmental management and protection. Environmentalists play a critical role in ensuring that the environment is safe from the actions of organisations through the relevant environmental protection acts and regulatory frameworks. These include the Zimbabwe Environmental Management Agency, International Organization for Standardization (ISO) 14000, United Nations Global Compact Local Network (UNGC), Worldwide Fund for Nature, Non-Governmental Organizations (NGOs) among others.

In support of stakeholder theory, EPE studies have acknowledged and applied the theory across the contexts of those particular studies (Bellandi & Chiacchierini, 2025; Djafar et al., 2025;

Saleem et al., 2020). Organisations' actions may directly or indirectly negatively affect the environment, for example, through emissions of hazardous gases, disposal of hazardous chemicals into water bodies, and similar practices. In this context, organisations should be accountable for their actions and act in an environmentally responsible manner. Organisations in general should be regulated to protect the environment. This assertion aligns with the study's main objective of developing an EPE framework.

It appears that Freeman's stakeholder theory is a response to Milton Friedman's shareholder approach/theory (the Friedman doctrine). The shareholder theory, however, contradicts the stakeholder approach. According to the shareholder approach, businesses do not have any moral obligations or social responsibilities save for maximising shareholder wealth through profit-making (Friedman, 1970). Friedman's view was that the only important thing businesses should be concerned with is shareholder profit maximisation. This might have created a profit-maximisation drive among organisations, potentially at the expense of environmental sustainability. However, Friedman's view has been criticised, as evidenced by the development of a variety of EPE frameworks over the preceding decades, all purportedly aimed at protecting the environment (Obi, 2025; Bosetti, 2023). This indicates how EPE matters are being valued and prioritised.

The literature suggests a general reluctance among organisations to disclose environmental impacts and interactions with the environment. Generally, small-scale miners have been observed to be reluctant to observe regulatory EPE developments voluntarily (Kwang & Blagogie, 2025; Nitschke et al., 2025; Singo et al., 2022). Such a scenario may be better discussed through the lens of the institutional isomorphism theory. It can be assumed that the stakeholder theory encourages small-scale miners to conduct their mining activities not only for profit but with environmental management accounting in mind. They should respect the environmental interests of other stakeholders for a sustainable future.

2.2.3 Institutional Isomorphism Theory

This theory was developed by DiMaggio and Powell in 1983. DiMaggio and Powell (1983) argued that isomorphism explicitly describes the process of homogenisation. The authors identified three mechanisms through which institutional isomorphic change occurs. These are coercive, mimetic and normative isomorphism (DiMaggio & Powell, 1983). Coercive isomorphism derives from political influence and challenges of legitimacy, and mimetic isomorphism emanates from issues of standardisation in relation to responses to unclear

situations, whilst normative isomorphism relates to professionalisation (DiMaggio & Powell, 1983). The authors argue that coercion can be formal or informal, for example, through mandatory government programs such as air pollution control regulations. At times, through mimetic pressures, institutions may voluntarily or involuntarily model themselves, especially against the successful ones, for instance, through staff movements as a result of fear of the unknown (March & Olsen, 1975). Based on Armstrong's (1981) work, normative pressures were interpreted as force or persuasion to comply with the prescriptions of particular frameworks that regulate a profession.

Several prior studies suggest that the institutional isomorphism theory is a prominent influence on EPE practices and related organisational practices. Biesenthal et al. (2018) contend that institutional theories can be used to resolve grey areas in the management of mega projects, and that such problems are more related to institutional frames than technical issues. In the same context, some studies were conducted to establish the extent to which the three mechanisms of institutional theory influenced environmental management accounting practices (EMAPs) and related corporate practices. In this regard, Gunarathne and Lee (2019) discovered that the three mechanisms had varied influences at different levels of environmental management accounting (EMA), with coercive pressures taking the centre stage at the reactive stage, whilst mimetic pressures were found to have the greatest influence on the internal integration stage. The combined mimetic and normative pressures had the greatest influence at the external integration stage.

Shubham, Charan and Murty (2018) showed that normative isomorphism had the greatest influence on the implementation of eco-design and environmental management practices, although they acknowledged the influences of coercive and mimetic isomorphism. Phan and Baird (2015) discovered that coercive and normative pressures were the chief drivers of environmental management systems (EMSs). According to Martínez-Ferrero and García-Sánchez (2017) voluntary assurance of sustainability reports is greatly influenced by normative factors, followed by coercive pressures, though mimetic pressures also drive voluntary assurance of sustainability reporting. On the other hand, Joo, Larkin and Walker (2017) found that all three isomorphism mechanisms are drivers of corporate social responsibility practices in South Korea.

In other studies, all three isomorphism mechanisms were discovered to be relevant in influencing environmental management practices (Kalyar, Shafique & Abid, 2019; Amor-Esteban, Galindo-Villardón & García-Sánchez, 2018; Alonso, Andrews & Hodgkinson,

2016).Institutional isomorphism theory remains relevant for understanding how external pressures may influence the mining organisations' approaches to EPE. Organisations might adopt specific environmental metrics or EPE standards outlined in regulations such as the GRI or championed by stakeholders, even if these metrics do not fully reflect their true environmental impact (Peng et al., 2022). This resembles coercive isomorphism.

Moreover, mining organisations might adopt certain EPE practices simply because they are seen as the noble thing to do or the norm within their particular industry, even though the benefits are unclear or the practices are poorly defined. This relates to normative isomorphism. This can lead to compliance-based EPE practices over true sustainability practices (Peng et al., 2022). Institutional isomorphism theory explains why small-scale miners may behave as they do in EPE. Coercive, mimetic or normative pressures can influence their EPE practices. A clear understanding of this may prompt researchers to investigate the true EPE positions of small-scale miners, thereby informing EPE decision-making. The institutional factors may be embedded in factors affecting organisational EPE practices. This study investigates the impact of institutional factors on organisational EPE practices through the identification of factors affecting the monitoring of environmental performance evaluation indicators by the Zimbabwean small-scale miners.

The tragedy of the commons theory, stakeholder theory and institutional isomorphism theory were operationalized in the selection of variables at a broad construct level due to data constraints within the small-scale mining sector in Zimbabwe using parsimonious, field realistic variables. Institutional isomorphism theory was operationalized through "monitoring extent of EPE indicators" as a proxy for institutionalized practice. Stakeholder theory was operationalized using miner-elicited fuzzy AHP weights in the dependent variable to reflect primary stakeholder priorities and "monitoring extent" in the independent variable to capture whether the miners allocated attention consistent with those priorities. The tragedy of the commons theory was operationalized by treating the minerals as a finite shared resource with the "monitoring extent" representing the key governance solution to resource depletion. Thus, each theory was tested through its core mechanism using variables suited to field conditions, with the "why" explained in the results analysis and discussion chapter.

The theories were also operationalized in the design of research instruments through their core mechanisms and not their direct labels. Institutional isomorphism was captured by "EPE monitoring extent" items on the questionnaire with high monitoring resembling isomorphic institutional practice. Stakeholder theory was operationalized on the questionnaire through the

dependent variable-miners' fuzzy AHP prioritization of environmental, economic and social sustainability, and the independent variable "EPE indicator monitoring extent" to test if attention matched stakeholder salience. The tragedy of the commons theory was operationalized by treating the minerals as a finite shared resource and using "EPE indicator monitoring extent" as the key governance measure to unsustainable resource exploitation. Interviews then validated the theory-driven EPE framework through practitioner utility and indicator relevance assessment questions.

2.3 CHAPTER SUMMARY

The chapter focused on the theoretical framework, discussing how the study fits into the highlighted theoretical lens. The discussion was centred on the tragedy of the commons, stakeholder, and institutional isomorphism theories as the guiding theories for the study. In conclusion, the EPE practices of small-scale miners can be examined through the lens of the three (3) aforementioned theories. Through the lens of the tragedy of the commons, effective EPE strategies should be implemented to protect the commons (environment) for sustainable development. Moreover, stakeholder theory encourages small-scale miners to respect the environmental interests of other stakeholders as they attempt to maximise their profits. This may promote a sustainable future. It has further been noted that coercive, mimetic or normative pressures influence small-scale miners' EPE practices. An understanding of this position may motivate further research into the actual EPE practices of small-scale miners, thereby enabling empirically grounded EPE decision-making. The next chapter presents the literature review empirical findings, and the conceptual framework.

CHAPTER 3: LITERATURE REVIEW-EMPIRICAL FINDINGS AND CONCEPTUAL FRAMEWORK

3.1 INTRODUCTION

The purpose of this chapter is to review literature around EPE. The concept of EPE is discussed in detail in Section 3.2. Section 3.3 discusses research dynamics in EPE, clearly outlining how the EPE field has evolved. Section 3.4 presents the systematic literature review conducted to identify the existing EPE frameworks and discuss their strengths and weaknesses to inform the current study. Section 3.5 outlines the avenues for the proposed framework. Section 3.6 discusses factors affecting EPE. The concept of sustainable development, as it links with EPE, is discussed in detail in Section 3.7. The conceptual framework emerging from the literature review is presented in Section 3.8. The chapter concludes with a summary and conclusion in Section 3.9.

3.2 ENVIRONMENTAL PERFORMANCE EVALUATION

Environmental performance evaluation (EPE) is a sub-concept of EMA, as defined in the international standard ISO 14031. ISO stands for International Organization for Standardization. This global organisation was founded in 1947, comprising more than 120 member states (Sorooshian, Qi & Li Fei, 2018). ISO primarily aims to develop technical standards that promote efficient, safe, and clean service provision. ISO developed the ISO 14000 series, which is a family of voluntary standards and guidance documents meant to help organisations manage environmental impacts in a more sustainable manner (Sorooshianet al., 2018). ISO 14031(Environmental Performance Evaluation [EPE]) is part of the ISO 14000 series.

EPE is a structured process of collecting and analysing data to establish an informed position about an organisation's environmental performance (ISO 14031, 2021). Evidently, EPE should be considered a valuable tool for organisations to identify their environmental impacts, track progress over time, and make informed decisions to improve their environmental performance.

There are guiding principles which should be observed when conducting an EPE. These principles are outlined as follows, as prescribed by the ISO 14031standard:

- **Comprehensiveness** - the EPE process should be comprehensive to the extent that it covers all significant environmental aspects of an organisation.

- **Objectivity** -the EPE process should be conducted objectively and without bias.
- **Accuracy** - the EPE process should be based on accurate data and information for the results to be credible.
- **Relevance** - the principle implies that the EPE process should be aligned with the organisation's specific environmental needs and objectives.
- **Utility** - this implies that the EPE process should be able to serve the needs and expectations of all relevant stakeholders (ISO 14031, 2021).

The EPE process is not conducted randomly. There are prescribed steps which should be followed when executing the process. The ISO 14031 standard outlines the following steps for conducting an EPE (ISO 14031, 2021). Firstly, planning should take place. The organisation should create a well-defined plan for the EPE process. The plan must clarify the scope of the EPE process, the data and information to be gathered, the approaches or techniques to be used, and the expected EPE completion timeframe. The second step is data collection. The organisation should gather relevant data and information to assess its unique environmental performance. The third step is data analysis. The data and information gathered should be analysed to assess the organisation's environmental performance, track its time-lined progress, and discover areas for further improvement. Reporting, as the last step, highlights that the organisation should prepare a detailed report on the results and findings of the EPE process (ISO 14031, 2021).

The outlined steps might assist to make the EPE process concise, clear, and simplified, thereby enabling the achievement of credible environmental performance results. According to ISO (2021), EPE uses environmental performance indicators (EPEIs) to monitor, assess, and manage environmental impacts. EPIs are discussed in detail in Section 3.2.1.

The structured EPE implementation, guided by the outlined principles and procedures, can be beneficial to the small-scale mining sector, considering its documented environmental burden. Such an effective EPE implementation process, by the small-scale miners, may enable them to measure their environmental performance and potentially promote sustainable operations.

3.2.1 Environmental performance evaluation indicators (EPEIs)

EPEIs are measures that integrate various forms of environmental data to facilitate the process of target setting, control, and evaluation of performance to be communicated to stakeholders (United Nations [UN], 2001). EPEIs assist decision-makers in monitoring environmental

performance progress and the identification of environmental protection challenges still outstanding (UN, 2001). Broadly, EPEIs can either be physical or monetary.

- **Physical indicators:** measure the physical use and emissions of resources, such as materials, water, energy, and waste. Examples include energy (kWh/unit of output), water (m^3/unit output), and material (kg/unit of output) consumption (UN, 2001).
- **Monetary indicators:** on the other hand, monitor the financial costs and savings related to environmental impacts. Examples of monetary indicators are environmental costs (as a percentage of revenue), environmental savings (as a percentage of revenue), and environmental investment (as a percentage of revenue) (UN, 2001).

EPEIs are categorised into three distinct groups. These are management performance indicators (MPIs), operational performance indicators (OPIs) and environmental condition indicators (ECIs) (ISO 14031, 2021).

3.2.1.1 Management performance indicators (MPIs)

MPIs are environmental performance indicators that provide information relating to the management efforts influencing an organisation's environmental performance (ISO 14031, 2021). Through MPIs, organisations can measure the extent to which their EMSs are effective in achieving environmental objectives and targets. Examples of MPIs include, but are not limited to, the number of environmental audits conducted, environmental workshops delivered to employees and environmental development projects implemented, and the percentage of relevant environmental aspects managed under EMSs (ISO 14031, 2021).

3.2.1.2 Operational performance indicators (OPIs)

OPIs are environmental performance indicators that provide information concerning the environmental performance of an organisation's operations (ISO 14031, 2021). These indicators assess the environmental impacts of an organisation’s activities, products and services. Examples of OPIs are energy, water and air emission indicators, and waste production indicators (ISO 14031, 2021).

3.2.1.3 Environmental condition indicators (ECIs)

ECIs present useful information concerning the quality of the environment at local, regional, national or global level, for instance, baseline indicators against which environmental trend

analysis can be conducted, for example, measurement of the impact of pollution emissions on local air quality over time (ISO 14031, 2021). Other examples of ECIs include water quality index, biodiversity index, deforestation rate, and climate change indicators (ISO 14031, 2021).

To ensure the proposed EPE framework is comprehensive and adequate, indicators are drawn from each of the three indicator domains. According to ISO 14031 (2021), the EPEI selection process should be well-informed and guided.

3.2.2 Selection of environmental performance evaluation indicators (EPEIs) to promote sustainable organisational operations

The selection of EPEIs should be treated as a critical process that organisations should approach with due care. ISO 14031 (2021) guides the selection and use of EPEIs. According to the standard, organisations should select only those EPEIs that are relevant to their environmental performance targets and goals. The indicators should be specific, attainable and measurable within a specified timeframe. The standard further specifies that consistency is also a factor to consider in the selection process. EPEIs should be consistent with the environmental policies and objectives of an organisation. Since most organisations grapple with limited financial resources, organisations should also consider selecting cost-effective indicators (ISO 14031, 2021; Puig, Wooldridge & Darbra, 2014). Organisations should select ECIs whose measurement scale aligns with products, services and activities of the organisation. Moreover, organisations should consider selecting indicators that they can control and suit their decision-making and information management systems (Feil et al., 2025; ISO 14031, 2021). ISO 14031 (2021) recommends that organisations should have a holistic view of the indicators. They should consider integrating MPIs, OPIs and ECIs in their EPE systems (Feil et al., 2025; Puig et al., 2014).

The following discussion outlines some of the most critical predetermined EPEIs that can support organisational sustainability.

3.2.2.1 Greenhouse Gas (GHG) Emissions (Scope 1, 2, and 3)

The measurement and reporting of GHG emissions are grouped into three categories. These are scope 1 (direct), scope 2 (indirect from electricity and heat purchased), and scope 3 (value chain). These three resemble the critical pillars of climate change mitigation (Wiedmann et al., 2020). By monitoring and measuring these GHG emission scopes, organisations can identify

the main sources of emissions and facilitate the development of mitigation strategies for sustainable development (Feil et al., 2025; Wiedmann et al., 2020).

3.2.2.2 Energy intensity and consumption

It seems that energy intensity and consumption are key and widely adopted EPE indicators. Measuring energy intensity and consumption helps identify energy inefficiencies in organisational systems. This facilitates the implementation of energy-saving measures (Feil et al., 2025; Halkos & Argyropoulou, 2021). This practice enables organisations to conduct trend analysis of environmental performance against industry norms and best practices. This could improve environmental performance (Feil et al., 2025; Puig et al., 2014).

3.2.2.3 Water intensity and consumption

Water supply is generally a contemporary issue worth prioritising for sustainable livelihoods. Accordingly, water intensity and consumption have proven to be critical indicators warranting proper attention in EPE (Halkos & Argyropoulou, 2021). Organisations are often recommended to track their water intensity and consumption and act appropriately to reduce their water footprint (Feil et al., 2025; Halkos & Argyropoulou, 2021; Puig et al., 2014). The literature suggests that efforts are underway to guide the measurement and reporting of water intensity and consumption, including initiatives such as the Global Reporting Initiative (GRI) standards.

3.2.2.4 Waste generation and diversion

Waste generation is almost always an inevitable feature of any production system. As Feil et al. (2025) argue, waste generation and diversion are critical EPE indicators evaluating organisational environmental performance. Waste generation and diversion rates are valuable indicators of resource efficiency and circular economy practices. Organisations can track, measure, and report waste generation and diversion in accordance with frameworks such as the GRI standards (Feil et al., 2025; Halkos & Argyropoulou, 2021).

3.2.2.5 Environmental management system (EMS) certifications

Organisational environmental management system certifications are increasingly regarded as an important benchmark for supply chain sustainability. This makes such certifications a key indicator in EPE (Mosgaard & Kristensen, 2023). EMS certifications serve as a crucial measure

of an organisation's commitment to environmental management (Mosgaard & Kristensen, 2023). Such EMS certifications can be pivotal in establishing organisational environmental policies, setting targets, and environmental performance monitoring.

3.2.2.6 Life cycle assessment (LCA) metrics

LCA metrics enable organisations to track the environmental footprints of commodities throughout their entire life cycle (Gibon et al., 2020). This holistic approach to EPE can promote sustainability. Accordingly, LCA metrics are valuable indicators in EPE that organisations should prioritise in their EPE initiatives. Examples of LCA metrics worth considering include carbon, water, and ecological footprints. Organisations can identify hotspots in these indicators and develop mitigatory measures to promote sustainable operations (Gibon et al., 2020; Chang, Lee & Chen, 2014).

Regulatory compliance and mitigation of environmental accidents

Environmental accidents and low environmental regulatory compliance are common across many organisations, especially in developing economies (Singo et al., 2022). As a result, tracking environmental accidents and regulatory compliance has become contemporary as it helps minimise environmental risks (Afolayan et al., 2021). The frequency of environmental accidents and regulatory non-compliance cases serves as a benchmark for the effectiveness and efficiency of an organisation's environmental management systems (Nitschke et al., 2025; Yang et al., 2025; Afolayan et al., 2021).

These prescribed indicators, often embedded in existing frameworks, appear to guide the consistent measurement and comparison of environmental performance. By using these indicators, organisations may promote sustainable operations and potentially help build a more sustainable future. The EPE indicator selection guidance, discussed here, also guides the indicator selection process for this study.

This study aims to develop an EPE framework that integrates all three indicator categories: MPIs, OPIs and ECIs. The EPEIs are crucial to this study, as they underpin the proposed framework. The next section presents typical environmental performance evaluation indicators from the literature.

3.2.3 Management performance indicators (MPIs), operational performance indicators (OPIs) and environmental condition indicators (ECIs)

Table 3.1 presents a generic set of EPI measures across MPIs, OPIs, and ECIs to guide organisations in selecting EPIs.

Table 3.1: Generic environmental performance indicators (EPIs)

MPI	OPI	ECI
• Percentage of environmental training sessions delivered to employees	• Water consumption indicators • Water pollution indicators • Water footprint of products/ services	• Water quality index • Freshwater depletion indicators • Water pollution mortality rate • Ocean acidification indicators
• Percentage of environmental audits conducted	• Air emission indicators • Air pollution indicators	• Air quality index • Air pollution mortality rate
• Number of environmental improvement projects implemented	• Greenhouse gas emission indicators • Carbon footprint of products/ services	• Ozone depletion indicators
• Percentage of operational units with certified EMS	• Material consumption indicators	• Climate change indicators
• Number of environmental regulatory violations	• Level biodiversity impact	• Biodiversity index
• Percentage of suppliers adhering to environmental standards	• Soil pollution indicators	• Soil erosion indicators
• Implementation of environmental risk assessment procedures	• Resource depletion	• Deforestation rate • Land degradation indicators
• Frequency of stakeholder consultations	• Energy consumption indicators	
• Number of community engagement programs	• Waste generation indicators • Hazardous waste generation indicators	
• Responsiveness to stakeholder concerns	• Noise pollution indicators	
• Adherence to ESG reporting frameworks	• Eutrophication and acidification potential	

MPI	OPI	ECI
• Materiality assessment outcomes	• Percentage of product returned	
• Percentage of significant environmental	• Percentage of product reused	
• Aspects that are managed under the EMS	• Percentage of materials that are recycled	
• Percentage of environmental incidents and accidents that are investigated and corrected	• Durability of products	
• Percentage of environmental compliance obligations that are met		
• Employee satisfaction rate with the EMS		
• Level of management commitment to environmental protection		
• Environmental risk management effectiveness		
• Environmental communication and reporting effectiveness		
• Environmental performance evaluation process effectiveness		

Source: *(ISO, 2021; UN, 2001)*

Table 3.1 presents typical EPIs for MPIs, OPIs and ECIs. Organisations can exercise discretion and select EPIs that suit their needs from the generic EPIs provided in the literature (ISO 14031, 2021). For successful environmental performance assessments, organisations may rely on environmental performance indicator systems. The benefits related to environmental performance indicator systems are discussed next.

3.2.4 Benefits of environmental performance indicator systems (EPISs)

Environmental performance indicator systems (EPISs) are an important part of EPE. An EPIS is a set of indicators that is used to measure and monitor the environmental performance of an

organisation over a given timeframe (ISO 14031, 2021). Organisations can benefit from using EPISs. With EPISs, organisations can measure and track environmental performance over time and establish if performance is improving or deteriorating (Solomon, 2023; ISO 14031, 2021; Aboud & Diab, 2018). Moreover, organisations can identify areas of environmental performance deficiencies and subsequently act on them. Organisations can also benchmark their performance against other organisations through EPISs. By establishing EPISs, organisations can enhance their compliance with environment regulations. EPISs can help organisations improve their communication with stakeholders concerning environmental performance (Messerli et al., 2019; Scherer et al., 2018). EPISs are valuable tools for improving environmental performance. The EPE field is evolving rapidly, with numerous researchers contributing to its growth (Cagalawan, 2025; Alsayegh, Rahman & Homayoun, 2020; Asche et al., 2018; Bhaduri et al., 2016). Multifaceted EPE frameworks and guidelines exist in the literature to support organisations in monitoring their environmental impacts. In Section 3.2.5 these frameworks and guidelines are discussed.

3.2.5 Environmental performance evaluation frameworks and guidelines for indicator monitoring

The following frameworks and guidelines from the literature are pivotal for promoting the monitoring of EPE indicators.

ISO 14031: Environmental performance evaluation guideline

The EPE guideline is crucial for the monitoring of EPE indicators by organisations. ISO 14031 is an internationally recognised standard that guides the identification and use of EPEIs. Access to ISO standards is not always free, as organisations should subscribe to a service to obtain the full standard. Organisations may end up relying on freely accessible previews. This may be challenging for small-scale miners, who operate with limited financial resources. Despite this limitation, ISO 14031 provides a systematic framework for monitoring EPE indicators. The standard is not industry specific; it allows organisations to tailor the EPEIs to their specific needs (Grigoroudis, 2017; ISO, 2021). However, it does not specify a framework for the development, measurement and evaluation of the EPE indicators (Grigoroudis, 2017; ISO, 2021). Another limitation of the standard is that its adoption and implementation are not mandatory (Sorooshian et al., 2018). This may lead to substantial variation and distortion in its application within the same domain. This may pose challenges in business EPE comparisons.

ISO 14064: Greenhouse gases (GHG) guideline

The greenhouse gases (GHG) guideline is another guideline that sets the organisational level for the quantification, monitoring, reporting, and verification of GHG emissions and controls. ISO 14064 provides a standardised methodology which enhances consistency and comparability of GHG reporting. The standard is a comprehensive guideline as it addresses all scopes of GHG emissions (Feil et al., 2025; Wiedmann et al., 2020). However, ISO 14064 may be limited in that it focuses solely on GHG emissions, thereby overlooking other environmental impacts. Also, the standard may be criticised for being too complex to implement. In addition, it is usually expensive to acquire, and the verification process is costly (Feil et al., 2025; Wiedmann et al., 2020). This may pose challenges for small businesses, including small-scale miners.

Life cycle assessment (LCA) standards (ISO 14040/14044)

Life cycle assessment (LCA) standards (ISO 14040/14044) provide broader guidance for the monitoring of EPEIs. The standards can reveal the stages in a product's life cycle that have the greatest environmental impacts and associated costs. This helps organisations to pinpoint the critical environmental evaluation indicators to prioritise. As LCA standards consider environmental costs over the entire life of a product or service, organisations are directed to monitor indicators related to business longevity, recyclability and end-of-life product or service management (Aboud & Diab, 2018; Klüppel, 2005). The standards also guide organisations in the monitoring of indicators related to resource waste reduction. The standards do this by facilitating assessments of the economic and environmental viability of the circular economy goals through comparisons of the life-cycle costs and environmental impacts of linear versus circular strategies (Aboud & Diab, 2018; Pati, 2022; Klüppel, 2005).

Despite these benefits for guiding EPE indicator monitoring, LCA standards have some challenges. They are often associated with complex implementation and are resource-intensive because they require accounting for environmental costs. Their implementation usually requires specialised expertise and tools, which are often lacking among small businesses such as small-scale miners. Above all, obtaining comprehensive data on a product's life cycle across all its stages is not straightforward (Pati, 2022; Klüppel, 2005).

Material flow analysis (MFA)

Material flow analysis (MFA), also known as substance flow analysis (SFA), is an important approach for guiding the systematic analysis of material flows and the inventory of materials within a system over a defined period. MFA provides direct support for monitoring of EPEIs in multiple ways (Brunner & Rechberger, 2016). By tracking the flow of materials, MFA helps organisations identify the exact hotspots where waste and emissions are generated. This necessitates monitoring waste generation rates and emission levels to water, air, and soil. The material flow tracking also helps organisations identify pollution sources (Brunner & Rechberger, 2016).

MFA also provides guidance on comparing material inputs and useful outputs, thereby enabling resource-efficiency assessments. Accordingly, MFA helps organisations identify inefficiencies and losses within the system, thereby encouraging them to monitor indicators related to yield, by-product ratios, and consolidated resource productivity. MFA generates detailed quantitative data that serve as a basis for monitoring the effectiveness of an organisation's environmental initiatives (Brunner & Rechberger, 2016). However, conducting a comprehensive MFA is costly as requires extensive data on all material flows within a specified system. The data collection process requires adequate time and financial resources which small businesses may find challenging. Moreover, in MFA, system boundaries should be clearly defined, a task that is often complex, especially for small businesses (Brunner & Rechberger, 2016).

Material flow cost accounting (MFCA)

Material flow cost accounting (MFCA) is another practice that provides crucial guidance for monitoring EPEIs. MFCA is partially grounded in material flow analysis (MFA), integrating physical flows of materials and energy with their associated costs. MFA promotes the monitoring of EPEIs in different ways. One way is the monetisation of environmental inefficiencies (Wagner, 2015). This is achieved by converting environmental inefficiencies into financial terms by allocating costs to material losses or non-product output. This significantly encourages organisations to monitor and reduce waste and emissions. This directly affects EPEIs, including waste costs and the financial overload of environmental impacts (Wagner, 2015). MFCA is crucial in identifying win-win scenarios for environmental and economic performance by identifying areas in which reducing material losses result in both environmental benefits and cost savings. Despite the benefits of MFCA, its implementation is often problematic as it requires integrating physical flow data with financial accounting

systems. It is a complex task and may be resisted by traditional accounting centres (Bux & Amicarelli, 2022; Wagner, 2015). As with MFA, MFCA primarily focuses on tangible material and energy flows at the expense of other environmental aspects. It fails to capture a full environmental evaluation picture (Bux & Amicarelli, 2022; Wagner, 2015).

United Nations Sustainable Development Goals (SDGs)

The United Nations Sustainable Development Goals (SDGs) represent a framework in their capacity. The SDGs provide a universal framework guiding sustainable development. The framework provides specific indicators for monitoring progress towards environmental targets (Messerli et al., 2019). The SDGs address a wide range of environmental concerns, such as climate change, biodiversity, and resource management, among others. The SDGs are globally recognised and cover a wide range of economic, social and environmental issues (Messerli et al., 2019; Scherer et al., 2018). The SDGs facilitate the alignment of organisational goals with global sustainability targets. However, the SDGs are primarily high-order indicators that typically require further disaggregation to suit organisational-level indicator monitoring. There is no legal enforcement for the implementation of the SDGs and organisations may choose not to implement them, which may, in turn, derail sustainable development (Messerli et al., 2019).

Science-Based Targets Initiative (SBTI)

The Science-Based Targets Initiative (SBTI) is a framework that guides corporate climate action by motivating organisations to set science-based emission-reduction goals aligned with the latest climate science. SBTI guides the target setting to limit global warming levels to well below 2°C, with a focus on limiting global warming to 1.5°C (Giesekam et al., 2021). SBTI is commended for facilitating the setting of targets grounded in climate science, thereby promoting reasonable contributions to climate change mitigation. Targets anchored in SBTI are independently validated, thereby enhancing their credibility. The framework is pivotal to achieving significant reductions in GHG emissions (Giesekam et al., 2021). SBTI is limited in that it primarily focuses on GHG emissions, ignoring other environmental impacts. Similarly, the SBTI target setting process can be complex and requires specialised expertise (Reisinger et al., 2024; Giesekam et al., 2021). Small businesses, such as small-scale miners, may find it challenging to implement such a framework because they often lack the requisite expertise. Moreover, because it is not a mandatory framework, its benefits may not be appreciated if businesses choose to discontinue its implementation.

Carbon disclosure project (CDP)

The Carbon Disclosure Project (CDP) is a global disclosure framework that enables organisations, cities, states, and regions to assess and manage their environmental impacts. The framework provides standardised questionnaires and reporting guidelines for the disclosure of information on water security, deforestation, and climate change (Garcia-Sanchez & Martinez-Ferrero, 2021). The CDP offers standardised questionnaires for adoption, thereby promoting comparability. Investors widely use the framework to make informed decisions about environmental risks and opportunities (Garcia-Sanchez & Martinez-Ferrero, 2021). The CDP is limited in that its primary focus is on disclosing environmental impacts rather than performance improvement. The standardised questionnaires can be quite exhaustive. It usually requires much commitment from the players involved. Small businesses often find this challenging as they usually devote much of their time to revenue-generating activities (Garcia-Sanchez & Martinez-Ferrero, 2021).

Drivers, Pressures, State, Impacts, and Responses (DPSIR) framework

The Drivers, Pressures, State, Impacts, and Responses (DPSIR) framework provides a causal framework for describing interactions between society and the environment. It assists organisations to identify the drivers of environmental change, the pressures they exert, the resulting state of the environment, the impacts on ecosystems and human health, and the responses to these impacts (Spanò et al., 2016). The framework provides a systematic methodology for analysing environmental impacts. The DPSIR enables organisations to have a holistic understanding of environmental issues. Overall, the framework supports the development of effective environmental policies (Spanò et al., 2016). However, the DPSIR framework can be complex to implement, which may make it unsuitable for small businesses. Moreover, implementing the framework requires extensive data to accurately model environmental interactions. Usually, the framework is not freely accessible (Lewison et al., 2015). These issues may complicate the implementation of the framework, particularly for small businesses like small-scale miners.

Natural capital protocol

The natural capital protocol provides a standardised, holistic approach for organisations to identify, monitor, and value their direct and indirect impacts and dependencies on natural capital (Temmes et al., 2017). Additionally, the protocol is integral to the decision-making

process, as it aims to integrate natural capital considerations (Temmes et al., 2017). Nonetheless, the framework is often criticised for its complexity. The valuation of natural capital usually requires specialised expertise (Whitaker, 2018). It seems that small businesses, such as small-scale miners, may have a limitation with regard to these specialised skills.

Eco-management and audit scheme (EMAS)

The Eco-Management and Audit Scheme (EMAS) is another framework that provides crucial guidance on monitoring EPE indicators. EMAS is a voluntary EPE framework developed by the European Union (EU). It seeks to provide guidelines for organisations to evaluate, report, and improve their environmental performance (Wenk, 2005). EMAS is a comprehensive environmental management framework which requires public disclosure of environmental performance. The framework is limited since it primarily focuses on the EU context, which might make the generalisation problematic. The implementation of EMAS can be exhaustive as it requires extensive data. This significant administrative burden may discourage small businesses, such as small-scale miners (Gurvitsh, 2017; Wenk, 2005).

Dow Jones Sustainability Indices (DJSI)

The Dow Jones Sustainability Indices (DJSI) is a distinct framework that uses a comprehensive, dynamic assessment process to identify companies demonstrating leadership in environmental performance. The DJSI monitors various environmental performance indicators, including, but not limited to, energy consumption, GHG emissions, water and waste management, biodiversity, and land use (Tehrani et al., 2024; Schmutz et al., 2020). The DJSI are a family of indices that assesses the environmental, social, and governance (ESG) performance of publicly traded organisations. The indices provide a benchmark for investors and other stakeholders seeking to assess the sustainability of organisations. Organisations included in the DJSI are monitored for any critical environmental issues or controversies that may arise (Tehrani et al., 2024; Schmutz et al., 2020). However, the DJSI is often criticised for their complex assessment process and relatively high participation costs. Also, the indices focus on large, publicly traded organisations (Tehrani et al., 2024). This framework cannot be applied to small-scale miners despite its usefulness.

Global Reporting Initiative (GRI) Standards

The Global Reporting Initiative (GRI) Standards also provide a useful framework for monitoring EPE indicators. The standards are a globally recognised framework that provides a systematic approach meant to guide organisations to report on a wide range of sustainability topics, including their environmental performance (de Villiers, La Torre & Molinari, 2022). The GRI standards help organisations monitor EPEs by providing a comprehensive set of environmental topics and disclosures. For instance, the GRI 300 series of standards focuses on environmental topics, covering but not limited to material and energy consumption, biodiversity, emissions, effluents and wastes, as well as environmental compliance (Bosetti, 2023; de Villiers et al., 2022). For each environmental area, the GRI standards prescribe specific disclosures which organisations should report. The disclosures usually include quantitative metrics such as the volume of waste generated (Bosetti, 2023). On the contrary, it seems the standards are generally detailed and resource-intensive to implement, particularly for smaller organisations. While flexibility can be considered a strength, the GRI standards can lead to variations in reporting due to their generic nature. This may lead to inconsistencies in reporting and compromise performance comparisons among organisations in the same industry. GRI standards are generally voluntary (Bosetti, 2023; de Villiers et al., 2022; Haladu, 2019), which limits their implementation in various organisations.

UNEP's Global Environment Outlook (GEO)

UNEP's Global Environment Outlook (GEO) is another framework which presents a comprehensive assessment of the state of the global environment, analysing environmental trends, pressures, and policy responses. It presents insights into global environmental performance and supports policy development. GEO plays a pivotal role in promoting EPEI monitoring through its robust assessment process (Al-Amri et al., 2019). GEO provides a systematic process for synthesising vast amounts of environmental data and information from various sources, including scientific research, national reports, and monitoring networks. This process of data integration emphasises the significance of consistency and reliability in data collection for effective EPE (Al-Amri et al., 2019). The comprehensive GEO reports often highlight critical environmental issues that require monitoring. Typical areas of concern may include biodiversity loss, pollution levels, and resource depletion, among others. GEO also focuses on bridging the gap between science and policy regarding EPE (Al-Amri et al., 2019).

GEO underscores the importance of monitoring environmental performance through indicator tracking to facilitate evidence-based decision-making. GEO promotes the monitoring of implemented policies for sustainable development. While GEO can be commended for highlighting crucial areas requiring attention, it is often criticised for its inability to directly mandate or standardise the specific EPE indicators to be used at country or organisational level (Al-Amri et al., 2019). This may cause significant variations and possibly distortions in EPE indicator monitoring. Such a scenario may potentially result in compromised EP comparisons by organisations within the same industry. Moreso, GEO falls short in providing detailed localised guidance on EPE indicator monitoring because of its broad nature as a global outlook (Al-Amri et al., 2019).

Environmental performance index (EPI)

The other crucial framework for monitoring EPE indicators is the Environmental Performance Index (EPI). EPI is a structured framework used to check how countries are performing on the environment. The EPI clearly outlines the categories of environmental health and ecosystem vibes. This naturally highlights the areas that require tracking using indicators (Solomon, 2023). The EPI framework guides organisations on the important data that needs to be collected and monitored for EPE purposes. The framework is typically implemented at the country level to compare countries based on their environmental performance. Accordingly, the EPI focuses on policy goals and encourages governments to monitor the indicators they implement to assess their environmental standing (Solomon, 2023). Although EPI may be a crucial framework, policy implementation has always been problematic in many countries, especially developing countries whose institutional isomorphic pressures are weak (van der Poll, 2022; Howes et al., 2018). The prevailing environmental regulations in any country can present barriers to or opportunities for EPE implementation initiatives (Dissanayake et al., 2020; Fuchs et al., 2020; Agyemang et al., 2019; Tura et al., 2018). Ineffective EPE implementation has often been linked to lax EPE regulations (Dissanayake et al., 2020; Fuchs et al., 2020). Seemingly, EPI may not be easy to implement in many African countries.

Corporate Sustainability Reporting Directive (CSRD)

The Corporate Sustainability Reporting Directive (CSRD) is a significant piece of EU legislation designed to revolutionise organisations' reporting procedures on their environmental, social, and governance (ESG) impacts. The CSRD framework significantly

promotes the monitoring of EPEIs (Celli, Arduini & Beck, 2024; Farkas & Matolay, 2024; Allgeier & Fieldmann, 2023). The CSRD framework inherently requires organisations to identify, measure and monitor relevant EPEIs and report them through a standardised reporting framework (Celli et al., 2024).

The framework specifies information to be disclosed on issues such as, but not limited to, climate change, pollution, water and marine resources, biodiversity, resource use, and the circular economy. Over time, the CSRD will require organisations to report on sustainability issues through their value chain. This will facilitate the monitoring of environmental performance by organisations as they interact with one another (Celli et al., 2024; Allgeier & Fieldmann, 2023). However, the implementation of the CSRD pronouncements is often complex and exhaustive, especially for small businesses. Setting up the necessary monitoring system and data-gathering process can be resource-intensive. This can be problematic for small businesses. Since the CSRD primarily focuses on reporting, there is a risk that organisations may prioritise compliance and reporting at the expense of improving their environmental performance (Celli et al., 2024).

Global Real Estate Sustainability Benchmark (GRESB)

The Global Real Estate Sustainability Benchmark (GRESB) is a globally recognised investor-driven framework that significantly promotes the monitoring of EPEIs within the real estate sector. GRESB focuses on monitoring a wide range of environmental, social, and governance (ESG) indicators (Anders et al., 2025). The environmental component focuses on guiding areas related to energy consumption, GHG emissions, water usage, waste management and building certifications. The framework provides a standardised approach to monitoring and reporting environmental performance data. GRESB is complex and time-consuming to implement and only targets the real estate sector. It may not apply to small-scale miners (Anders et al., 2025).

EU Taxonomy of Sustainable Activities

The EU Taxonomy of Sustainable Activities (EUTSA) is a classification framework that lists environmentally sustainable economic activities. The framework is pivotal in promoting the monitoring of EPEIs. The framework prescribes recognition criteria for economic activities (Dobija et al., 2025; Schütze & Sandbaek, 2025). For an economic activity to be sustainable, according to the framework, it should contribute substantially to one of the six (6) prescribed environmental objectives. These prescribed objectives are climate change mitigation, climate

change adaptation, sustainable use and protection of water and marine resources, transition to a circular economy, pollution prevention and control, and protection and restoration of biodiversity and ecosystems (Dobija et al., 2025; Hao & Dragomir, 2025). This directly encourages the monitoring of these EPEIs to achieve the required compliance.

The framework also prescribes the Do No Significant Harm (DNSH) principle, which seeks to ensure that the monitoring of one indicator does not negatively impact other indicators. The framework mandates large organisations and financial market participants to disclose information on how and to what extent their activities are taxonomy-aligned (Hao & Dragomir, 2025; Schütze & Sandbaek, 2025). On the contrary, the framework is often considered complex to implement, as its implementation requires intensive data. Moreover, the quality of the evaluations relies on the quality and availability of the required data of which the data collection process is often exhaustive (Dobija et al., 2025; Schütze & Sandbaek, 2025).

Sustainability Accounting Standards Board (SASB) Standards

The Sustainability Accounting Standards Board (SASB) Standards, now under the purview of the International Financial Reporting Standards (IFRS) Foundation, play a crucial role in promoting the monitoring of EPEIs by focusing on financially material sustainability information for investors. The standards provide industry-specific metrics that enable meaningful comparisons of environmental performance players within the same category (Torea, 2022; Busco et al., 2020). Similarly, the standards pinpoint key EPEIs most likely to impact the organisation's financial health within a specific industry.

SASB standards are designed with investors in mind. This encourages relevant organisations to focus more on monitoring and managing the EPEIs that matter to the investors (Torea, 2022). The usefulness of the SASB standards for other stakeholders appears limited, as they primarily address investor needs. Moreover, their core principle of financial materiality may exclude other important environmental issues that do not immediately translate into direct financial impacts. The SASB standards are evolving rapidly, keeping pace with these changes might be challenging for businesses. Above all, the implementation of the standards appears complex and may require resources, which small businesses may lack.

Empirical review seems to reveal no documented contextualisation or piloting of the EPE frameworks at small-scale mining level in Zimbabwe, with policy documents confirming the existence of generic tools non-operationalised for the small-scale mining realities (Zimbabwe Ministry of Mines and Mining Development, 2019; United Nations Development Programme,

2016). The failure of adaptation stems from a structural mismatch between the data-intensive, expert-driven design of formal EPE systems and the resource incapacitated operations of the small-scale miners (Pact, 2019). This mismatch creates an implementation cliff whereby the complexity of the frameworks exceeds the operational and administrative capacity of the small-scale miners, complicating adoption efforts regardless of intent (Nilsen, 2015). As such, the generic, non-operationalised tools constitute simplified parallel tools rather than adaptations, affirming that downscaling the frameworks without compromising integrity is untenable thus necessitating a novel, context-aligned EPE framework (Pact, 2019). This study therefore seeks to propose an EPE framework aligned with the environmental concerns of Zimbabwean small-scale miners to promote their sustainable operations.

To provide further insights into the EPE phenomenon, the following section examines prevailing research dynamics in EPE.

3.3 RESEARCH DYNAMICS IN ENVIRONMENTAL PERFORMANCE EVALUATION

EPE, a dynamic field, has attracted numerous studies assessing its nature and extent across domains (Cagalawan, 2025; Alsayegh et al., 2020; Asche et al., 2018; Bhaduri et al., 2016). Some studies were sector or industry-specific, whilst others spanned across multiple sectors or industries (Djafar et al., 2025; Feil et al., 2025; Dixon et al., 2024; Dissanayake et al., 2020). However, the literature appears to indicate a concentration of research on high environmental impact sectors such as mining, construction and agriculture (Hutagalung et al., 2025; Kwang & Blagogie, 2025).

While the majority of the studies focused on assessing EPE practices in different sectors or industries (Djafar et al., 2025; Feil et al., 2025; Dixon et al., 2024; Dissanayake et al., 2020), some studies focused on seemingly unique spheres like EPE and circular economy advocacy (Massari & Giannoccaro, 2023; Agyemang et al., 2019) and EPE-technology integrations (Wang et al., 2022; Bai et al., 2020). This clearly shows how the EPE field is evolving. Moreover, some studies examined EPE in greater depth through systematic literature reviews (SLRs) (Vitale, Rosignuolo & Riccaboni, 2025; van der Poll, 2022; Sorooshian, Qi & Li, 2018). This also demonstrates the active research in this area.

The literature seems to lament EPE distortions, complexities and malpractices (Kevser et al., 2025; Singo et al., 2022; Shahabadi et al., 2017), indicating a need for robust EPE regulations and guidance globally. To address such anomalies, diversified empirical EPE frameworks have

been proposed in the literature. The following section presents a systematic literature review conducted to gain a more in-depth and credible analysis of existing empirical EPE frameworks.

3.4 A SYSTEMATIC REVIEW OF LITERATURE ON EXISTING EMPIRICAL EPE FRAMEWORKS FOR SMALL-SCALE MINERS

A literature review is an overview of scholarly work within a particular field of study. It can manifest as part of a conceptual or empirical study and an independent study (Limet al., 2022). As part of a conceptual or empirical study, a literature review connects readers to the theoretical background of a particular topic and clarifies the key concepts within that particular area of study. This enables the formulation of research hypotheses or propositions (Lim et al., 2022). Generally, literature reviews provide a rationale for conducting a study and establish scientific contexts within which a study is conducted (Lim et al., 2022; Wong et al. 2015). Traditional literature reviews and advanced systematic reviews have been pivotal in establishing epistemological research progress in any field of study (Pahlevan-sharif, Mura & Wijesinghe, 2019). However, traditional literature reviews are often criticised for lacking scientific rigour because researchers' assumptions and biases often influence them. They also lack reproducibility as they are not anchored on a predefined literature search protocol (Stratton, 2020).

SLRs can address such limitations (Stratton, 2020; Liberati et al., 2009). Systematic reviews of the literature are often the preferred method for researchers to ensure research rigour, employ predetermined research protocols that limit bias and ensure scientific validity aimed at producing impartial analyses. The search protocol makes the SLR reproducible, thereby enhancing its credibility. They also clearly specify inclusion and exclusion criteria on the search function (Stratton, 2020; Liberati et al., 2009). SLRs follow predefined scientific methods like the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) (Liberati et al., 2009). Studies in various fields have employed SLRs to address distinguished research problems (Vitale, Rosignuol & Riccaboni, 2025; van der Poll, 2022; Kirongo & Odoyo, 2020; Distribution, 2018; Horodnic, 2018; Sorooshian et al., 2018). The same goes for the EPE field.

It is acknowledged that a significant number of SLRs have been performed in the EPE field (Vitale et al., 2025; Subarmanim & Chin, 2022; Mas-Machuca & Marimon, 2019; Wong et al., 2015). However, to the best of the researcher's knowledge, no studies have focused on establishing the available EPE frameworks and assessing their scopes, strengths, and

weaknesses. This SLR of available empirical EPE frameworks was therefore necessary to assess their scopes, strengths and weaknesses. The results of the SLR identify avenues for future research and justify the current study.

To address the aim of the SLR, the PRISMA approach was followed(Liberati et al., 2009). The comprehensive PRISMA methodology is discussed in the next section.

3.4.1 The PRISMA methodology

The SLR was performed for two reasons. Firstly, it was performed to establish the existing empirical EPE frameworks. Secondly, to assess the frameworks' strengths, shortfalls, and scopes. The SLR was guided by the reporting checklist of PRISMA (Liberati et al., 2009). To ensure a comprehensive literature search, a carefully predetermined protocol was implemented using the Scopus advanced search platform, supported by the University of South Africa library. Caution was exercised in all protocols involved to ensure the credibility of the results. Boolean operators (AND, OR) were used in the search string to separate the specified key terms. To ensure a comprehensive search for the frameworks, several relevant synonyms were included in the search string. The search protocol was configured to retrieve the specified keywords from the journal title, abstract and/or keywords.

To obtain a comprehensive, longitudinal overview of existing EPE frameworks, the search protocol was liberalised and not limited by date. However, the search was limited to English-language articles in the business, management, and accounting domains, thereby streamlining the search and excluding potentially irrelevant articles. The decision to consider only research articles was informed by the fact that such articles are typically peer-reviewed by experts in the field. This would increase the chances of extracting credible EPE frameworks. Some of the key features of SLRs include their reproducibility and clarity (Stratton, 2020; Liberati et al., 2009). To ensure this, the search protocol is explicitly stated as follows:

> TITLE-ABS-KEY (("environmental performance evaluation" OR "environmental management accounting" OR "environmental performance monitoring" OR "environmental performance measurement" OR "environmental performance assessment" OR ("environmental performance evaluation" AND indicator)) AND ("framework" OR "model" OR "tool" OR "approach" OR "technique" OR "index" OR "system" OR "guideline" OR "guide" OR "protocol" OR "basis" OR "matrix")). Section 3.4.2 outlines the article screening process.

3.4.2 Article screening PRISMA flow chart

Figure 3.1 depicts the article selection process, as guided by PRISMA. The flowchart clarifies the article selection process used in the SLR.

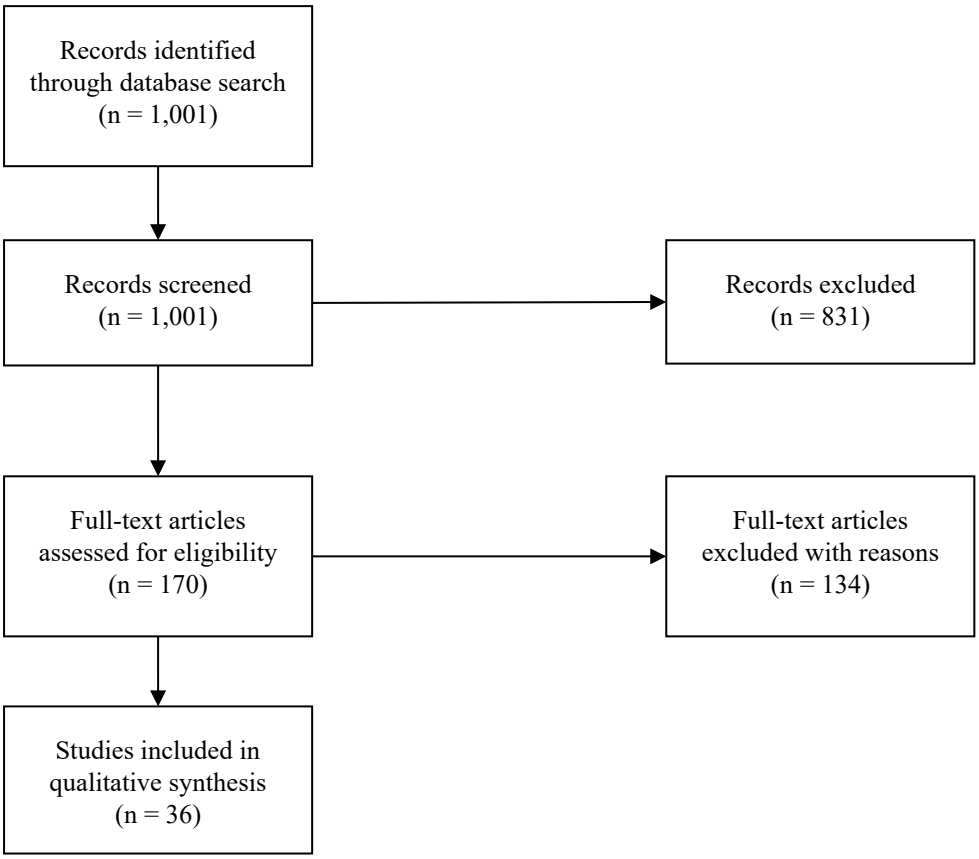


Figure 3.1: Article screening PRISMA flowchart

The article identification process was anchored on the search protocol discussed earlier. The search operation was limited to the document title, abstract, and keywords. Following the initial search, 1,001 documents were identified, as shown in the flowchart. The results were screened, and 831 documents were excluded by limiting the search to English as well as the business, management, and accounting domains. This resulted in 170 full-text articles remaining for further eligibility test. An MS Excel sheet with all 170 articles was imported from Scopus and saved in a separate folder for further screening. The article abstracts were read primarily to assess the articles' relevance to the study. Codes were used to identify the articles. All articles considered irrelevant were coded 0. Relevant articles were coded 1. Nevertheless, some article abstracts were unclear and obscured the article's relevance. Such articles were coded as 2 and subsequently assessed further through full-text scanning. The screening process excluded 134 articles from the final analysis because they were deemed irrelevant to the study. Only 36 full-

text articles qualified for inclusion in the final qualitative analysis, as they were deemed relevant to the study (see Appendix E).

The following subsections indicate the results for the qualitative analysis of the final 36 full-text articles.

3.4.3 Analysis by target country

Table 3.2 presents the distribution of results by target country.

Table 3.2: Analysis by target country

Code	Groundedness	Frequency (%)
China	9	25
Brazil	4	11.11
Italy	4	11.11
Spain	3	8.33
Canada	2	5.56
France	2	5.56
Iran	2	5.56
Netherlands	2	5.56
Portugal	2	5.56
India	1	2.78
Malaysia	1	2.78
Morocco	1	2.78
Romania	1	2.78
Sweden	1	2.78
Thailand	1	2.78
Total	**36**	**100**

The distribution shows that China, Brazil, and Italy lead with the number of proposed EPE frameworks, accounting for 25%, 11.11% and 11.11%, respectively. The distribution also shows that all the research was conducted in the context of either developed economies

(Canada, France, Italy, Netherlands, Portugal, Spain, and Sweden) or emerging economies (Brazil, China, India, Malaysia, Morocco, Romania, Thailand and Iran), despite low research output per country. To the best of the researcher's knowledge, no research on the EPE framework's search output has been identified in the Zimbabwean context. The results indicate that substantial research remains to be conducted on the development of EPE frameworks, both globally and locally in Zimbabwe. These results correspond with prior findings, which also revealed low uptake of EPE initiatives, particularly in developing economies (Ndiweni & Seif, 2024).

The next section analyses the results by target sector.

3.4.4 Analysis by target sector

Table 3.3 presents the distribution of results by target sector.

Table 3.3: Analysis by target sector

Code	Groundedness	Frequency (%)
Manufacturing sector	14	38.89
Agriculture sector	10	27.78
Public sector	5	13.89
Multi-sector	5	13.89
Education sector	2	5.56
Total	**36**	**100**

The results indicate that the majority of the studies proposed EPE frameworks for the manufacturing (38.89%) and agriculture (27.78%) sectors. However, some EPE frameworks were proposed for the public (13.89%) and education (5.56%) sectors, and others were designed to serve multiple sectors (13.89%). These results are noteworthy as the entire mining sector was not represented in the studies despite its substantial environmental impacts. This suggests that EPE is generally followed with less enthusiasm despite the sectors' significant environmental impacts (Kwang & Blagogie, 2025; Nitschke et al., 2025; Ndiweni & Seif, 2024; Singo et al., 2022). The next section presents the distribution of the results by year.

3.4.5 Distribution of results by year

Figure 3.2 presents the distribution of results by year of framework publication.

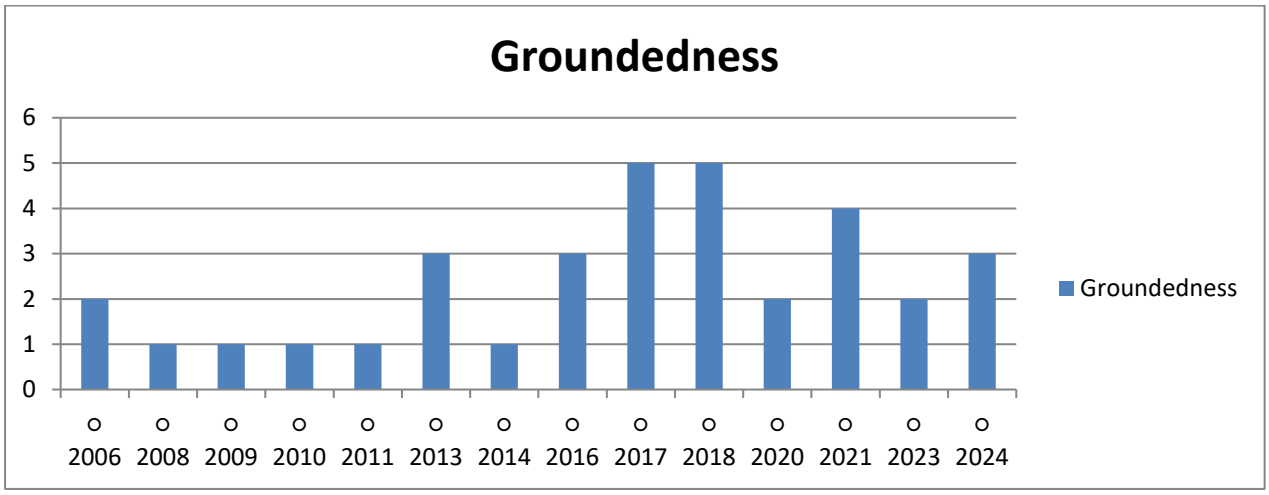


Figure 3.2: Distribution of results by year

The search operation was liberalised by not restricting it by publication year. This enabled a longitudinal analysis of the publications over the years. As shown in Figure 3.2, research on EPE frameworks dates back to 2006. On average, the number of publications from 2008 to around 2014 was constant with a slight increase in 2013. A general steady increase was observed from 2016 to around 2018, after which the growth in publications was seemingly uneven through 2024. Overall, this distribution indicates that research on EPE frameworks appears to be ongoing, although it remains low. This observation calls for further research in the subject area to build on existing EPE frameworks (Bosetti, 2023; Gurvitsh, 2017). The next section discusses the identified strengths and weaknesses of the EPE frameworks.

3.4.6 EPE frameworks' strengths and weaknesses

It has been concluded that all 36 EPE frameworks assessed have the potential to promote sustainable development by leveraging their strengths. Of the 36 frameworks, 31 (86.11%) were proposed for specific sectors, whilst 5 (13.89%) were multi-sector. It has also been discovered that the majority of the frameworks (32 out of 36) (88.89%) were validated and generally comprehensive enough to cater for critical indicators for the EPE needs of the organisations. Nevertheless, it has also been revealed that (29 out of 36) (80.56%) frameworks were seemingly complex and could pose implementation challenges, especially for small businesses. Their implementation required extensive data, which could be costly to gather.

Moreover, the multi-sector frameworks (5 out of 36) may struggle to address sector-specific EPE needs since specific EPE problems often require specific solutions.

As noted, the available empirical EPE frameworks and other EPE guidelines, such as ISO standards, GRI standards, and the environmental performance index, among others, are either context-specific or generalised and adaptable. Either way, problems may arise with the two setups. Adaptable frameworks may be applicable within certain limits; anything beyond the limits may create problems. Adaptable frameworks often provide general guidance that may require tailoring it to specific contexts. However, it appears that the required tailoring or customisation is often challenging and problematic for most organisations. This is also the case with generic international standards, such as ISO 14031 for EPE. ISO 14031 is primarily meant to facilitate internal management decision-making, which impedes its value when it comes to extensive external communication of environmental performance (ISO 14031, 2021).

The conclusion is that adaptable frameworks may not be the answer in some cases, as it has been empirically confirmed that downscaling existing frameworks to suit specific contexts without compromising integrity, is a complex task (Pact, 2019). Context-specific frameworks may be more valuable and practical because they are designed to address context-specific needs. For instance, environmental problems affecting the Zimbabwean small-scale mining sector may be best addressed by EPE frameworks developed specifically for this sector. This may be true if the right methodologies are adopted for the development and implementation of the frameworks. It can therefore be argued that the Zimbabwean small-scale mining sector needs an EPE framework specifically designed for its needs. Therefore, this study aims to develop an environmental performance evaluation framework to promote the sustainable operations of Zimbabwean small-scale miners.

3.5 AVENUES FOR THE PROPOSED FRAMEWORK

The extensive literature review suggests that little progress has been made in developing EPE frameworks specific to the Zimbabwean small-scale mining sector. Primarily, a context adaptation gap exists as it is now evident that EPE guidelines and frameworks exist, despite them falling short in addressing crucial environmental concerns specific to the Zimbabwean small-scale mining context. Most of the frameworks are too broad and complex and originate in formal, capital-intensive mining contexts thus misaligning with the sector's informality, mobility, capital constraints, and tenure insecurity (Bosetti, 2023; de Villiers et al., 2022; ISO 14031, 2021). This misalignment produces a policy gap wherein environmental legislation

exists but with design assumptions rendering compliance prohibitively costly and technically inaccessible for the Zimbabwean small-scale miners (Kevser et al., 2025; Yu et al., 2025). The policy misfit, in turn, entrenches a knowledge gap, as technical solutions remain locked in expert discourse and are rarely translated into low-cost, context specific EPE practices accessible to the Zimbabwean small-scale miners (Kevser et al., 2025; Yu et al., 2025). These three antecedent gaps converge to yield an implementation gap, wherein deficient adoption of EPE frameworks cannot be easily attributed to the miners' defiance, but should instead be conceptualized as a structural manifestation of institutional misalignment, characterised by regulatory instruments, knowledge infrastructures, and technical EPE frameworks configured for a divergent mining context (Bansah, Yalley & Dumakor-Dupey, 2021).

Small-scale miners may require a simple, less costly baseline EPE framework to guide them in achieving sustainable operations in their unique contexts (Kevser et al., 2025; Yu et al., 2025; Shahabadi et al., 2017). Above all, to the best of my knowledge, the systematic literature review conducted has not identified any environmental performance evaluation framework that addresses the unique needs of Zimbabwean small-scale miners. This study, therefore, seeks to address the identified gaps by proposing a simple, more affordable, baseline EPE framework to promote sustainable operations of Zimbabwean small-scale miners.

As part of the framework development process, this study investigates the factors affecting the monitoring of EPE indicator practices of the small-scale miners. The next section reviews literature on typical factors affecting environmental performance evaluation.

3.6 FACTORS AFFECTING ENVIRONMENTAL PERFORMANCE EVALUATION

The literature identifies several factors that can influence EPE in many ways (Dixon, Martin & Field, 2024; van der Poll, 2022; Fuchs, Aghajanzadeh & Therkelsen, 2020). As noted by Khatter et al. (2021), an organisation’s innovation and technological capacity can shape EPE. Innovative organisations with a drive for technological advancement often perform better in EPE initiatives than their counterparts (Khatter et al., 2021; Tura et al., 2018). Short-term, profit-oriented organisations are often less proactive in EPE implementation as their main focus is profit maximisation at the expense of environmental protection (Tura et al., 2018; Howes et al., 2017).

Community engagement and the public relations policy standing of an organisation has also been viewed as a potential driver of EPE. Organisations with proactive community engagement

and public relations polices are more likely to be advanced in implementing EPE. As the organisations frequently engage with local communities and other relevant stakeholders in environmental performance initiatives, they often earn stakeholder trust (Dissanayake et al., 2020; Howes et al., 2017). Further exploration by Tura et al. (2018) highlights third-party certifications as a potential factor influencing EPE. They argue that organisations with recognised environmental certifications, such as ISO 14001, may be motivated to enhance their EPE practices. However, overreliance on such certifications without demonstrable EPE practices may be dangerous, as it may encourage greenwashing tendencies by organisations.

Organisations that have implemented circular-economy approaches are more likely to demonstrate improved EPE practices. Closed-loop production systems and waste-reduction strategies are circular-economy principles that align with sustainability efforts (Agyemang et al., 2019; Tura et al., 2018). Management support and commitment for EPE initiatives can positively drive EPE. Their active stance and participation in EPE projects show an organisation's commitment to better EPE. This is more likely to result in enhanced EPE (Fuchs et al., 2020). Moreover, organisations active in co-creation and partnerships are more likely to execute positive EPE than their counterparts. Active stakeholder collaboration on EPE issues is more likely to foster shared ownership and may lead to effective EPE solutions (Dissanayake et al., 2020; Howes et al., 2017).

Multi-dimensionality and complexity are additional factors that may also affect an organisation's EPE practices. EPE can be a complex process as it involves many issues that resemble an organisation's environmental footprint. An organisation's environmental footprint can comprise resource consumption, emissions, waste generation, and biodiversity effect, chief among others (Dissanayake et al., 2020; Agyemang et al., 2019; Tura et al., 2018). Data unavailability, typically due to limited technical expertise and financial resources, often makes it relatively difficult to capture the complexity involved effectively (Dixon et al., 2024; Khatter et al., 2021; Agyemang et al., 2019).

Stakeholders, including investors, clients, and non-governmental organisations, often have differing and occasionally conflicting expectations. Striking a balance among these many needs may often be challenging (Tura et al., 2018; Howes et al., 2017). Balancing immediate financial objectives with long-term environmental sustainability goals can be problematic, especially when upfront payments are required. Furthermore, the lack of internal EPE expertise has been identified as a key problem affecting EPE in the literature (Dixon et al., 2024; Dissanayake et al., 2020; Agyemang et al., 2019; Tura et al., 2018). The authors concur that organisations may

lack the necessary internal expertise to conduct credible EPE processes for sustainable development.

Organisations' EPE practices may also be affected by the costs associated with implementing, monitoring, and tracking of indicators. Such costs include assurance and verification procedures. The use of third-party audits, to confirm the accuracy of environmental data, can be costly and time-consuming. High EPE investment costs can be involved (Dixon et al., 2024; Dissanayake et al., 2020; Tura et al., 2018). This negatively affects EPE practices of many organisations, as financial resources are often a challenge for most businesses (Khatter et al., 2021).

In addition, van der Poll (2022) contributes that EPE practices can be affected by institutional isomorphic pressures. The author argues that developed countries have stronger institutional isomorphic pressures than developing countries. The literature appears to agree that prevailing environmental regulations in a country can present barriers to, or opportunities for EPE initiatives (Dissanayake et al., 2020; Fuchs et al., 2020; Agyemang et al., 2019; Tura et al., 2018). Lax regulations often compromise the effectiveness of EPE (Dissanayake et al., 2020; Fuchs et al., 2020). As Howes et al. (2018) argue, most environmental challenges arise from failures in policy implementation. Organisational culture plays a significant role in shaping how an organisation behaves in EPE issues (Fuchs et al., 2020; Laurian, Walker & Crawford, 2016). Healthy organisational cultures can promote positive EPE.

This section has discussed typical factors which can influence EPE in different ways. Such factors may be the same for small-scale mining organisations. However, the literature identifies mining methods adopted by a small-scale mining organisation as a potential factor influencing EPE. However, the literature on how mining methods influence EPE remains limited, despite a comprehensive presentation of the likely environmental impacts of each mining method. The main mining methods, that small-scale mining organisations may adopt, are discussed next.

3.6.1 Mining methods

Open-pit mining is one of the methods used in small-scale mining. Open-pit mining resembles gaping wounds gouged into the earth and causes barren wastelands and fragmented ecosystems. Dust generation from mine operations pollutes the air and affects surrounding communities (Upadhyay, 2025). The other method is strip mining. It is associated with linear scars resembling open wounds over the landscape. The method is commonly known for destroying habitats and surface-water ecosystems (Upadhyay, 2025). Strip mining's footprint is typically

smaller than that of open-pit mining; however, its environmental impacts can similarly be considerable. Tunnelling and shaft mining can also be used in small-scale mining. This method has a lower visual impact; however, it is often prone to land subsidence, which can cause infrastructure damage and disrupt groundwater flow (Upadhyay, 2025). This method is associated with ventilation emissions, which may pollute the air. Human life can be at risk as miners can be trapped underground (Upadhyay, 2025).

In-situ leaching can also be used as a mining method. This is a seemingly gentler method associated with minimal surface destruction. However, the method is associated with a high risk of groundwater contamination from leachate used in mineral extraction. This is a serious concern that cannot be ignored. Chemical spills and leakages can destroy water quality and associated ecosystems (Upadhyay, 2025). Mineral resources such as shale gas and oil can also be extracted through hydraulic fracturing (fracking). Hydraulic fracturing often causes groundwater and air pollution as well as seismic activity (Upadhyay, 2025).

In addition to the other factors discussed, different mining methods are associated with distinct environmental impacts, thereby producing different magnitudes of EPE. In this study, the potential of mining methods to influence EPE practices of the Zimbabwean small-scale miners is also investigated. The mining methods adopted by a small-scale miner are also considered in this study as factors that can influence the organisation's EPE practices. The framework proposed in this study is expected to promote the sustainable operations of Zimbabwean small-scale miners. The concept of sustainable development, one of the study's main pillars, is discussed next.

3.7 SUSTAINABLE DEVELOPMENT

Sustainable development is increasingly a contemporary issue due to the prevalence of climate change, resource constraints, and persistent inequalities at a global scale. It is necessary to consider future resource needs during current resource exploitation to ensure sustainability (Halkos & Argyropoulou, 2021; Jackson, 2021; Soubbotina, 2004). Sustainable development is the concept of meeting the needs of the present generation without compromising future generations' ability to meet their own needs from the same pool of resources (Brundtland Commission, 1987). It is an approach with a holistic view of development. It recognises the three pillars of sustainability commonly referred to as the TBL. These are the economic (profit/prosperity), social (people), and environmental (planet) dimensions of sustainability (Brundtland Commission, 1987).

The term sustainable development appears to have gained prominence and wide acceptance in the late 1980s, when it was introduced in the 1987 Brundtland report, also known as Our Common Future. Various definitions for the term have been coined in literature, with no universally accepted one (Oghenekohwo & Frank-Oputu, 2017; Adejumo & Adejumo, 2014; Soubbotina, 2004). However, many scholars concur that sustainable development entails the exploitation of natural resources without compromising the future.

Klarin (2018), Zikic (2018) and Soubbotina (2004) agree that sustainable development is anchored in the concepts of development, needs, and future generations through the lens of the TBL framework (environmental, economic, and social sustainability). The term sustainable development is therefore viewed in this study as a model for the exploitation of natural capital for economic development, without preventing future generations from satisfying their needs from the same natural capital reserves. Next, the three dimensions of sustainability are discussed.

3.7.1 Economic, social, and environmental sustainability

Economic sustainability refers to an economy's ability to produce and consume goods and services in a way that can be sustained over time without depleting natural capital or destroying the environment (Messerli et al., 2019; Brundtland Commission, 1987). On the other hand, social sustainability can be understood as the capacity of a society to meet its essential needs, such as water, food, shelter and education, while also ensuring the prevalence of social justice and equality among its members (Messerli et al., 2019; Brundtland Commission, 1987). Environmental sustainability is the capacity of natural ecosystems to provide essential resources and services, such as clean water and air, climate stability, and biodiversity, while absorbing and mitigating the impacts of human activity (Messerli et al., 2019; Brundtland Commission, 1987). The TBL does not exist in a vacuum. The three pillars of sustainability should be addressed holistically to promote sustainable development (Rodríguez-Serrano et al., 2017). The next section discusses the interconnectedness of the TBL components.

3.7.2 The link among the triple bottom line (TBL) components

The three dimensions of sustainability are closely interconnected. Social sustainability can be considered necessary for economic sustainability. For instance, improved social concerns may lead to higher productivity. This can contribute to economic development and maybe associated with economic sustainability (Sidhoum, Dakpo & Latruffe, 2022). Similarly,

economic sustainability can provide the resources and opportunities required to address social challenges. This way, economic sustainability is linked to social sustainability (Messerli et al., 2019). On the other hand, environmental sustainability may be crucial for both social and economic sustainability.

A healthy environment provides crucial resources necessary for survival. These include water, clean air and food. This phenomenon leads to social sustainability (Messerli et al., 2019; Scherer et al., 2018; Brundtland Commission, 1987). A reduction in air pollution can likely yield significant health benefits. This promotes social sustainability. The relationships among social, economic, and environmental sustainability may affect the long-term sustainability (longevity) of small-scale miners in various ways. The relationship between EPE indicator monitoring and sustainability is discussed next.

3.7.3 Environmental performance evaluation indicator (EPEI) monitoring as a need for sustainable operations

The need for sustainable organisational operations has been emphasised due to the increase in environmental burden globally (Kwang & Blagogie, 2025; Nitschke et al., 2025). Tracking of EPEIs is an important procedure for measuring the environmental performance of organisations (Rodríguez-Serrano et al., 2017). EPE indicator monitoring involves systematic collection, analysis, and reporting of data regarding an organisation's environmental performance. The process can include the tracking of resource consumption, emissions, and waste generation (Messerli et al., 2019). Effective EPE indicator monitoring mechanisms can guide organisations in evaluating their environmental performance and in taking corrective environmental measures to ensure sustainable operations (Messerli et al., 2019). It seems that a more transparent disclosure system of EPE indicator data is necessary to promote clarity, accountability, and the strengthening of stakeholder trust. The role of environmental data in sustainable decision-making is discussed next.

3.7.4 The role of environmental data in sustainable decision-making systems

Data gathered from monitoring EPE indicators serves as the foundation for decision-making towards sustainable operations. Trends in organisational environmental performance can be assessed to establish potential drivers of environmental impacts (Rodríguez-Serrano et al., 2017). This enables organisations to establish mitigation strategies to promote sustainable organisational operations (Rodríguez-Serrano et al., 2017). For example, tracking energy

consumption can reveal energy consumption hotspots, while waste generation tracking can provide insights for waste minimisation initiatives (Messerli et al., 2019; Rodríguez-Serrano et al., 2017). Furthermore, it is critical that quantitative interactions between sustainability data be clearly understood to promote the development of integrative EPE policies (Scherer et al., 2018).

Overall, the preceding discussions indicate that tracking EPEIs is a prime motivator of sustainable organisational performance. By providing evidence-based information on environmental impacts, EPE indicator monitoring can enable organisations to make fact-based decisions. This can enhance their accountability and allow continuous improvement. In the next section, the link between the TBL and the longevity of small-scale miners is discussed.

3.7.5 Triple bottom line (TBL) and small-scale miners' longevity

Globally, many people rely on small-scale mining for their livelihoods, despite such businesses facing challenges to their longevity. This section discusses the social, economic, and environmental factors that can impact the long-term sustainability of small-scale mining businesses. To start with, systems to ensure dust control, safety, and adequate ventilation are often absent from small-scale mines. This makes them vulnerable to accidents and diseases, as small-scale miners are exposed to serious lung diseases, wounds, and hazardous materials, such as mercury (Kwang & Blagogie, 2025; Singo et al., 2022). Such situations can adversely affect the operations of small-scale miners, leading to reduced productivity, increased medical expenses, and even fatalities.

To make matters worse, some small-scale miners use child labour, depriving the children of education and a healthy upbringing. The children are also exposed to dangerous job environments. Such unfair labour practices may compromise small-scale miners' access to fair-trade markets due to bad publicity. Subsequently, their long-term sustainability may be negatively affected (Meaza et al., 2015). Similarly, small-scale miners are often adversely affected by international commodity price fluctuations (Jiménez, Smith & Holley, 2024). Accordingly, they may be forced to sacrifice environmental safety protocols in favour of short-term survival when commodity prices fall, due to limited financial resources. This may accelerate the environmental damage (Nitschke et al., 2025; Jiménez et al., 2024). In most cases, small-scale miners are unable to obtain formal financing from financial institutions due to insufficient collateral security. Most of them incur high debt, which may compromise their long-term sustainability (Jiménez et al., 2024).

In addition, small-scale miners often target shallow, easily accessible mineral resources due to limited access to advanced equipment. The shallow minerals are quickly depleted, triggering early and rampant relocations. Such practices are usually associated with high business costs (Yu et al., 2025; Jackson, 2021). On the other hand, reckless environmental management practices by small-scale miners may attract bad publicity and legal action against them. This may compromise the small-scale miners' long-term existence.

It may be critical to note that various small-scale mining problems can compound and threaten the longevity of small-scale miners. The miners ought to adopt a multifaceted approach that strikes a reasonable balance among economic, social, and environmental sustainability factors in their decision-making to ensure prosperity. The next section discusses the balancing of the TBL.

3.7.6 Balancing the triple bottom line (TBL)

It appears that the TBL is not always easy to balance, and there are no prescribed TBL weights in literature (Qaim et al., 2020; Bhaduri et al., 2016). For example, economic growth may sometimes come at the expense of social or environmental well-being (Qaim et al., 2020). Nevertheless, it is crucial to strive for development that meets the needs of the present without compromising the ability of future generations to meet their own needs from the same pool of natural capital (Halkos & Argyropoulou, 2021; Jackson, 2021). One way to achieve this is to have a holistic view of sustainability. This implies observing the link among the three dimensions of sustainability and addressing all three pillars simultaneously (Asche et al., 2018; Rodríguez-Serrano et al., 2017).

As illustrated by Bhaduri et al. (2016), efforts to address local water needs may generate unfavourable environmental externalities and stress on water systems at regional and global levels. So, a holistic approach is necessary when addressing sustainability issues. Bhaduri et al. (2016) argue that the implementation of sustainability is a societal process of development. The implementing authorities should consider how the process relates to public interests. This should be communicated to the general public to build public trust. Liner and deMonsabert (2010) concur that management efforts should consider alternatives in addressing likely conflicting sustainability goals to achieve a balanced TBL. Through well-coordinated efforts, sustainable solutions that potentially benefit everyone may be realised. The next section presents the conceptual framework.

3.8 CONCEPTUAL FRAMEWORK

The existing EPE knowledge presented in the literature review is synthesised in the form of a conceptual framework. The conceptual framework discloses key variables and relationships that shape EPE in small-scale mining. The framework provides a basis for the final empirical EPE framework proposed in this study, as it informed the research design. Figure 3.3 presents the conceptual framework, followed by a discussion.

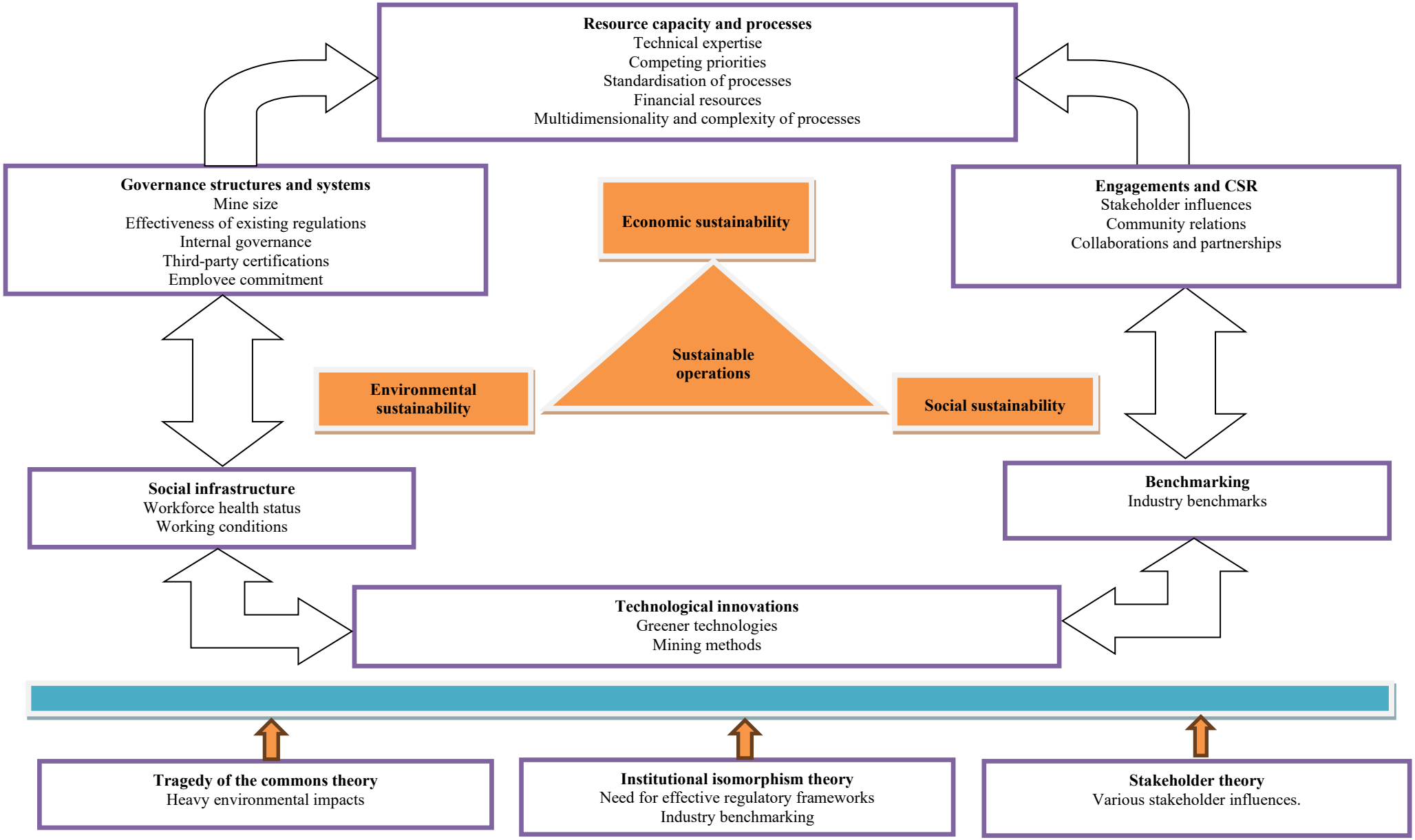


Figure 3.3: A conceptual framework to promote sustainable operations of Zimbabwean small-scale miners

The framework places economic, social, and environmental sustainability at the centre, connected with a triangular shape. This indicates the interplay that exists among the three sustainability pillars. Social, environmental, and economic sustainability have been found to be associated in the literature (Asche et al., 2018; Rodríguez-Serrano et al., 2017). They influence one another either through their activities or outcomes, as illustrated in the literature. As highlighted by the TBL approach, the three sustainability pillars should be addressed holistically (Asche et al., 2018). This promotes sustainable operations of the small-scale miners (Kwang & Blagogie, 2025; Jiménez et al., 2024; Singo et al., 2022). This is why the sustainable operations block is shown at the centre, connecting to the three sustainability variables.

The blocks at the outer part of the framework represent categories of factors that moderate the associations among economic, social, and environmental sustainability. The blocks are connected by arrows for illustrative purposes only. The outer blocks show that the associations among the sustainability pillars are moderated by governance structures and systems, resource capacity and processes, engagements and CSR, social infrastructure, technological innovations, as well as benchmarking (Khatter et al., 2021; Dissanayake et al., 2020; Fuchs et al., 2020; Agyemang et al., 2019; Tura et al., 2018). The arrows do not represent any associations among the moderators. Moreso, the framework presents theories at the base. This shows that all the associations among the sustainability pillars and the moderating effects are anchored on the tragedy of the commons, stakeholder, and institutional isomorphism theories. These theories help readers to better understand the research phenomenon in this study, as outlined in the literature (Freeman, 1984; DiMaggio & Powell, 1983; Hardin, 1968).

As noted, the conceptual framework has presented the interplay among environmental, economic, and social sustainability in promoting small-scale miners' sustainable operations. It has also presented the factors that can affect the attainment of sustainable operations. In doing so, the conceptual framework feeds into the development of the proposed EPE framework, the final output of the study.

During the development of the final EPE framework, the three sustainability pillars (environmental, economic, and social sustainability) shown on the conceptual framework were empirically investigated through the fuzzy AHP approach (discussed later in Section 4.3.7.1) to compute a composite sustainability index, which served as the dependent variable in establishing indicators which can promote sustainable operations of Zimbabwean small-scale miners. The statistically significant indicators constituted the final EPE framework, which was validated through interviews. Moreover, the factors presented in the conceptual framework

were statistically tested to establish if they truly influenced EPE indicator monitoring by the small-scale miners. The statistically proven factors played a role in informing study recommendations. The chapter summary and conclusion are presented next.

3.9 CHAPTER SUMMARY

The chapter has reviewed literature on environmental performance evaluation (EPE). EPE indicators, which constitute the main pillars of the proposed framework, are also discussed in this chapter. The chapter discussed sustainable development and explained how it links with EPE. The balancing of the TBL to achieve sustainable development has also been addressed. Hence, this Section warrants special attention. A discussion of the available EPE frameworks or guidelines has been presented. This further facilitated the establishment of the research gap. The chapter interrogated the results of the systematic review of literature on available EPE frameworks for the small-scale mining sector. This SLR further justified the need for the current study. The following conclusions are drawn from the literature review.

EPE indicators are a critical component of EPE. In general, organisations are encouraged to adopt a holistic view of EPE indicators by integrating operational, management performance, and environmental condition indicators in their indicator systems to promote sustainable operations. This study seeks to integrate all three indicator categories within the proposed framework to achieve sustainable operations of small-scale miners.

Several attempts to regulate the EPE field have been made with various frameworks existing in the literature. One attempt has been to introduce the EPE standard, ISO 14031, within the ISO 14000 series of standards. However, most EPE frameworks are either generic, costly to implement, or otherwise limited in meeting the EPE needs of small-scale miners as they target other sectors. This study proposes a more affordable, basic EPE framework serving the EPE needs of small-scale miners.

It has also been noted that commonly, organisations' EPE implementation initiatives are affected by various factors. These include the extent of EPE expertise, financial resources, level of management, and employee commitment, magnitude of local community pressure, need for environmental management certifications, environmental management compliance fines in place and mining methods in use. Factors affecting EPE practices of small-scale miners are expected to be integral to the study's proposed framework. In the next chapter, the adopted research methodology to address the research objectives is discussed.

CHAPTER 4: RESEARCH METHODOLOGY

4.1 INTRODUCTION

This chapter focuses on the research methodology. For an empirical study to be successful, the research design should be well planned. Section 4.2 covers the purpose of the study. Section 4.3 describes the research methodology, whilst Section 4.4 focuses on reliability and validity issues. Section 4.5 concentrates on research ethics and the chapter concludes with a summary in Section 4.6.

4.2 AIM OF THE RESEARCH

This study aims to develop an environmental performance evaluation framework to promote the sustainable operations of Zimbabwean small-scale miners. This is achieved through the following objectives: 1) Identification of environmental performance evaluation (EPE) indicators being monitored by Zimbabwean small-scale miners. 2) Assessment of how Zimbabwean small-scale miners balance economic, environmental, and social sustainability in their operations. 3) Establishment of EPE indicators which can promote the sustainable operations of Zimbabwean small-scale miners. 4) Identification of factors affecting the monitoring of EPE indicators by Zimbabwean small-scale miners. The EPE framework was developed by using these objectives.

4.3 RESEARCH METHODOLOGY

In this Section, the research onion by Saunders, Lewis and Thornhill (2023) is the basis for the discussion. The research onion is presented in Figure 4.1.

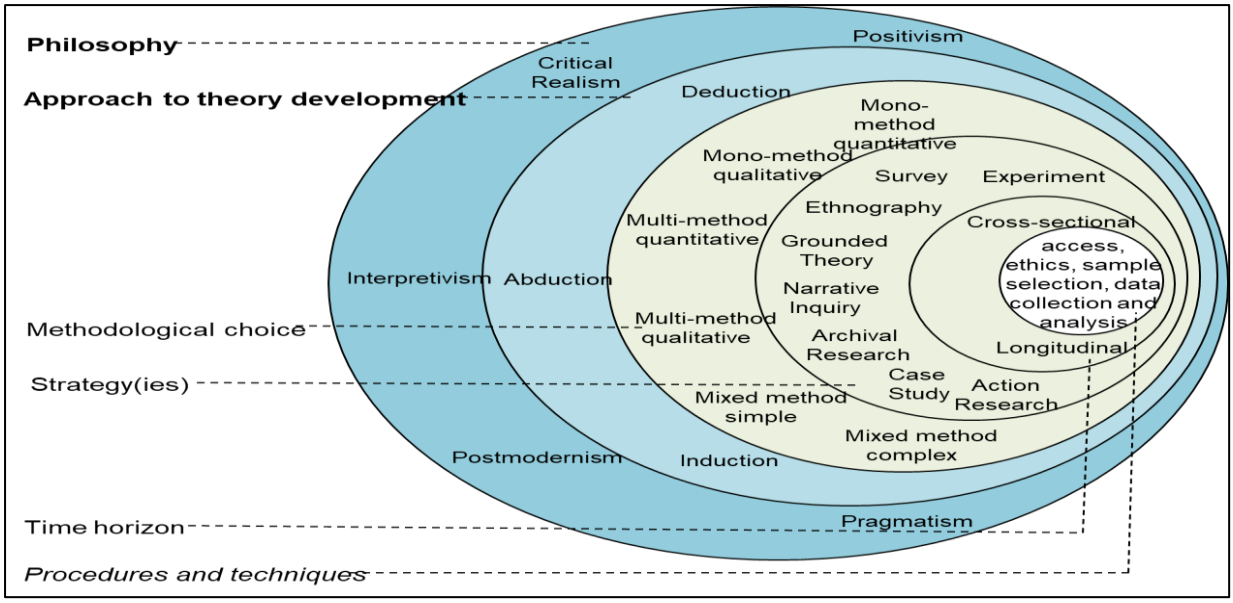


Figure 4.1: The Research Onion

Source: *Saunders et al. (2023)*

4.3.1 The research philosophy

This study adopted pragmatism as the research philosophy. Pragmatism combines elements of positivism and interpretivism (Saunders et al., 2023). In this study, positivism was employed to examine objective reality. Knowledge generation in this study was based on observable phenomena, which were measured and analysed through quantitative methods (Saunders et al., 2023). Quantitative data were collected using a questionnaire and analysed statistically, as discussed in Sections 4.3.7 and 4.3.8. It can be concluded that positivism was relevant for this study. Conversely, interpretivism focuses on understanding the subjective meanings and experiences of research participants, often through qualitative methods (Saunders et al., 2023). The final data collection phase of this study involved interviewing research participants to theoretically validate the proposed framework. The proposed framework was developed from quantitative data analysis. The interviews conducted confirm interpretivism.

4.3.2 The research approach

This study adopted the deductive and inductive research approaches. The deductive approach was associated with quantitative research using questionnaires, whereas the inductive approach was associated with qualitative research through interviews (Saunders et al., 2023). The final output of this study was an EPE framework, which emerged from the quantitative phase of the

research, grounded in questionnaire data. The conceptual framework presented in Figure 3.3 was a basis for the final EPE framework as articulated in Section 3.8.

The questionnaire had four roles leading to the development of the final EPE framework. The roles are discussed in Section 4.3.4. Hence, the deductive approach was appropriate for the study. The EPE framework, which emerged from the quantitative phase, was validated qualitatively using interview data. This way, the inductive approach was also relevant for the study.

4.3.3 The research strategy

The study employed questionnaires and interviews, targeting employees involved in EPE and sustainability. The employees selected for the study were perceived as knowledgeable about EPE and sustainability issues. The questionnaire enabled the researcher to gain an in-depth understanding of the prevailing EPE and sustainability practices of the small-scale miners (Saunders et al., 2023). Interview data were used to validate the proposed framework which emerged from the quantitative study.

4.3.4 The methodological choices

The study employed both qualitative and quantitative methods, resulting in a mixed-method study. The mixed-method study followed an explanatory sequential transformative design. The transformative lens focused on transforming environmental performance assessment practices for the Zimbabwean small-scale mining sector by centering miner realities and proposing a context-aligned EPE framework. Through this design, the study was done in two distinct phases (Saunders et al., 2023). The first phase was the quantitative phase, during which quantitative data were collected via questionnaires administered to selected small-scale miners. This phase focused on collecting data to address the following objectives: firstly, to identify EPEIs monitored by small-scale miners. Secondly, to assess how the miners balanced the TBL in their pursuit of sustainable operations. Thirdly, establishing EPEIs to promote the sustainable operations of small-scale miners. Fourthly, identification of factors affecting the monitoring of EPEIs by the small-scale miners.

The second phase was the qualitative phase, during which qualitative data were collected from interviewees. The qualitative data were used to validate the proposed framework.

4.3.5 Time horizon

The study is cross-sectional rather than longitudinal because the data were gathered at a given point in time rather than over a long period of time (Saunders et al., 2023).

4.3.6 Techniques and procedures

This Section focuses on identifying the study population, sample, and sampling procedure, research instruments used, and data analysis. The issues are discussed in detail in the following sub-sections.

Population

The target population comprised all active, registered small-scale miners operating in Mashonaland Central Province, Zimbabwe. Mashonaland Central Province was purposively selected as one of the provinces with significant mining operations in Zimbabwe. The study targeted this province mainly because of its significant proportion of active small-scale miners. According to the Zimbabwe Miners Federation, the estimated nationwide number of small-scale miners ranges from 50,000 to 1,500,000. The majority are gold miners. The target population size for Mashonaland Central was estimated at 1,500 small-scale gold miners through triangulation of milling infrastructure and national registration statistics as explained next.

National data indicate that 85% of small-scale miners are not registered, leading to a formal registration rate of 15% (Portfolio Committee on Mines and Mining Development, 2025). Mashonaland Central province has 12 gazetted gold milling centres (Economic Commission for Southern African Countries and Southern African Development Community (ECSAC/SADC), 2022). Based on the ECSAC/SADC (2022) survey data, Shamva and Bindura districts recorded 5,000 small-scale miners across 6 mills, yielding an average of 833 miners per centre (5,000/6). Applying this average to the province yields approximately 10,000 small-scale miners (12*833). Applying the 15% national registration rate produces 1,500 small-scale miners (10,000*0.15).

Sample and sampling procedures

Simple random sampling was adopted to ensure a representative sample for the questionnaire survey. Slovin's formula was adopted to estimate the study sample size as it is typically used

for simple random sampling. The formula for determining sample size is $n = \frac{N}{(1 + Ne2)}$, where n is the required sample size, N is the population size, and e is the desired margin of error as a decimal. With N = 1,500 and e = 0.05, the sample size was 315 respondents. In employing simple random sampling, each miner within the sampling frame was assigned a unique number. IBM SPSS 29 was commanded to execute the random selection of the 315 miners.

The exact number of interviews for the qualitative study was informed by data saturation. The number of interviews required to reach saturation varies with context. Homogeneous groups whose population has similar experiences, characteristics, or backgrounds may require small-scale studies, with saturation typically reached with 5-15 interviews (Creswell, 2021). Based on data saturation assessments, 16 out of the 25 planned interviews were conducted with 16 small-scale miners selected through convenience sampling. In employing convenience sampling to select telephone interviewees, a participant exclusion list was built and used to avoid interviewing the same participants for the questionnaire survey to reduce research bias. Phone calls were made to the participants who were not on the exclusion list. Those who were reachable and willing to participate constituted the sample. A screening question was asked at the beginning of each interview to confirm if the potential participant was the right person.The interviewees shared their views on the usefulness of the framework in promoting their sustainable operations.

Data collection procedures

Data was collected through questionnaires and interviews. Permission to collect data was sought from the individual small-scale miners through their management. Consent letters were sent to the selected participants prior to the administration of the questionnaires. A pilot study was conducted before the main study. The details of the pilot study are discussed later in this chapter. Questionnaires for the main study were administered only to those who accepted the invitation to participate. This was used as a screening process. The same procedure was used for interviewees. In the following section, the study's data collection instruments are discussed.

Data collection instruments

The conceptual framework played a critical role in informing the design of the research instruments, particularly the questionnaire, since the interview guide was only for the theoretical validation of the proposed framework. The questionnaire included a Likert scale on the extent to which the small-scale miners monitored EPE indicators. This was in line with the

environmental sustainability pillar of the conceptual framework. Questionnaire items on the factors affecting EPE indicator monitoring practices were also informed by the outer blocks of the conceptual framework representing factors moderating the interplay among environmental, economic and social sustainability. Moreover, since the conceptual framework portrayed an interplay among economic, environmental, and social sustainability, the questionnaire gathered data to test, through fuzzy AHP, how the small-scale miners balanced the 3 sustainability pillars.

Questionnaires were administered to only those participants who accepted the invitation to participate in the study. Three hundred and fifteen (315) questionnaires were successfully administered through hand delivery. Physical administration of questionnaires expedited data collection, as most respondents responded immediately, whereas a few requested additional time to respond in their spare time. Such participants had up to one month to respond to the questionnaires. The researcher sent reminders every two weeks to enhance the response rate. The questionnaires were a suitable data collection tool because they allowed respondents to respond at their convenience. The researcher's email address, phone numbers, and physical address were provided on the questionnaire in case respondents needed clarity on some issues.

Telephone interviews were conducted by appointment with 16 of the 25 planned interviewees. The interviews were conducted only with those who accepted the study invitation. The interviews enabled the researcher to elicit richer responses from the participants. The interviews offered flexibility in terms of the questions asked and the ability to follow up on interesting or unexpected responses. This potentially led to a comprehensive validation process of the framework. The main purpose of conducting the interviews was to validate the proposed framework before it was presented as the final framework. A different set of participants from the questionnaire respondents was selected to mitigate research bias. The proposed framework was sent to the interviewees via email or WhatsApp for review prior to the interview sessions. This likely promoted comprehensive constructive criticisms for the framework.

4.3.7 Data analysis

Data from questionnaires was analysed using IBM SPSS 29 and complemented by the fuzzy AHP technique. Interview data were analysed using ATLAS.ti 25.

Quantitative data analysis

Percentage distributions and mean rankings were primarily used to assess the monitoring practices of the environmental performance evaluation (EPE) indicators of small-scale miners in **RO1**. Exploratory factor analysis was also performed to identify underlying themes in the EPE indicators monitored by the small-scale miners in **RO1**. Exploratory factor analysis is a technique employed to reduce many items of a research instrument into fewer underlying factors or themes. It establishes the items that were grouped based on how respondents answered the questions, revealing hidden patterns without assuming them beforehand (Costello & Osborne, 2005).

The Kaiser-Meyer-Olkin (KMO) measure, Bartlett's test of sphericity, and scree plot are critical tools in exploratory factor analysis. KMO tests sampling adequacy by checking if variables share enough common variance for factor analysis; Bartlett's test of sphericity checks if item correlations are significantly different from zero at $p<0.5$ to confirm factors exist; and the scree plot establishes the number of factors that should be retained by referring to the "elbow" where eigenvalues level off (Costello & Osborne, 2005; Watkins, 2018).

The detailed procedure for exploratory factor analysis (EFA) is discussed in depth later in Chapter 5. Spearman's rank-order correlation and multiple linear regression analyses were conducted to provide statistical insights into the factors affecting the EPE indicator monitoring practices of the small-scale miners in **RO4**. The factor variables from the exploratory factor analysis in **RO1** were used as independent variables for the multiple linear regression analysis for **RO3**. The multiple linear regression model was mainly used to establish EPE indicators that could promote sustainable operations of small-scale miners.

For the second objective **(RO2)**, the balancing of environmental, social, and economic sustainability by small-scale miners was assessed using a Multi-Criteria Decision-Making (MCDM) technique known as Fuzzy Analytic Hierarchy Process (Fuzzy AHP). Fuzzy AHP was employed to handle uncertainties in human judgments (Kahraman et al., 2020). The group-level TBL weights were used to develop EPE policy recommendations later in the study. Company-level composite sustainability indices were computed using the fuzzy AHP protocol to serve as the dependent variable in the multiple linear regression analysis for **RO3**. The multiple linear regression analysis streamlined the EPEIs and facilitated the identification of indicators that could promote sustainable operations of the small-scale miners. The fuzzy AHP is outlined next according to Kahraman et al. (2020).

- **Fuzzy Analytic Hierarchy Process (FAHP)**

FAHP was implemented as described in steps 1-7 that follow:

Step 1: Defining the decision-making criteria

The decision-making criteria were economic sustainability (profit/prosperity), environmental sustainability (planet), and social sustainability (people). The main goal was to assess the TBL balance of the criteria.

Step 2: Preparing pair-wise comparisons

A pairwise comparison matrix was constructed from data collected, using a developed AHP questionnaire that included the aforementioned criteria. The matrix was constructed from mean ranking comparison scores using the FAHP 9-point scale. Crisp values were used at this stage to determine stakeholders' level of attention to the TBL.

Step 3: Constructing fuzzy comparison matrices

The AHP pairwise comparison matrix prepared in Step 2 was fuzzified by assigning fuzzy numbers. Fuzzification enabled fuzzy AHP to account for inherent imprecision in human judgements and allowed for a more realistic representation of the decision-making process. The fuzzification process employed triangular membership functions, assigning triangular fuzzy numbers (TFNs) to each linguistic variable. Each TFN was represented by a triplet (l, m, u), where l was the lower bound, m the most likely value, and u the upper bound.

Step 4: Calculating the fuzzy geometric mean

The geometric mean of each row in the fuzzy comparison matrix was calculated by applying the following formula.

M(A_i) = (Π(a_{ij})^1/n)^(1/n)

where:

M(A_i) is the geometric mean of the i^{th} row,

a_{ij} is the element in the i^{th} row and j^{th} column, and

n is the number of elements in the row

Step 5: Calculating the fuzzy consistency ratio

The fuzzy consistency ratio (CR) was calculated to assess the consistency of the pair-wise comparisons. This enabled the identification of potential biases in respondents' judgments in the FAHP questionnaire. The fuzzy consistency ratio was calculated as CR = $\frac{\mathrm{CI}}{RI}$, where:

CR is the consistency ratio,

RI is the random consistency index and

CI is the fuzzy consistency index.

where:

λ is the largest eigenvalue of the comparison matrix and

n is the number of criteria.

The random consistency index (RI) is a pre-calculated value

A CR less than 0.1 is considered an acceptable ratio.

Step 6: Defuzzification and criteria weights

The fuzzy weights were converted into crisp values, resulting in a crisp weight for each criterion. In this case, the TBL components were assigned crisp weights.

Step 7: Normalising the weights

To normalise the weights, each crisp weight was divided by the sum of all weights to obtain normalised weights that sum to 1. The normalised weights represented the TBL ratio of the criterion.

Qualitative data analysis: Framework validation process

The EPE framework that emerged from the quantitative data analysis phase was validated through qualitative analysis of interview data using ATLAS.ti 25. Framework validation is a systematic process of testing whether the framework is sound, complete, and accurately represents the real-world phenomenon it claims to explain (Jabareen, 2009). After the data were collected, the interview transcripts were imported into ATLAS.ti 25. Coding was performed using a structural line-by-line approach. Whenever an interviewee referred to an indicator, the relevant framework code was applied, along with a validation code that resembled the interviewee's opinion. Such a dual-coding mechanism enabled the capture of both technical content and evaluative judgment, providing a clear foundation for interpreting subsequent results.

The qualitative validation stage was conducted to assess whether the EPE framework was relevant, complete, and had a practical utility in the context of Zimbabwean small-scale mining operations. The main aim of this stage was to determine whether the EPE indicators, identified in the quantitative study, reflected the realities of small-scale mining operations. Validation did not depend on numerical polls or "majority perceptions" but on the clarity and strength of the

views gathered from the interviewees, as well as the consistency of emerging patterns and the alignment of the interviewees' insights with established theory (Jabareen, 2009).

The validation process aimed to address three fundamental issues. First, checking if the framework indicators were relevant and meaningful in practice. Second, checking if any indicators were unclear, impractical, or inapplicable. Third, establishing whether there were any important indicators or environmental aspects not captured in the quantitative phase. The qualitative validation stage, therefore, strengthened the EPE framework by integrating statistical results, theoretical grounding, and practical operational experience.

4.4 RELIABILITY AND VALIDITY

Reliability refers to the replicability or consistency of a research instrument, test or measurement (Taherdoost, 2017). Reliability alone is not sufficient for a research instrument, it should also be valid (Saunders et al., 2015). For an instrument to be valid, it should be reliable (Liang et al., 2014). Validity generally refers to the extent to which an instrument or measure accurately measures what it is intended to measure. There are various dimensions of validity, however, researchers often refer to content validity, criterion-related validity and construct validity (Saunders et al., 2015). Seemingly, the most important facets of validity are content validity and construct validity (Saunders et al., 2015). This study focused on these two forms of validity.

A pilot study was conducted to assess the reliability and content validity of the research instruments administered in the main study. The pilot study was conducted as follows. Twenty small-scale miners were conveniently selected from Mashonaland Central Province, Zimbabwe, for the questionnaire in accordance with Julious' (2005) 12-per-group rule of thumb. It is argued that at least 12 participants per group are required to balance main study feasibility with the accuracy of mean score and variance estimates (Julious, 2005). Moreover, five questionnaires and five interview guides were reviewed by five (5) senior researchers for item judgment. These were the researcher's supervisors at the University of South Africa and lecturers from the Midlands State University. Subject experts play a crucial role in judging the items of a research instrument (Taherdoost, 2017).

Internal consistency reliability of the questionnaire was assessed using Cronbach's Alpha (α), computed in IBM SPSS 29. The acceptable and minimum alpha estimate for pilot studies in social science research should be 0.7 (Nunnally, 1978). Content validity refers to the extent to which a measurement device comprehensively represents the investigative questions

(Taherdoost, 2017; Bolarinwa, 2015). The judgmental approach to assessing content validity was through a literature review and evaluations by experts (Taherdoost, 2017). Content validity was achieved through a comprehensive literature review to extract relevant and significant items on EPE indicators and sustainability. After the review of the literature, the questionnaire and interview guide developed were subjected to item judgment by the mentioned seasoned researchers (Taherdoost, 2017). Trustworthiness is a critical consideration in qualitative data. The next section discusses trustworthiness in relation to the qualitative data collected in this study.

4.5 TRUSTWORTHINESS IN QUALITATIVE DATA

Trustworthiness is viewed as the extent to which the findings of research are considered credible, dependable, and transferable to other research settings. In every qualitative research, credibility, dependability, confirmability and transferability should be ensured as the four aspects of trustworthiness (Ahmed, 2024). To ensure credibility, follow-up questions were asked, and responses were recapped during interviews. This ensured the capturing of accurate representations of the small-scale miners' views. To ensure dependability, notes were taken during interviews to capture context, interruptions, and tone. For example, if a miner sounded hesitant to respond to a question, this would be captured as a note. To ensure transferability, the socio-demographic data were captured so that any interested parties could judge applicability issues. Moreso, in ensuring confirmability, the findings were discussed with the research supervisors to identify potential biases and flaws. Feedback was received and concerns addressed. A pilot study was conducted before the main study. The pilot study is discussed in Section 4.6.

4.6 PILOT STUDY

The pilot study was conducted in December 2024 to pre-test the survey questionnaire for clarity, structure, reliability, and validity. The pilot study was conducted with 20 small-scale miners, who were conveniently selected from the Mashonaland Central Province. The pilot study sample consisted of 16 small-scale miners whose years in operation fell in the 6–10 year category, two in the 11–15 year category, whilst the other two were in the 1–5 year category. The structure of the pilot sample represents the general longevity structure of the target population. The entire sample was engaged in gold mining, apparently due to the province's predominantly gold-bearing mineral distribution. Appointments were made with participants

who had accepted the pilot study invitations. Eventually, respondents were asked to comment on the clarity, redundancy, and length of the questionnaire, and this was successfully achieved.

Table 4.1 presents reliability test results for the pilot study, obtained using IBM SPSS 29.

Table 4.1: Reliability test results for the EPE indicator constructs

Overall Statistics	**Cronbach's Alpha(α)**			**N of Items**
Measure	.93			26
Item-Total Statistics				
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**
EPI:Training for employees on environmental matters	88.95	88.26	.10	.93
EPI:Environmental auditing	88.70	86.85	.24	.93
EPI:Environmental improvement projects implemented	88.60	85.62	.41	.93
EPI:Achievements of environmental objectives	88.45	83.63	.43	.93
EPI:Occurrence of environment related accidents	86.30	89.38	NaN	.93
EPI:Compliance with environmental obligations	88.10	81.36	.60	.93
EPI:Employee adherence to environmental management systems	88.40	86.04	.57	.93
EPI:Management commitment to environmental protection	88.40	84.88	.78	.93
EPI:Effectiveness of the environmental performance evaluation process	88.50	85.74	.46	.93
EPI:Effectiveness of environmental risk management	88.35	84.13	.53	.93
EPI:Energy consumption rate	86.70	81.17	.63	.93

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
EPI:Water consumption rate	86.55	82.05	.89	.92
EPI:Waste recycling levels	88.95	78.05	.53	.93
EPI:Greenhouse gas emissions	90.05	87.84	.16	.93
EPI:Material consumption	86.60	81.09	.77	.92
EPI:Hazardous waste generation	86.65	79.19	.82	.92
EPI:Air pollution	86.65	82.13	.79	.92
EPI:Soil pollution	86.75	81.14	.63	.93
EPI:Noise pollution	86.80	79.75	.75	.92
EPI:Air quality	86.90	76.62	.84	.92
EPI:Water quality	86.90	80.94	.65	.93
EPI:Deforestation rate	86.80	77.54	.84	.92
EPI:Fresh water depletion	87.10	79.36	.77	.92
EPI:Land degradation	86.90	81.04	.64	.93
EPI:Water pollution related deaths	89.70	87.06	.22	.93
EPI:Air pollution mortality rate	89.75	83.67	.58	.93

The overall Cronbach's Alpha for the EPE indicator constructs was 93%. This coefficient was way above the minimum acceptable coefficient of 70%. The result indicated that the constructs were very fit for their purpose (Nunnally, 1978). The individual constructs' Cronbach's Alpha coefficients shown in Table 4.1 indicate the revised Cronbach's Alpha if the corresponding construct was deleted from the list of constructs. The distribution suggests insignificant variations from the overall Cronbach's Alpha.

However, the very high Cronbach's alpha coefficient of 0.93 may also imply item redundancy, suggesting that some EPE indicators might be overlapping in meaning. To decide whether to remove or retain the items, the 'corrected item-total correlation' values were used. All items

with correlations ≥ 30 were retained as a rule of thumb. The items with coefficients < 30 were not dropped but rephrased as they were deemed critical, as guided by the extensive literature review. The items that were rephrased were water pollution-related deaths, employee training on environmental matters, environmental auditing, GHG emissions and the occurrence of environmental-related accidents. Accordingly, no construct was delisted. Table 4.2 shows Cronbach's alpha for the factors affecting EPE indicator monitoring.

Table 4.2: Reliability test for factors affecting EPE indicator monitoring

Case Processing Summary		
Overall Statistics	**Cronbach's Alpha(α)**	**N of Items**
Measure	.49	8
Cases	N	Percent
Valid	20	100.0%
Excluded	0	.0%
Total	**20**	**100.0%**

The results showed an overall Cronbach's alpha of 0.49. This Cronbach's alpha value was below the recommended threshold of 0.70, suggesting low internal consistency. Nevertheless, this result was theoretically expected, as each factor measures a distinct, independent dimension of EPE monitoring practices rather than multiple indicators of a single construct. Accordingly, the low alpha does not compromise the validity of the data. Hence, all eight factors were retained for the main study.

The pilot study, using Cronbach's alpha, confirmed that the questionnaire was a reliable data collection instrument. Minor wording modifications were made to all questionnaire items with low item-total correlations below 30. Based on respondents' feedback, the questionnaire instructions were also clarified. The questionnaire and interview guide were subjected to expert review for content validity.

4.7 CONTENT VALIDITY ASSESSMENT

The five experts mentioned earlier evaluated each item of the questionnaire and interview guide for clarity, relevance, and coverage using a three-point scale (relevant, somewhat relevant, not relevant). After the review, feedback was collated. Items rated 'not relevant' by at least two

reviewers would be dropped or rephrased. None of the items in the instruments was rated 'not relevant'. Hence, the instruments were approved for content validity. The following table summarises pilot study results based on Cronbach's Alpha.

Table 4.3: Pilot study Cronbach's alpha-based results summary

Construct	No. of items	Cronbach's Alpha(α)	Interpretation	Decision
EPE indicator constructs	26	0.93	Excellent	Retained with minor wording revisions
Factors influencing EPE indicator monitoring	8	0.49	Below threshold	Retained based on theoretical validity

Based on content validity assessments and reliability results, both the questionnaire and the interview guide were deemed valid and reliable instruments for the main study. Ethical considerations observed in the study are discussed next.

4.8 ETHICAL CONSIDERATIONS

This research was expected to pose minimal risk, as with other social sciences research. Therefore, potential ethical problems were considered. This research examined the three ethical principles of beneficence, respect for persons, and justice as outlined in the Belmont Report, which appears to have gained international approval (United States National Commission for the Protection of Human Subjects of Biomedical and Behavioural Research, 1979).

The first step taken was to obtain clearance from the UNISA College of Accounting Sciences research ethics committee. The ethics clearance certificate was granted with reference number 2667. The second step, written consent to participate in the study was sought from the potential participants. An official ethics clearance certificate issued by the University of South Africa, together with the consent form, was emailed, sent through WhatsApp, or hand-delivered to the selected respondents. The objectives of the study, potential benefits and any likely study consequences were highlighted to the targeted participants.

Names of research participants and organisations were omitted from the questionnaire to ensure participants' privacy and confidentiality. Pseudonyms were used for interviewees to protect privacy and confidentiality.

The principle of beneficence assesses the risks and benefits of research participation, with the two principles of minimising harm and maximising benefits associated with the research

(United States National Commission for the Protection of Human Subjects of Biomedical and Behavioural Research, 1979). This research falls under the low research risk category. Participants perceived a minimal risk, likely due to minor discomfort, such as limited free time to participate in the research. However, this research seeks to maximise potential benefits to both the researcher and the participants. This research aimed to address crucial environmental concerns by developing an EPE framework to promote the sustainable operations of small-scale miners. Sustainable mining operations may yield social and economic benefits for all stakeholders.

Finally, the study was guided by the ethical principle of justice. The principle of justice requires that the research benefits and burdens must be distributed fairly, and that research avoid the injustice resulting when some benefit to which a person is entitled is denied without good reason (Dal-Réet al., 2014; United States National Commission for the Protection of Human Subjects of Biomedical and Behavioural Research, 1979). In this context, the research participants were ensured access to the study's final results, which would be provided upon request.

4.9 CHAPTER SUMMARY

The chapter first outlines the study's purpose, then presents the appropriate methodology. The research philosophy guiding the study has been discussed. The research approach adopted in the study has also been discussed. After a discussion of the study's research strategies, the mixed-methods approach was selected. The chapter also discussed the study as cross-sectional rather than longitudinal. The next chapter presents the quantitative analysis of the questionnaire survey data.

CHAPTER 5: DATA PRESENTATION, ANALYSIS AND DISCUSSION

5.1 INTRODUCTION

This chapter presents the analysis of quantitative data collected through questionnaires. IBM SPSS 29 was used to analyse the quantitative data. The chapter seeks to address five research objectives. Objective 1 (**RO1**) sought to determine the EPEIs being monitored by Zimbabwean small-scale miners. The analysis of this objective is presented in Section 5.2. Percentage distributions and mean scores were the primary analysis tools for this objective. Exploratory factor analysis (EFA) was also conducted to reveal underlying themes within the EPE indicators. Objective 2 (**RO2**), analysed in Section 5.3, sought to assess the extent to which small-scale miners in Zimbabwe balance economic, environmental, and social sustainability in their operations. The fuzzy analytic hierarchy process (FAHP) was the primary analysis tool employed for this objective.

Objective 3 (**RO3**), analysed in Section 5.4, aimed to establish EPEIs that could promote sustainable operations of Zimbabwean small-scale miners. Multiple linear regression analysis was employed to address this objective. The analysis of objective 4 (**RO4**) is presented in Section 5.5. The objective sought to identify factors affecting the monitoring of EPE indicators by Zimbabwean small-scale miners. Mean scores, Spearman's rank-order correlations, and multiple linear regression analysis were employed to establish the influence of the factors on the monitoring of the EPE indicators. Objective 5 (**RO5**) focused on developing the EPE framework based on the outcomes of **RO1, RO2** and **RO3.**

Table 5.1 presents the sample distribution by demographics, to develop a better understanding of the sample before addressing the study objectives.

Table 5.1: Sample distribution by demographics, n = 289

Variable	Category	Frequency	Percentage (%)	Mode
Education	**Secondary**	**164**	**56.7**	**Yes**
	Mining/environment	51	17.6	-
	Business	42	14.5	-
	Other	32	11.1	-
Experience	**<5 years**	**131**	**45.3**	**Yes**

Variable	Category	Frequency	Percentage (%)	Mode
	5-10 years	84	29.1	-
	11-15 years	49	17.0	-
	Above 15 years	25	8.7	-
Mine age	<1 year	30	10.4	-
	1-5 years	**101**	**34.9**	**Yes**
	6-10 years	84	29.1	-
	11-15 years	49	17.0	-
	16+ years	25	8.7	-
Mining method	**Open pit**	**142**	**49.1**	**Yes**
	Tunnelling and shafting	82	28.4	-
	Strip	52	18.0	-
	In-situ	13	4.5	-

Frequency analysis with mode was adopted as it is methodologically appropriate for nominal and ordinal data, avoiding interval assumptions required by parametric measures and thus accurately capturing the central tendency of categorical attributes (Pallant, 2020). The results show four salient patterns: highest educational attainment is skewed toward secondary education, 56.7%, with only 32.1% holding tertiary qualifications; operational experience is relatively nascent, with 45.3% reporting <5 years and 74.4% <11 years. Mines were predominantly newly formalized, with 45.3% operating ≤5 years, and extraction is generally surface-based, with 49.1% using the open-pit method.

This convergence on a modal profile of a secondary-educated, relatively inexperienced, surface miner reflects broader small-scale mining dynamics in Zimbabwe and SADC, where low formal education and short operational tenure are consistently associated with reliance on rudimentary surface mining methods and limited uptake of formal environmental management practices (Mkodzongi & Spiegel, 2018). This clustering has been recently attributed to

structural barriers including poor access to technical training and ASM formalization programs (Hilson et al., 2021). As a result, understanding this distribution is foundational for the proposed EPE framework because the sample is not heterogeneous but clustered. Hence, the framework must be calibrated to the indicated modal actor rather than dispersed minorities. A framework misaligned with the modal dimensions would likely lack ecological validity and may fail to promote sustainable operations at sector scale. The next section analyses the first objective.

5.2 ANALYSIS OF OBJECTIVE 1: DETERMINING THE ENVIRONMENTAL PERFORMANCE EVALUATION INDICATORS BEING MONITORED BY ZIMBABWEAN SMALL-SCALE MINERS

The focus of objective 1 was to establish which EPEIs is monitored by Zimbabwean small-scale miners. Data collection was done using a questionnaire administered to selected small-scale miners in Mashonaland Central Province, Zimbabwe. A Likert-scale questionnaire, assessing the extent of monitoring of the outlined EPEIs, was used to collect data. Using IBM SPSS 29, percentage-scale scores and mean-rank analysis were employed to analyse the indicator monitoring data. Underlying data themes to support the addressing of **RO3** were identified through exploratory factor analysis. The questionnaire survey response rate is presented next.

5.2.1 Questionnaire response rate

A total of 315 questionnaires were administered to the small-scale miners. Two hundred and eighty-nine valid questionnaires were successfully returned. This represented a response rate of 92%, which is considered sufficient for a credible study (Saunders et al., 2015).

5.2.2 Reliability test

To ensure data reliability, the EPEIs were tested for internal consistency using Cronbach's Alpha. Tables 5.2 and 5.3 show the results of the reliability test.

Table 5.2: Reliability statistics

Case processing summary		
Cases	**N**	**Percent**
Valid	289	100.0%
Excluded	0	.0%
Total	**289**	**100.0%**
Cronbach's Alpha(α)		**N of Items**
0.85		26

Table 5.2 presents the overall Cronbach's Alpha coefficient for all 26 EPE indicators. A Cronbach's Alpha between 0.80 and 0.89 indicates good reliability for the constructs (Nunnally, 1978). The EPE constructs yielded a Cronbach's Alpha of 0.85 and reflected strong internal consistency for the 26 EPE constructs. This suggests that the constructs were good for the research (Nunnally, 1978).

Table 5.3 indicates the Cronbach's Alpha statistics for individual EPEIs. The statistics were computed using the "if items deleted function". This function was used to check if there were any items that could be deleted from the list of 26 EPE items to increase the reliability to an overall reliability value of 0.85.

Table 5.3: Cronbach's Alpha statistics for individual EPEIs

Item-total statistics				
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**
EPI:Employee trainings for environmental matters	95.22	114.08	-.11	.86
EPI:Environmental audits conducted	95.01	113.05	-.04	.86
EPI:Environmental improvement projects implemented	94.91	111.98	.07	.86
EPI:Achievements of environmental objectives	93.93	99.06	.64	.84

Item-total statistics				
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**
EPI:Occurrence of environmental accidents	93.06	112.55	-.01	.86
EPI:Compliance with environmental obligations	93.96	100.17	.60	.84
EPI:Employee adherence to environmental management systems	94.16	99.74	.73	.84
EPI:Management commitment to environmental protection	94.15	99.43	.69	.84
EPI:Effectiveness of the environmental performance evaluation process	94.09	98.29	.75	.84
EPI:Effectiveness of environmental risk management	93.82	97.67	.68	.84
EPI:Energy consumption rate	93.02	112.78	-.02	.86
EPI:Water consumption rate	93.04	112.88	-.03	.86
EPI:Waste recycling levels	93.99	96.40	.56	.84
EPI:Greenhouse gas emission levels	94.58	90.58	.63	.84
EPI:Material consumption	93.04	111.98	.04	.86
EPI:Hazardous waste generation	93.03	109.63	.24	.85
EPI:Air pollution	93.12	109.11	.27	.85
EPI:Soil pollution	93.16	107.53	.38	.85
EPI:Noise pollution	93.19	107.64	.35	.85
EPI:Air quality	93.22	106.56	.41	.85
EPI:Water quality	93.20	106.50	.43	.85
EPI:Deforestation rate	93.18	106.95	.39	.85

Item-total statistics				
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**
EPI:Fresh water depletion	93.27	106.87	.42	.85
EPI:Land degradation	93.25	104.85	.44	.85
EPI:Water pollution mortality rate	94.89	96.87	.57	.84
EPI:Air pollution mortality rate	95.08	97.22	.58	.84

Table 5.3 proves that seven items could increase reliability from .85 to .86 if removed from the list. However, the increase in reliability if the items were deleted was not significant. Therefore, no item was deleted from the list of EPE items. The rest of the items could either reduce the Cronbach's Alpha to 0.84 or lock it at 0.85 if deleted. This implied that overall, all the items were good EPE constructs. A Cronbach's Alpha of 0.85 was considered sufficient to proceed with analysis based on the 26 EPE constructs. Section 5.2.3 presents the results from monitoring the EPE constructs.

5.2.3 Environmental performance evaluation indicator monitoring results

The Likert-scale questionnaire data were analysed to gain insights into the indicator-monitoring practices of the small-scale miners. The results relate to percentages and mean scores generated from the IBM SPSS analysis. First, codes for all EPE indicators involved in the analysis are presented in Table 5.4.

Table 5.4: EPE indicator codes

EPE Indicator	EPE Indicator Code
Training related to environmental matters delivered to employees	EPI:1
Environmental audits conducted	EPI:2
Environmental improvement projects implemented	EPI:3
Achievement of environmental objectives and targets	EPI:4
Occurrence of environmental accidents	EPI:5

EPE Indicator	EPE Indicator Code
Compliance with environmental obligations	EPI:6
Employee adherence to environmental management systems	EPI:7
Level of management commitment to environmental protection	EPI:8
Effectiveness of the environmental performance evaluation process	EPI:9
Effectiveness of environmental risk management	EPI:10
Energy consumption rate	EPI:11
Water consumption rate	EPI:12
Waste recycling levels	EPI:13
Greenhouse gas emission levels	EPI:14
Material consumption	EPI:15
Hazardous waste generation	EPI:16
Air pollution	EPI:17
Soil pollution	EPI:18
Noise pollution	EPI:19
Air quality	EPI:20
Water quality	EPI:21
Deforestation rate	EPI:22
Fresh water depletion	EPI:23
Land degradation	EPI:24
Water pollution mortality rate	EPI:25
Air pollution mortality rate	EPI:26

All codes listed in Table 5.4 are used in the subsequent tables of results to ensure a clear presentation. Table 5.5 presents the EPE indicator monitoring results.

Table 5.5: Environmental performance evaluation indicator monitoring results

EPE Indicator	Never Monitored (%)	Very Low (%)	Low (%)	Moderate (%)	High (%)	Very High (%)	Mean Ranking	Average Monitoring Status
	Scale							
	1	2	3	4	5	6		
EPI:11	0	0.7	5.9	34.3	59.2	0	4.52	High
EPI:16	0	0	4.8	39.4	55.7	0	4.51	High
EPI:12	0.7	1.4	2.8	37.4	57.8	0	4.50	High
EPI:15	0.7	0.7	2.4	41.2	54.3	0.7	4.50	High
EPI:5	0	2.8	6.9	29.1	61.2	0	4.49	Moderate
EPI:17	0	0.7	4.8	46.4	48.1	0	4.42	Moderate
EPI:18	0	0.7	5.9	48.1	45.3	0	4.38	Moderate
EPI:22	0	1.4	6.6	46.7	44.6	0.7	4.37	Moderate
EPI:19	0	1.4	6.9	46.4	45.3	0	4.36	Moderate
EPI:21	0	2.1	5.5	48.8	43.6	0	4.34	Moderate
EPI:20	0	1.4	9.3	45.0	44.3	0	4.32	Moderate
EPI:23	0	1.4	6.9	54.7	37.0	0	4.32	Moderate
EPI:24	0.7	4.8	4.5	43.9	46.0	0	4.30	Moderate
EPI:10	0	14.2	30.1	25.3	30.4	0	3.72	Moderate
EPI:4	0	16.3	29.4	31.1	23.2	0	3.61	Moderate
EPI:6	0.7	10.4	41.2	24.9	22.8	0	3.59	Moderate
EPI:13	8.3	21.8	6.9	32.5	30.4	0	3.55	Moderate
EPI:9	0	15.2	39.1	30.4	15.2	0	3.46	Low
EPI:7	0	13.1	46.7	28.4	11.8	0	3.39	Low
EPI:8	0	15.9	42.6	27.7	13.8	0	3.39	Low
EPI:14	33.6	11.1	4.2	27.7	23.5	0	2.97	Low
EPI:25	20.8	31.5	21.5	14.5	11.8	0	2.65	Low
EPI:3	0	37.7	61.6	0.7	0	0	2.63	Low

EPE Indicator	Never Monitored (%)	Very Low (%)	Low (%)	Moderate (%)	High (%)	Very High (%)	Mean Ranking	Average Monitoring Status
EPI:2	0	46.7	53.3	0	0	0	2.53	Low
EPI:26	24.6	35.3	19.4	11.1	9.7	0	2.46	Very low
EPI:1	18.7	30.1	51.2	0	0	0	2.33	Very low

The results reveal elevated levels of monitoring for energy consumption, hazardous waste generation, water consumption, and material consumption. This is a positive and commendable result. This result aligns with previous findings by Feil et al. (2025) and Halkos and Argyropoulou (2021), who reported that the same indicators are critical and widely monitored in advancing economic sustainability. They also argued that monitoring hazardous waste generation promotes resource efficiency and the circular economy for sustainable development. These results also appear to contribute to the literature arguing that small-scale miners prioritise economic sustainability over social and environmental sustainability (Nitschke et al., 2025; Jiménez et al., 2024). The literature argues that miners often have limited income streams and solely rely on profits from their mining operations (Jiménez et al., 2024). By prioritising economic sustainability, the miners may compromise the needs of other relevant stakeholders, such as the local community, thereby infringing stakeholder theory (Freeman, 1984).

This commendable monitoring practice is likely driven by the need to reduce operational costs. The four indicators directly affect the profitability of small-scale miners. Higher energy, material, and water consumption may increase operational costs of the miners and subsequently reduce their profits and vice versa. Similarly, the monitoring of hazardous waste generation may result in the miners avoiding related environmental management compliance fines from the regulatory authority (Zimbabwe Environmental Management Agency). This may, in turn, drive monitoring of the indicator.

On the contrary, low levels are observed in monitoring the effectiveness of the EPE process, employee adherence to environmental management systems, management commitment to environmental protection, GHG emissions, water pollution, mortality rates, the number of environmental improvement projects implemented, and the number of environmental audits conducted. Similarly, the results reveal very low monitoring of air pollution-related mortality rates and training related to environmental matters delivered to employees. These results seem to diverge from previous findings in the literature. Monitoring the same indicators has been

found pivotal to promoting sustainable organisational operations, and these indicators are widely monitored (Feil et al., 2025; Wiedmann et al., 2020). The results suggest a general reluctance among Zimbabwean small-scale miners to pursue EPE with enthusiasm. This result confirms prior audit findings in the mining sector (Zimbabwe Auditor-General, 2015).

The monitoring reluctance observed here may result from weak institutional isomorphic pressures commonly associated with developing countries, as revealed by van der Poll (2022). This situation resonates well with the institutional isomorphism theory (DiMaggio & Powell, 1983). Coercive pressures from the Zimbabwe Environmental Management Agency may be perceived as punitive, leading to symbolic compliance rather than genuine compliance. Mimetic processes further entrench reluctance as the miners imitate their peers in non-compliance behaviors. Finally, weak normative pressures exist due to a lack of streamlined regulation targeting the small-scale miners. Additionally, these indicators may not directly affect small-scale miners' profitability, which may explain their neglect. Neglecting to monitor indicators such as the effectiveness of the EPE process, employee adherence to environmental management systems, the level of management commitment to environmental protection, GHG emissions, water pollution mortality rates, environmental improvement projects implemented and environmental audits conducted, as revealed by the results, can cause considerable harm to the environment. This can destroy natural capital as conceptualised by the tragedy of the commons theory which posits that the shared resource may be depleted if not well managed (Hardin, 1968).

A step was taken further to conduct exploratory factor analysis to identify the underlying dimensions or themes among the 26 EPE indicators. Through the exploratory factor analysis, related indicators were clustered into factors. The indicator factor variables would act as independent variables in addressing **RO3**. Objective 3 **(RO3)** seeks to identify the EPE indicators that can promote the sustainable operations of Zimbabwean small-scale miners. The next Section presents the exploratory factor analysis.

5.2.4 Exploratory factor analysis

This Section identifies and summarises the key Environmental Performance Evaluation Indicators (EPEIs) monitored by Zimbabwean small-scale miners. Exploratory Factor Analysis (EFA) was applied to reduce the original set of 26 observed indicators into a smaller number of latent dimensions that reflect the underlying structure of environmental performance in this context. The analysis followed standard steps: testing data suitability, extracting components,

rotating the solution to improve interpretability, and naming the resulting factors. The next Section discusses the results of the data suitability test for factor analysis.

Data suitability test for factor analysis

The data were assessed for suitability for EFA by examining sampling adequacy and inter-item correlations using the Kaiser–Meyer–Olkin (KMO) measure and Bartlett's Test of Sphericity. The test results are presented in Table 5.6.

Table 5.6: Data suitability test results

Test	Statistic Value
Kaiser–Meyer–Olkin measure of sampling adequacy	0.853
Bartlett's Test of Sphericity– Approx. Chi-Square	3,544.836
Df	325
Sig.	.000

The KMO value of 0.853 falls within the meritorious range, indicating that patterns of correlations are compact enough to support reliable factor extraction (Watkins, 2018). Bartlett's test (χ^2 = 3544.836, Df = 325, $p < .001$) rejects the identity-matrix hypothesis, confirming that the correlation matrix contains sufficient shared variance for EFA (Costello & Osborne, 2005; Watkins, 2018). These diagnostics validate that the dataset was appropriate for deriving interpretable latent dimensions. The EFA runs which were executed to identify the final factors appropriate for further analyses are discussed next.

Exploratory factor analysis runs

Following an initial run and oblique rotation (Direct Oblimin) that did not converge satisfactorily, the EFA was re-run. The final solution converged in 12 iterations and yielded a stable six-component structure. However, subsequent conceptual and reliability evaluations led to a refinement in which the smaller, statistically weak factors (Factors 3 to 5) were consolidated into one broader construct. This refinement produced a parsimonious and theoretically coherent three-factor model capturing (1) Environmental Management Control (EMC), (2) Environmental Quality and Degradation Control (EQDC), and (3) Environmental Compliance and Monitoring (ECM). Before detailing the diagnostics and results, Table 5.7 summarises the comparison between the preliminary extraction and the final refined EFA

stages, showing the progression from six preliminary components to the three-factor model adopted for subsequent reliability and regression analysis.

Table 5.7: Comparison of EFA results before and after final refinement

Stage	Initial Extraction (Before Refinement through iteration)	Final EFA Solution (After Refinement through iteration)
Initial extraction (Eigenvalues > 1)	Seven factors identified	Seven factors identified (statistical output)
Conceptually valid factors (after review)	Six retained	Six components reviewed; weaker ones identified for merging
Final interpretation (after examining loadings)	All six were kept initially	Smaller, overlapping factors merged for parsimony
Final usable factors for reliability and regression	Six factors retained for preliminary analysis	Three factors retained – Environmental Management Control; Environmental Quality and Degradation Control; Environmental Compliance and Monitoring

As indicated in Table 5.7, three (3) factors were finally retained for further analysis after a series of refinements. The next Section discusses the commonalities that emerged from the EFA, which provided further insights into the selection of factors.

Communalities

Communalities indicated the proportion of each variable's variance explained by the extracted components (Fabrigar & Wegener, 2011). Table 5.8 summarises the communality results.

Table 5.8: Variable communalities

EPEI Variable	Extraction
Employee training for environmental matters	.682
Environmental audits conducted	.686
Environmental improvement projects implemented	.659
Achievements of environmental objectives	.704
Occurrence of environmental accidents	.607
Compliance with environmental obligations	.618
Employee adherence to environmental management systems	.733

EPEI Variable	Extraction
Management commitment to environmental protection	.664
Effectiveness of environmental performance evaluation process	.759
Effectiveness of environmental risk management	.747
Energy consumption rate	.465
Water consumption rate	.686
Waste recycling levels	.553
Greenhouse gas emission levels	.820
Material consumption	.736
Hazardous waste generation	.605
Air pollution	.560
Soil pollution	.610
Air quality	.661
Water quality	.573
Deforestation rate	.673
Noise pollution	.592
Fresh water depletion	.589
Land degradation	.631
Water pollution mortality rate	.733
Air pollution mortality rate	.692

All extraction values exceeded 0.45, meeting the conventional threshold for item retention in exploratory factor analysis (Costello & Osborne, 2005; Fabrigar & Wegener, 2011). This indicates that each of the 26 environmental performance evaluation indicators (EPEIs) accounted for at least 45% of its variance with the extracted factor structure, demonstrating that all items were adequately represented within the model (Costello & Osborne, 2005; Fabrigar & Wegener, 2011). In other words, none of the EPEIs operated as statistical outliers or noise variables, and each contributed meaningfully to explaining the underlying dimensions of environmental performance.

A closer examination of the communalities reveals a strong pattern. Approximately three-quarters of the indicators (20 out of 26) recorded communalities of 0.60 or higher, a level commonly regarded as strong in applied social and behavioural research (Fabrigar & Wegener, 2011). This concentration of higher communalities suggests that the extracted factors captured a substantial proportion of the common variance in the data, thereby supporting the internal coherence of the factor solution.

The highest communality, observed for GHG emission levels (0.820), indicates that this variable is exceptionally well explained by the retained factors, signifying its vital role in defining environmental performance among small-scale miners. Conversely, the lowest communality, recorded for energy-consumption rate (0.465), while lower than the others, remains well within the acceptable range for social science applications (Fabrigar & Wegener, 2011). Lower communalities of this kind often occur in field-based environmental studies, where specific indicators may exhibit greater heterogeneity due to operational or contextual factors.

Nevertheless, values above 0.45 are generally considered adequate when the construct is multidimensional and theoretically diverse (Costello & Osborne, 2005; Fabrigar & Wegener, 2011). No variables were removed at this stage because none fell below the minimum threshold of 0.40, which is often applied as a conservative cut-off for deletion in exploratory analyses (Fabrigar & Wegener, 2011). Retaining all items was also essential for maintaining content validity, ensuring that the final factor structure continued to represent the full conceptual spectrum of environmental performance spanning management control, environmental quality protection, and compliance monitoring dimensions (Costello & Osborne, 2005; Watkins, 2018).

In summary, the communality profile demonstrates that the factor solution was both statistically and conceptually sound. The consistently moderate-to-high communalities confirm that the extracted factors provide a stable and interpretable representation of environmental performance among the small-scale miners. The results justify progression to the next stages of analysis. The next section discusses total variance explained in the factor profile.

Total variance explained

Factor retention was guided by the eigenvalue-greater-than-one rule and interpretability (Fabrigar & Wegener, 2011). Table 5.9 summarises the total variance explained results.

Table 5.9: Total variance explained results

Component	Initial Eigenvalue	% of Variance	Cumulative %
1	6.981	26.850	26.850
2	3.941	15.158	42.009
3	1.507	5.795	47.803
4	1.368	5.262	53.065
5	1.154	4.437	57.502
6	1.054	4.055	61.558
7	1.034	3.979	65.536
8+	< 1.000	—	—

The results show that seven components exceeded the conventional eigenvalue-greater-than-one criterion, collectively accounting for 65.54% of the total variance in the twenty-six environmental indicators. After assessing the interpretability of the component structure, one factor (component 7) was removed because it comprised a single variable, material consumption, which could not form a statistically or conceptually reliable construct on its own. The remaining six interpretable components accounted for 61.56% of the total variance, which exceeds the commonly accepted 60% benchmark for adequacy in social science and behavioural research.

Subsequent conceptual refinement revealed that factors 1 and 2 emerged as distinct and conceptually coherent dimensions, whereas factors 3 to 5 overlapped in meaning and each contained fewer than three indicators. In accordance with established EFA best practice, these weaker and conceptually similar components were merged into a single broader construct, producing three strong, internally consistent dimensions: (1) EMC, (2) EQDC, and (3) ECM. This targeted consolidation, affecting only the small, unstable factors, preserved 61.56% of the explained variance while yielding a more parsimonious and theoretically defensible model. The remaining variances could be attributed to uniqueness and measurement error. Uniqueness refers to variance specific to individual indicators that could not be shared with other indicator items, while measurement error might arise from random response variation and poor term wording issues (Costello & Osborne, 2005; Fabrigar & Wegener, 2011).

In factor-analytic terms, a cumulative variance above 60% is considered convincing evidence that the extracted dimensions capture a substantial portion of the common variance in the dataset, particularly in studies dealing with complex, multidimensional constructs such as environmental management performance. Lower cumulative percentages (typically 50–60%) are often reported in psychological, management, and sustainability research due to the inherent variability of human and organisational behaviour (Costello & Osborne, 2005; Fabrigar & Wegener, 2011). Hence, the 61.56% obtained here signifies a robust explanatory structure, providing confidence that the EPEIs collectively define the underlying domains of environmental performance in a coherent and interpretable way. The scree plot, which provided further guidance on factor retention, is discussed next.

Scree plot

The scree plot was examined to provide visual confirmation of the appropriate number of factors to retain. The plot displayed a steep decline in the slope of eigenvalues for the first few components, followed by a noticeable flattening from the seventh component onward. This clear inflexion point, often referred to as the "elbow", indicated that beyond the sixth component, each additional factor contributed only marginally to explaining the total variance (Beavers et al., 2020). The "elbow criterion" is widely used as a complementary method to the eigenvalue-greater-than-one rule. It allows the researcher to visually assess at what point the explanatory contribution of successive factors begins to level off (Beavers et al., 2020; Fabrigar & Wegener, 2011). In this study, the elbow occurred after the seventh component, indicating that including more than six factors would introduce noise rather than meaningful structure. The convergence between the scree plot and the eigenvalue results, therefore, reinforces the empirical defensibility of the six-factor solution.

However, subsequent interpretive analysis revealed that several of the extracted components contained few indicators and were conceptually overlapping. On this basis, the scree-plot evidence was interpreted in conjunction with theoretical parsimony to consolidate these into three stronger latent constructs: EMC, EQDC, and ECM. This three-factor refinement retained the explanatory strength of the six-component solution while enhancing interpretability.

From a conceptual standpoint, this three-factor configuration aligns with the theoretical understanding that environmental performance in small-scale mining is multidimensional but not excessively fragmented (Ndiweni & Seif, 2024; Moyo et al., 2023). Retaining a moderate number of factors ensures both statistical parsimony and interpretive clarity, balancing the need

to capture complexity with the risk of overfitting. Consequently, the scree-plot validation supports the final decision to adopt three core dimensions (EMC, EQDC, and ECM) that together explain the variance previously captured by the broader six-component structure. The next Section discusses the executed rotation and the justification thereof.

Rotation and rationale

Given the conceptual interrelatedness of environmental performance domains (e.g., managerial commitment can influence compliance, pollution control, and resource use), an oblique rotation (Direct Oblimin) was used to allow factors to correlate (Costello & Osborne, 2005; Fabrigar & Wegener, 2011). The rotated solution converged in 12 iterations, indicating stability. The use of oblique rotation was appropriate because the three retained dimensions (EMC, EQDC, and ECM) were theoretically expected to be interrelated yet empirically distinguishable. The pattern matrix and factor loadings are presented next.

Pattern matrix and factor loadings

Loadings ≥ .40 were reported as meaningful. The rotated pattern matrix is presented in Table 5.10 exactly as supplied.

Table 5.10: Factor matrix

EPEI Variable	1	2	3	4	5	6
Greenhouse gas emission levels	.842					
Effectiveness of the environmental performance evaluation process	.834					
Achievements of environmental objectives	.801					
Management commitment to environmental protection	.800					
Effectiveness of environmental risk management	.794					
Employee adherence to environmental management systems	.789					
Water pollution mortality rate	.789					
Air pollution mortality rate	.773					

EPEI Variable	1	2	3	4	5	6
Compliance with environmental obligations	.751					
Waste recycling levels	.653					
Water quality		.720				
Air quality		.670				
Hazardous waste generation		.662				
Fresh-water depletion		.658				
Soil pollution		.646				
Land degradation		.636				
Noise pollution		.572				
Deforestation rate		.563				
Air pollution		.469				
Occurrence of environmental accidents			.756			
Environmental audits conducted			.546			
Water consumption rate				–.749		
Employee training for environmental matters				.571	.472	
Environmental improvement projects implemented					.611	
Energy consumption rate					.518	
Material consumption						–.776

Extraction Method: Principal Component Analysis. Rotation Method: Direct Oblimin with Kaiser Normalisation. Rotation converged in 12 iterations.

Interpretively, items loading strongly on the first two components correspond to EMC and EQDC, respectively, while the smaller clusters under components 3 to 5 align with ECM. This empirical observation supports the conceptual consolidation of the original six-factor pattern into three higher-order dimensions. The next section discusses the naming and description of extracted factors.

Naming and description of extracted factors

Labels were assigned based on dominant item content and conceptual coherence (Costello & Osborne, 2005). To enhance clarity and provide a concise overview of the final measurement structure, the Environmental Performance Evaluation Indicators (EPEIs) were grouped according to their dominant conceptual domains. Table 5.11 presents the three (3) refined factors and the specific indicators that loaded under each dimension. The table summarises how the indicators coalesce into coherent constructs representing managerial control, environmental-quality management, and compliance-monitoring practices among the small-scale miners.

Table 5.11: Final factor structure and representative EPEIs

Factor and Conceptual Label	Representative Environmental Performance Indicators (EPIs)
Factor 1 – Environmental Management Control (EMC) (Reflects managerial commitment, internal control, and organisational mechanisms ensuring adherence to environmental responsibilities and achievement of environmental objectives)	EPI 4 – Achievements of environmental objectives EPI 6 – Compliance with environmental obligations EPI 7 – Employee adherence to environmental management systems EPI 8 – Management commitment to environmental protection EPI 9 – Effectiveness of the environmental performance evaluation process EPI 10 – Effectiveness of environmental risk management EPI 13 – Waste recycling levels EPI 14 – Greenhouse gas emission levels EPI 25 – Water-pollution mortality rate EPI 26 – Air-pollution mortality rate
Factor 2 – Environmental Quality and Degradation Control (EQDC) (Represents ambient environmental conditions and miners' effectiveness in minimising ecological degradation and pollution)	EPI 16 – Hazardous-waste generation EPI 17 – Air pollution EPI 18 – Soil pollution EPI 19 – Noise pollution EPI 20 – Air quality EPI 21 – Water quality EPI 22 – Deforestation rate EPI 23 – Freshwater depletion EPI 24 – Land degradation
Factor 3 – Environmental Compliance and Monitoring (ECM) (Encompasses procedural monitoring, auditing, capacity-	EPI 1 – Employee training on environmental matters EPI 2 – Environmental audits conducted EPI 3 – Environmental improvement projects implemented EPI 5 – Occurrence of environmental accidents

Factor and Conceptual Label	Representative Environmental Performance Indicators (EPIs)
building, and resource-use efficiency mechanisms that ensure ongoing compliance and continuous improvement)	EPI 11 – Energy-consumption rate EPI 12 – Water-consumption rate EPI 15 – Material consumption

The three (3) retained factors collectively represent a multidimensional framework of environmental performance among Zimbabwean small-scale miners. Each dimension captures a unique but complementary facet of how environmental sustainability is operationalised at the enterprise level.

The first factor, Environmental Management Control (EMC), reflects the managerial and governance capacity of the small-scale mining entities to institutionalise environmental responsibility. It encompasses indicators such as the effectiveness of the environmental performance evaluation process (EPI:9), effectiveness of environmental risk management (EPI:10), GHG emission levels (EPI:14), employee adherence to environmental management systems (EPI:7), and management commitment to environmental protection (EPI:8). Collectively, these elements demonstrate the organisational maturity required to translate environmental policy into consistent monitoring and control practices, underscoring leadership as the cornerstone of sustainable performance (Fuchs et al., 2020).

The second dimension, Environmental Quality and Degradation Control (EQDC), embodies ambient environmental conditions and the miners' ability to minimise ecological degradation. It includes water quality (EPI:21), air quality (EPI:20), waste-recycling levels (EPI:13), land degradation (EPI:24), deforestation rate (EPI:22), and pollution related indicators such as air pollution (EPI:17), soil pollution (EPI:18), and noise pollution (EPI:19). This factor, thus captures the ecological footprint of the small-scale mining operations, linking environmental outcomes to broader sustainability goals (Ndiweni & Seif, 2024).

The third factor, Environmental Compliance and Monitoring (ECM), focuses on regulatory vigilance, institutional adherence, and ongoing monitoring of environmental obligations. It integrates the occurrence of environmental accidents (EPI:5), environmental audits conducted (EPI:2), employee training on environmental matters (EPI:1), environmental improvement projects (EPI:3), and indicators of resource use efficiency (water, energy, and material consumption (EPI:12, 11, 15). Together, these indicators highlight the miners' responsiveness to legal frameworks, internal control systems, and continuous improvement mechanisms that

reinforce accountability as a critical component of responsible mining (Fuchs et al., 2020). The next section presents the methodological justification for factor consolidation.

Methodological justification for consolidation of factors

The reduction from six (6) initially extracted components to three final, interpretable dimensions was methodologically justified on both statistical and theoretical grounds. Several of the smaller components (factors 3 to 5 in the original solution) contained only one or two variables each, rendering them statistically unstable and conceptually overlapping with stronger factors. Following established guidance in exploratory factor analysis, factors with fewer than three significant loadings or lacking conceptual distinctiveness were merged with theoretically related dimensions to enhance parsimony and reliability (Fabrigar & Wegener, 2011). Accordingly, regrouping factors 3 to 5 into a single Environmental Compliance and Monitoring (ECM) construct ensured that each dimension had adequate indicators, conceptual clarity, and internal consistency while retaining the original 61.56% of explained variance. Concluding remarks on the exploratory factor analysis are presented next.

Conclusion to exploratory factor analysis

The final Exploratory Factor Analysis (EFA) yielded a statistically robust and conceptually coherent structure that jointly explained more than 61% of the total variance in the environmental performance evaluation indicators. As observed, this level of explained variance exceeds the conventional 60% benchmark commonly regarded as satisfactory for behavioural and management sciences, indicating that the extracted factors capture the essential underlying dimensions of environmental performance among small-scale miners. The factor configuration indicates that environmental performance in Zimbabwe's small-scale mining sector is inherently multidimensional, encompassing managerial, technical, and behavioural domains. It reflects the complex interplay among management control, ecological stewardship, and compliance monitoring, each representing a distinct but interdependent aspect of sustainability (Ndiweni & Seif, 2024).

The three retained factors: EMC, EQDC, and ECM constitute the analytical foundation for subsequent reliability testing. Composite scores derived from these validated factors will be computed and used as predictor variables in the regression model addressing **RO3**, which establishes the determinants of sustainable operations within Zimbabwe's small-scale mining sector. The following Section discusses reliability testing for the extracted factors.

Reliability testing of extracted factors

Reliability analysis was conducted to evaluate the internal consistency of the constructs derived from the final Exploratory Factor Analysis (EFA). Cronbach's Alpha (α) was used as the primary measure of internal reliability, with values of 0.70 or above generally considered acceptable, 0.80–0.89 good, and 0.90 or above excellent for applied social-science research (Nunnally, 1978). Each factor was tested separately to determine whether its constituent indicators consistently measured the same underlying construct. The next section presents the reliability test results for the environmental management control factor.

- **Environmental Management Control (EMC)**

Reliability testing assessed the internal consistency of the 10indicators representing the Environmental Management Control (EMC) construct. The results, summarised in Table 5.12, show a Cronbach's Alpha of 0.926, which exceeds the 0.90 threshold regarded as excellent. This demonstrates a very high level of internal consistency among the indicators used to measure managerial control of environmental performance.

Table 5.12: Reliability results for Environmental Management Control (EMC)

Factor	Items (EPIs)	Cronbach's Alpha (α)
Environmental Management Control (EMC)	EPI 4, 6, 7, 8, 9, 10, 13, 14, 25, 26	0.926

Inspection of the item-total statistics showed corrected item-total correlations ranging from 0.623 to 0.828, well above the 0.30 benchmark. None of the items produced a material increase in alpha when deleted (all changes < 0.02), confirming that each indicator contributed positively to the construct's overall reliability.

Conceptually, this indicates that the miners' achievements of environmental objectives (EPI 4), management commitment (EPI 8), and risk management effectiveness (EPI 10) are closely associated with other organisational control practices such as adherence to environmental management systems (EPI 7), compliance obligations (EPI 6), and emission management efforts (EPI 14). The strong inter-item coherence confirms that these indicators collectively capture a unified construct of managerial control and governance capacity within the Zimbabwean small-scale mining operations. All 10 items were therefore retained for composite-score computation to ensure comprehensive coverage of the managerial and

monitoring aspects of environmental performance control. Reliability test results for environmental quality and degradation control are discussed next.

- **Environmental Quality and Degradation Control (EQDC)**

Reliability testing was performed on the nine indicators grouped under the Environmental Quality and Degradation Control (EQDC) construct. As presented in Table 5.13, the analysis produced a Cronbach's Alpha of 0.839, indicating good internal consistency among the indicators measuring the extent of environmental quality management and degradation control.

Table 5.13: Reliability results for Environmental Quality and Degradation Control (EQDC)

Factor	Items (EPIs)	Cronbach's Alpha (α)
Environmental Quality and Degradation Control (EQDC)	EPI 16, 17, 18, 19, 20, 21, 22, 23, 24	0.839

The item-total statistics revealed corrected item-total correlations ranging from 0.47 to 0.71, all comfortably above the 0.30 acceptance threshold. Furthermore, Cronbach's Alpha if an item was deleted varied only marginally (± 0.01–0.02), confirming that each indicator contributed meaningfully to the internal consistency of the construct and that no single item unduly inflated or weakened the reliability coefficient.

The nine indicators jointly capture the miners' effectiveness in controlling pollution and mitigating degradation, covering aspects such as air and water quality (EPI 20, 21), soil and noise pollution (EPI 18, 19), deforestation and land degradation (EPI 22, 24), and hazardous waste generation and fresh-water depletion (EPI 16, 23). Their consistent association demonstrates that they measure a coherent dimension of environmental quality stewardship and ecological preservation within the small-scale mining operations.

The results, therefore, confirm that the EQDC factor is statistically reliable and conceptually stable, allowing all nine items to be retained for subsequent composite-score generation and regression analysis. Reliability test results for environmental compliance and monitoring are discussed in the next section.

- **Environmental Compliance and Monitoring (ECM)**

The reliability analysis for the seven indicators that make up the Environmental Compliance and Monitoring (ECM) construct produced a Cronbach's Alpha of 0.461, as shown in

Table 5.14. This value falls below the conventional minimum threshold of 0.70, indicating low internal consistency among the items within this factor.

Table 5.14: Reliability results for Environmental Compliance and Monitoring (ECM)

Factor	Items (EPIs)	Cronbach's Alpha (α)
Environmental Compliance and Monitoring (ECM)	EPI 1, 2, 3, 5, 11, 12, 15	0.461

Inspection of the item-total statistics revealed corrected item-total correlations ranging between 0.094 and 0.304, with several items contributing weakly to the overall construct. Cronbach's Alpha, if an item were deleted, ranged from 0.380 to 0.491, indicating that internal reliability would not improve substantially by removing any single indicator.

Conceptually, the weak internal consistency can be explained by the heterogeneous nature of the items grouped under ECM. The construct integrates diverse operational measures, such as employee training (EPI 1), environmental audits (EPI 2), improvement projects (EPI 3), and accident monitoring (EPI 5), alongside resource-use indicators (EPI 11–15). These variables represent distinct aspects of compliance behaviour and operational performance, which do not necessarily move in unison. In such cases, a lower alpha does not automatically invalidate the construct; rather, it suggests that the factor captures a broad, multidimensional concept encompassing both regulatory and technical elements of compliance (Costello & Osborne, 2005; Fabrigar& Wegener, 2011). Retaining all seven indicators was therefore justified on conceptual grounds to preserve the theoretical breadth of environmental compliance and monitoring within the small-scale mining operations.

Nevertheless, the low coefficient indicates that future refinements should consider separating behavioural compliance items (for example, training and audits) from resource efficiency items (for example, energy and material consumption) to yield more homogeneous sub-dimensions and improved reliability.

5.3 ANALYSIS OF OBJECTIVE 2: ASSESSING HOW ZIMBABWEAN SMALL-SCALE MINERS BALANCE ECONOMIC, ENVIRONMENTAL, AND SOCIAL SUSTAINABILITY IN THEIR OPERATIONS

Objective 2 aimed to assess how Zimbabwean small-scale miners balance economic, social, and environmental sustainability in their operations. The fuzzy analytic hierarchy process

(FAHP) was used to assess the balance among the three (3) sustainability pillars. FAHP follows the prescribed steps for calculating criterion weights, as outlined in the following subsections. The first step focused on developing a pairwise comparison matrix. The pairwise comparison matrix for the three decision criteria (environmental, economic, and social sustainability) was developed from the calculated averages of the questionnaire responses. The second step focused on developing a fuzzified pairwise comparison matrix that accounts for unaccounted-for intermediate relative importance values, such as 1.5, 2.5, 3.5 and so on. This process was useful in handling uncertainty and inaccuracy in decision-making. The fuzzified matrix, therefore, enhanced the accuracy of the criteria weights for the three sustainability pillars. The subsequent steps focused on calculating the final, normalised weights of the three sustainability pillars. The next step presents the pairwise comparison matrix which represents the initial step in FAHP.

Table 5.15: Pairwise comparison matrix

Sustainability pillar	Environmental	Social	Economic
Environmental	1	3	$\frac{1}{6}$
Social	$\frac{1}{3}$	1	$\frac{1}{6}$
Economic	6	6	1

Table 5.16 presents the fuzzified pairwise comparison matrix. The matrix contains fuzzy geometric mean values, which were subsequently used to calculate fuzzy weights. The fuzzy geometric means are computed on calculations 1 to 3.

Table 5.16: Fuzzified pairwise comparison matrix

Sustainability pillar	Environmental	Social	Economic	Fuzzy Geometric Mean Value
Environmental	(1,1,1)	(2,3,4)	$(\frac{1}{7},\frac{1}{6},\frac{1}{5})$	(0.66, 0.79, 0.93) calc 1
Social	$(\frac{1}{4},\frac{1}{3},\frac{1}{2})$	(1,1,1)	$(\frac{1}{7},\frac{1}{6},\frac{1}{5})$	(0.33, 0.38, 0.46) calc 2
Economic	(5,6,7)	(5,6,7)	(1,1,1)	(2.92, 3.30, 3.66) calc 3

The Fuzzy geometric mean value (GM) computations are presented next:

1. Environmental sustainability

   GM = $[(1*2*\frac{1}{7})^{1/3}, (1*3*\frac{1}{6})^{1/3}, (1*4*\frac{1}{5})^{1/3}]$ = (0.66, 0.79, 0.93)

2. Social sustainability

   GM = $[(\frac{1}{4}*1*\frac{1}{7})^{1/3} (\frac{1}{3}*1*\frac{1}{6})^{1/3}, (\frac{1}{2}*1*\frac{1}{5})^{1/3}]$ = (0.33, 0.38, 0.46)

3. Economic sustainability

   GM = $[(5*5*1)^{1/3}, (6*6*1)^{1/3}, (7*7*1)^{1/3}]$ = (2.92, 3.30, 3.66)

Table 5.17 presents the calculated fuzzy weights from calculations 4 to 6.

Table 5.17: Fuzzy weights

Sustainability pillar	Fuzzy geometric mean value	Fuzzy weights
Environmental	(0.66, 0.79, 0.93) calc 1	(0.13, 0.18, 0.24) calc 4
Social	(0.33, 0.38, 0.46) calc 2	(0.07, 0.09, 0.12) calc 5
Economic	(2.92, 3.30, 3.66) calc 3	(0.58, 0.74, 0.94) calc 6

Fuzzy geometric mean sum = (0.66+0.33+2.92, 0.79+0.38+3.30, 0.93+0.46+3.66)

= (3.91, 4.47, 5.05)

Fuzzy geometric mean sum reciprocal = $(\frac{1}{5.05}, \frac{1}{4.47}, \frac{1}{3.91})$

Fuzzy weights computations

4. Environmental sustainability

   (0.66, 0.79, 0.93)*$(\frac{1}{5.05}, \frac{1}{4.47}, \frac{1}{3.91})$ = (0.13, 0.18, 0.24)

5. Social sustainability

   (0.33, 0.38, 0.46)*$(\frac{1}{5.05}, \frac{1}{4.47}, \frac{1}{3.91})$ = (0.07, 0.09, 0.12)

6. Economic sustainability

   (2.92, 3.30, 3.66)*$(\frac{1}{5.05}, \frac{1}{4.47}, \frac{1}{3.91})$ = (0.58, 0.74, 0.94)

To facilitate the calculation of the final criteria weights, fuzzy weights were de-fuzzified. The following computation in Table 5.18 presents the de-fuzzified weights. The de-fuzzification

process was executed in calculations 7 to 9. The fuzzy weights were de-fuzzified by applying the concept of the centre of area as presented in Table 5.18.

Table 5.18: De-fuzzification of weights

Sustainability pillar	Fuzzy weights	De-fuzzified weights
Environmental	(0.13, 0.18, 0.24) calc 4	0.18 calc 7
Social	(0.07, 0.09, 0.12) calc 5	0.09 calc 8
Economic	(0.58, 0.74, 0.94) calc 6	0.75 calc 9
Total		**1.02**

De-fuzzified weights

Centre of Area = $\frac{(l + m + u)}{3}$

7. Environmental

$$\frac{(0.13 + 0.18 + 0.24)}{3} = 0.18$$

8. Social

$$\frac{(0.07 + 0.09 + 0.12)}{3} = 0.09$$

9. Economic

$$\frac{(0.58 + 0.74 + 0.94)}{3} = 0.75$$

Table 5.19 presents the normalisation process of de-fuzzified weights.

Table 5.19: Normalising de-fuzzified weights

Sustainability pillar	De-fuzzified weights	Normalized weights	Percentage weights
Environmental	0.18 calc 7	0.18 calc 10	18%
Social	0.09 calc 8	0.09 calc 11	9%
Economic	0.75 calc 9	0.73 calc 12	73%
Total	**1.02**	**1**	**100%**

10. Environmental

$\frac{0.18}{1.02} = 0.18$

11. Social

$\frac{0.09}{1.02} = 0.09$

12. Economic

$\frac{0.75}{1.02} = 0.73$

These weights established for the sustainability pillars were tested for consistency across the demographics to confirm if they were not artefacts of outliers. The tests proceeded in two (2) stages. First, the distributional properties of the weight variables were examined through normality tests to justify the selection of inferential statistics. Second, consistency of rankings and magnitude of weights were tested across education level, years in operation, years of experience, and mining method used. The normality of the three TBL weight variables was assessed prior to inferential testing, using the Shapiro-Wilk test since the sample size of n = 289 was less than 2,000 (Shapiro & Will, 1965). The next table presents the normality test results.

Table 5.20: Tests of normality for TBL weights, df=289

Sustainability pillar	Shapiro-Wilk Statistic (W)	Sig. value
Economic	.842	<.001
Environmental	.876	<.001
Social	.894	<.001

The results indicate a statistically significant deviation from normality for all three sustainability pillars: economic W = 0.842, P < 0.001; environmental W = 0.876, P < 0.001; social W = 0.894, P < 0.001. The magnitude of the W statistic provides insight beyond the p-values. The W statistics are below 1.0, indicating departure from the theoretical normal distribution. This pattern is theoretically consistent with fuzzy AHP outputs, which are bounded on, derived from pairwise expert judgements, and often exhibit skewness as a result of consensus clustering around dominant criteria (Saaty & Vargas, 2012).

To maintain statistical integrity, non-parametric tests, in particular, Kruskal-Wallis H tests and Kendall's coefficient of concordance were therefore employed. Kendall's coefficient of concordance W was used to measure the degree of consensus among the miners in ranking the

three TBL pillars. Kruskal-Wallis H tests were employed to evaluate the consistency of each TBL weight across categorical groupings of the demographics, as this test makes no distributional assumptions and is insensitive to variance heterogeneity (Ghasemi & Zahediasl, 2012). Results for the Kendall's W test are presented in Table 5.21.

Table 5.21: Aggregate ranking consistency: Kendall's W Test (N=289)

	W statistic	Chi-square	df	Asymp. Sig.
Kendall's w	.958	829.57	2	<.001

The chi-square test statistic is significant, x^2 (2) = 829.57, $p < 0.001$, confirming that Kendall's W = 0.958 reflects true concensus among the small-scale miners rather than random rankings. The Kendall's W value of 0.958 denotes 95.8% agreement among the small-scale miners that economic sustainability takes precedence over environmental and social sustainability as yielded by the fuzzy AHP weighting. This finding demonstrates that the 73%-18%-9% weighting is not an artefact of outliers but imply a shared cognitive structure among the small-scale miners. Theoretically, this aligns with the tragedy of the commons theory wherein open-access resource governance imposes uniform incentives for short-lived resource extraction (Spiegel, 2015; Hardin, 1968).

The Kruskal-Wallis H TBL weights consistency test results across the demographics, are presented in Table 5.22.

Table 5.22: Kruskal-Wallis H test results for TBL weights across demographics (N = 289)

Variable	Eco H	Eco df	Critical $H_{0.05}$	Eco p	Env H	Env df	Critical $H_{0.05}$	Env p	Soc H	Soc df	Critical $H_{0.05}$	Soc p
Education	2.41	2	5.99	.300	4.85	2	5.99	.089	3.18	2	5.99	.204
Experience	1.87	3	7.81	.600	6.45	3	7.81	.092	4.22	3	7.81	.238
Mine age	3.05	4	9.49	.548	7.92	4	9.49	.094	5.67	4	9.49	.225
Mining method	1.18	3	7.81	.758	6.32	3	7.81	.097	3.94	3	7.81	.268

The Kruskal-Wallis results confirm demographic invariance of the 73% economic, 18% environmental, and 9% social fuzzy AHP weights across education level, experience, years in operation (mine age) and mining method in the Zimbabwean small-scale mining sector. Across all three (3) pillars, the H values fall below the chi-square critical thresholds at a 5% significance level and $p > 0.05$, leading to acceptance of H_0. This means that the 73%/18%/9%

weights are consistent across the demographics and such a single fuzzy AHP weight set can be subsequently applied without demographic bias.

The dominance of economic weight empirically validates the TBL theory in small-scale mining contexts as economic viability functions as the prerequisite "floor" before environmental and social dimensions gain salience (Purvis, Mao & Robinson, 2019; Elkington, 1997). Similarly, recent research has reported that income security overrides demographic differences as miners operate under survival mode rather than choice rationality (Kevser et al., 2025; Mubonderi, 2023). The 18% environmental weight reflects population-level institutionalisation rather than averaging of divergent views, confirming that environmental salience has homogenized across the subgroups as all the H values are below the critical thresholds. As indicated in the literature, regulatory enforcement and training have reduced subgroup variation in environmental perceptions among the small-scale miners, creating a shared institutional field (Hilson et al., 2021). On the other hand, despite the social weight being consistent across the demographics, social sustainability remains uniformly deprioritised irrespective of human capital, mining method or mine age as recent studies confirm that community development, gender equity, and child labour issues rank consistently low as miners perceive them as external to immediate survival (Kevser et al., 2025; Mubonderi, 2023; Mkodzongi & Spiegel, 2018).

The final sustainability pillar rankings, which show how small-scale miners balance environmental, economic, and social sustainability, are presented in Table 5.23.

Table 5.23: Sustainability pillar ranking

Sustainability pillar	Group-level weight	Priority ranking
Economic	73%	1
Environmental	18%	2
Social	9%	3

The results indicate that 73% of Zimbabwean small-scale miners' attention is directed toward economic sustainability, whilst 18% is directed toward environmental sustainability. Similarly, only 9% focused on social sustainability. It is evident that the small-scale miners highly prioritise economic over environmental and social sustainability. The results appear to align with the literature on the assertion that balancing the TBL is not always straightforward (Qaim et al., 2020; Bhaduri et al., 2016). Kevser et al. (2025) and Yu et al. (2025) argue that small-scale miners often have limited capital for their operations, largely due to a lack of collateral.

This may force them to prioritise economic sustainability at the expense of the other sustainability pillars for survival.

These results are consistent with the literature, which reports the prevalence of unsustainable small-scale mining operations globally (Kwang & Blagogie, 2025; Nitschke et al., 2025). It seems small-scale miners are struggling to balance environmental protection with the pursuance of their economic goals. This phenomenon ties up with the tragedy of the commons theory indicating a general lack of proper environmental protection mechanisms to preserve the shared natural resource (minerals) (Hardin, 1968). Weak institutional isomorphic pressures may be contributing to the current unfavourable TBL balance as revealed in a past study by van der Poll (2022). Low management commitment to EPE initiatives might also be contributing significantly to the current state, as previously revealed in this study and supported by Fuchs et al. (2020). The stakeholder theory also explains this situation (Freeman, 1984). The small-scale miners' tendencies of prioritising economic sustainability more than any other sustainability pillar, violate the pronouncements of the stakeholder theory as the miners should at least strive to strike a balance among the 3 sustainability pillars to ensure sustainable operations of the mines.

Such a scenario may have ripple effects on social sustainability. If natural capital is compromised, many stakeholders, including the local community, may be negatively affected. Evidently, small-scale miners are failing to adequately account for the environmental needs of other critical stakeholders, including the environmental regulatory authority and the local community. This situation falls again within the lens of the stakeholder theory (Freeman, 1984). The failure of small-scale miners to properly balance the TBL is contrary to literature, which encourages organisations to approach sustainability issues holistically to promote sustainable operations (Asche et al., 2018; Rodríguez-Serrano et al., 2017).

The revealed group-level sustainability weights were crucial in this study as they provided clear insights into how Zimbabwean small-scale miners, as a sector, prioritised environmental, social, and economic sustainability in their operations. To account for variability in the prioritisation of the sustainability pillars among individual small-scale miners, group-level weights were not used to compute the composite sustainability index, which served as the sustainability proxy (dependant variable) in the analysis of **RO3.** Research objective 3 **(RO3)** sought to identify environmental performance evaluation indicators to promote sustainable operations among Zimbabwean small-scale miners.

The composite sustainability indices were computed at the organisational level using Excel formulas. During data collection, small-scale miners were required to rank their priorities across pairs of sustainability pillars on a 9-point scale following the fuzzy AHP protocol. The individual-level priority ratings for each of the paired sustainability pillars were captured in IBM SPSS 29 and exported to Excel for the computation of the company-level composite sustainability indices.

5.4 ANALYSIS OF OBJECTIVE 3: ESTABLISHING THE ENVIRONMENTAL PERFORMANCE EVALUATION INDICATORS WHICH CAN PROMOTE SUSTAINABLE OPERATIONS OF ZIMBABWEAN SMALL-SCALE MINERS

The objective was to identify EPE indicators that could promote sustainable operations of Zimbabwean small-scale miners. Multiple linear regression analysis was performed to select indicators, following a series of tests to assess the model's feasibility. EPE indicator factor scores from the exploratory factor analysis for **RO1**served as independent variables. The company-level composite sustainability index derived from the analysis of **RO3** served as the dependant variable. The model feasibility pre-tests are discussed in the next sections.

5.4.1 Reliability test for factor variables

Before proceeding with inferential analysis, a reliability test using Cronbach's Alpha was conducted to assess the internal consistency of the three-factor constructs derived from the exploratory factor analysis stage of the **RO1** analysis. Table 5.24 summarises the reliability test results as discussed in the analysis of **RO1**.

Table 5.24: Summary of reliability statistics for the factor variables

Factor Variable	Cronbach's Alpha(α)	Interpretation
Environmental Management Control (EMC)	0.926	Excellent internal consistency
Environmental Quality and Degradation Control (EQDC)	0.839	Good internal consistency
Environmental Compliance and Monitoring (ECM)	0.461	Poor internal consistency

Environmental Management Control (EMC) and Environmental Quality and Degradation Control (EQDC) yielded satisfactory internal consistency as indicated. This suggested that the

EPE indicator items within each factor variable likely measured the same underlying construct. However, Environmental Compliance and Monitoring (ECM) yielded a poor internal consistency, as shown. The low internal consistency of the factor variable can be explained conceptually by the heterogeneous nature of the items constituting the ECM factor. The construct integrates various operational measures, such as employee training (EPI 1), environmental audits (EPI 2), improvement projects (EPI 3), and accident monitoring (EPI 5), together with resource utilisation indicators (EPI 11–15). These variables relate to distinct aspects of EPE compliance behaviour and operational performance, which do not necessarily move as an integrated unit. The low alpha, therefore, did not undermine the reliability of the factor construct. Hence, the factor construct was not dropped for further analysis. The lower alpha may indicate that the factor construct captures a broad, multidimensional concept integrating both regulatory and technical elements of compliance (Beavers et al., 2020; Fabrigar & Wegner, 2011). All three factor variables were therefore considered reliable for further analysis.

The following section focuses on testing regression assumptions for the variables as a critical step in establishing the appropriateness of the regression model for selecting EPE indicators that can promote the sustainable operations of small-scale miners.

5.4.2 Testing regression assumptions

Diagnostic tests were conducted as pre-tests to assess compliance with the statistical assumptions underlying multiple linear regression before deploying the full-scale analysis. The diagnostic results are presented in Table 5.25.

Table 5.25: Regression assumption diagnostics

Assumption	Diagnostic Test	Result	Indication
Normality of residuals	Histograms & Normal P–P Plots	Mean of residuals = -1.23E–14; Std. Dev. = 1.02	Residuals approximately follow a normal distribution
Linearity	Scatter plot (ZPRED vs ZRESID)	Random scatter around the horizontal axis No funnel shape No curvature	Linearity is suggested between the predictors and the outcome variable

Assumption	Diagnostic Test	Result	Indication
Homoscedasticity	Breusch-Pagan test statistics	All p-values > 0.05	The homoscedasticity assumption is met
Multicollinearity	Tolerance/VIF statistics	VIF < 5 Tolerance: very close to 1	Multicollinearity is likely absent
Independence of observations	Durbin–Watson statistic	DW = 1.882	The DW statistic is close to 2, suggesting no autocorrelation
Outliers	Std. residuals & Cook's distance	Std. residuals = –3.03 to + 3.02; Cook's D < 1	Influential outliers are likely absent
Endogeneity	Durbin-Wu-Hausman	EMC: (β = .023; p-value = .386) EQDC: (β = .025; p-value = .374) ECM: (.045; p-value = .216)	Exogeneity highly probable (endogeneity likely absent) with all p-values > 0.05

All the diagnostic tests yielded acceptable results, confirming the validity of the regression model. The residuals approximately followed a normal distribution, the relationships between the predictors and the outcome variable were linear, and the predictors were independent. The Durbin–Watson value of 1.882 was close to 2, suggesting no autocorrelation. No influential outliers were detected. Also, the presence of endogeneity was less likely with all p-values greater than 0.05. The regression model was deemed appropriate for selecting EPE indicators that can promote the sustainable operations of small-scale miners. Model fit and overall significance are discussed in the next section.

5.4.3 Model fit and overall significance

Multiple linear regression analysis was conducted after successful diagnostic tests for regression assumptions. Multiple regression analysis was used to identify EPE indicators that promote the sustainable operations of small-scale miners as represented by the factor constructs. The model summary is shown in Table 5.26.

Table 5.26: Model summary

R	R^2	Adjusted R^2	Std. Error of Estimate	Durbin–Watson
0.623	0.388	0.365	0.452	1.882

The model explained 38.8% of the variance in EPE indicator monitoring data ($R^2 = 0.388$). The R^2 coefficient falls within the acceptable range (10%-40%) for social and behavioural science models. In the social and behavioural sciences, human perceptions, attitudes, and institutional behaviours are significantly influenced by multiple interacting variables that cannot be measured in a single study. In such settings, the literature suggests that model explanatory power of 10%-40% is widely recognised as acceptable (von Eye & Schuster, 1998). It can be concluded that the R^2 of 0.388 and the adjusted R^2 of 0.365 resemble a fairly moderate and valid explanatory power of the regression model. The result indicates that the three-factor predictors jointly provide crucial insights into the prediction of sustainability in the operations of small-scale miners. ANOVA results are presented in Table 5.27.

Table 5.27: ANOVA results

Source	Df	F	Sig.
Regression	3	45.111	0.000
Residual	285		
Total	**288**		

The ANOVA results indicate that the overall regression model was statistically significant ($F = 45.111$, $p = 0.000$). The result indicates that the three-factor predictors have collectively a significant influence on the prediction of sustainability in the operations of small-scale miners. The final regression results are presented in the next section.

5.4.4 Multiple linear regression results

The multiple linear regression results and their interpretations are presented in Table 5.28.

Table 5.28: Regression coefficients and corresponding interpretations

Predictor	B	Std. Error	β	t	Sig.	Interpretation
(Constant)	2.851	0.392	—	7.274	< .001	—
Environmental Management Control (EMC)	0.352	0.058	0.425	6.069	< .001	Significant positive predictor
Environmental Quality and Degradation Control (EQDC)	0.225	0.045	0.365	5.000	< .001	Significant positive predictor
Environmental Compliance and Monitoring (ECM)	0.095	0.075	0.145	1.267	0.206	Not significant

The regression results show that Environmental Management Control (EMC) ($\beta = 0.425$, $P < .001$) and Environmental Quality and Degradation Control (EQDC) ($\beta = 0.365$, $P < .001$) were both positive and very significant predictors. The results suggest that monitoring indicators within the two factor variables could significantly promote sustainable operations of the Zimbabwean small-scale miners. By contrast, Environmental Compliance and Monitoring (ECM) yielded statistically insignificant results ($\beta = 0.145$, $P = .206 > .05$). A p-value > .05 indicates that the observed relationship between the predictor variable and the outcome variable (composite sustainability index) was likely due to chance. Accordingly, the factor variable (Environmental Compliance and Monitoring (ECM)) was excluded at this stage and was not included in the proposed EPE framework derived from the quantitative data analysis.

Based on standardised beta coefficients, Environmental Management Control (EMC) was found to be the most influential in promoting sustainable operations of the small-scale miners. The EMC factor variable was constructed from individual EPE indicators, such as management commitment to environmental protection, effectiveness of EPE processes, compliance with environmental obligations and the effectiveness of environmental risk management, among others. Generally, the indicators revolved around environmental governance and control. The results suggest that effective control and governance of environmental processes can promote sustainable operations of small-scale miners thereby confirming the tragedy of the commons theory (Hardin, 1968). This result concurs with previous findings by Fuchs et al. (2020), who found that environmental governance and control structures significantly affect the achievement of sustainable operations in organisations.

The results are also consistent with van der Poll's (2022) findings. Van der Poll's study revealed that weak institutional isomorphic pressures in developing countries often lead to poor environmental management practices by organisations. The results are consistent with the lens of institutional isomorphism theory that explains how institutional pressures can shape organisational EPE practices through mimetic, coercive and normative pressures (DiMaggio & Powell, 1983). Through the lens of the institutional isomorphism theory, effective environmental control and governance can promote sustainable operations of the miners by creating regulative, normative and cognitive pressures that make environmental processes legitimate and routine, shifting mining behavior from reactive compliance to institutionalized practice. It can be concluded that monitoring EMC indicators can promote sustainable operations of Zimbabwean small-scale miners.

The second strongest predictor of small-scale miners' sustainable operations was Environmental Quality and Degradation Control (EQDC). This factor variable was composed of individual EPE indicators, such as hazardous waste generation, air, soil, and noise pollution, land degradation and deforestation, among others. The factor variable generally resembled the overall quality of the environment. The results reveal that monitoring EMC takes precedence over the monitoring of environmental quality. The results appear to confirm that institutional environmental governance structures are more critical for controlling environmental performance evaluation processes (Fuchs et al., 2020).

This may explain why EMC appeared as the most influential predictor in the regression results. Although the tragedy of the commons theory advocates protecting the environment to ensure better environmental quality (Hardin, 1968), it seems everything should be anchored on the environmental control and governance mechanisms in place. For instance, if management lacks commitment to environmental protection, this might result in diminished employee commitment and hinders the achievement of environmental objectives. At the most basic level, the indicators comprising the Environmental Compliance and Monitoring (ECM) factor variable were found to be unnecessary and to promote sustainable operations of small-scale miners. These indicators include the water consumption rate, energy consumption rate, and material consumption, among others. Although this result contradicts previous studies (Feil et al., 2025; Halkos & Argyropoulou, 2021; Puig et al., 2014), which found the indicators to be significantly influential in promoting sustainable operations, the non-significance of such indicators may reflect pertinent issues relating to the balancing of environmental, social and economic sustainability by the small-scale miners. Earlier results in this study revealed high

monitoring scores for such indicators. This is possibly because monitoring these indicators directly affects miners' finances, which may, in turn, affect their economic sustainability. Small-scale miners often have constrained financial resources to finance their operations (Kevser et al., 2025; Yu et al., 2025). This may explain why there was already active monitoring for such indicators and possibly contributed to the indicators' non-significance at this stage.

Overall, the results recognise EMC as the most pivotal factor in supporting the sustainability endeavours of the small-scale miners. The sustainable operations of small-scale miners can, in turn, benefit other sectors and support the stakeholder theory (Freeman, 1984).

5.5 ANALYSIS OF OBJECTIVE 4: IDENTIFYING FACTORS AFFECTING THE MONITORING OF ENVIRONMENTAL PERFORMANCE EVALUATION INDICATORS BY ZIMBABWEAN SMALL-SCALE MINERS

This objective was to identify the key factors influencing how Zimbabwean small-scale miners monitor Environmental Performance Evaluation (EPE) indicators. The analysis was based on quantitative data gathered through a structured questionnaire. Each of the eight independent variables represented a possible influencing factor, while the dependent variable (EPE_Mean**)** captured the overall level of EPE monitoring, computed as the mean of the twenty-six EPE indicators assessed earlier in research objective 1 (**RO1**).

To achieve this objective, three analytical procedures were used:

1. A reliability test to confirm the consistency of the eight influencing factors (F1–F8).
2. A Spearman's rank-order correlation to establish relationships between each factor and the monitoring of EPE indicators.
3. A multiple linear regression analysis to determine the factors that statistically and significantly predict EPE monitoring among the Zimbabwean small-scale miners.

5.5.1 Reliability test for factors influencing EPE indicator monitoring

A reliability test was conducted to assess the internal consistency of the eight factor constructs (F1–F8) before proceeding with the inferential analysis. Table 5.29 presents the reliability test results.

Table 5.29: Reliability statistics for the possible influencing factors

Cronbach's Alpha	N of Items
0.152	8

The Cronbach's Alpha value of 0.152 was well below the recommended threshold of 0.70, indicating low internal consistency. However, this outcome was theoretically expected because the 8 factors represented distinct antecedents of EPE indicator monitoring, not indicators of a single latent construct. Cronbach's alpha assumes unidimensionality and internal consistency, which is appropriate for a set of conceptually independent, formative factors (Bolarinwa, 2015; Nunnally, 1978). A low alpha was therefore expected and might not indicate poor reliability for the constructs, as such, all eight (8) factors were accordingly retained for further analysis. The next section presents the results of the correlation analysis conducted.

5.5.2 Correlation analysis

After confirming the reliability of the results, the next step was to establish the strength and direction of the relationships between each influencing factor and EPE indicator monitoring. Although the residuals approximated a normal distribution, the individual variables were measured on an ordinal Likert scale, making Spearman's rank-order correlation more suitable than Pearson's correlation. Spearman's rank-order correlation results are presented in Table 5.30.

Table 5.30: Spearman's rank-order correlations between EPE indicator monitoring and influencing factors (N = 289)

Factor	Spearman's ρ	Sig. (2-tailed)	Strength & Direction	Interpretation
F1: Limited EPE expertise	.339	.000	Moderate positive	Greater expertise improves monitoring effectiveness.
F2: Limited financial resources	–.131	.026	Weak negative	Financial constraints slightly reduce EPE monitoring.
F3: Time-consuming EPE process	–.024	.683	Negligible	No meaningful relationship.

Factor	Spearman's ρ	Sig. (2-tailed)	Strength & Direction	Interpretation
F4: Avoiding compliance fines	.127	.031	Weak positive	Monitoring is partly motivated by avoidance of penalties.
F5: Low employee commitment	.076	.198	Weak	No significant correlation.
F6: Low management commitment	.399	.000	Moderate positive	Strong managerial commitment promotes consistent monitoring.
F7: Local community pressure	.302	.000	Moderate positive	Community oversight encourages environmental monitoring.
F8: Need for ISO certification	–.206	.000	Weak negative	Certification requirements discourage monitoring.

The correlation results indicate that four factors were significantly associated with EPE monitoring at the 0.01 or 0.05 significance levels. These were management commitment (ρ = .399), EPE expertise (ρ = .339), local community pressure (ρ = .302), and financial resources (ρ = –.131). The strongest positive relationship was observed for low management commitment, indicating that effective environmental monitoring improves when leadership support is high. Conversely, limited financial resources and certification requirements were negatively correlated with EPE monitoring, implying that financial and procedural burdens may hinder environmental compliance. To determine whether regression analysis was an appropriate model for the data, the model's assumptions were tested, and the results are presented in the next section.

5.5.3 Testing regression assumptions

Before proceeding with multiple linear regression analysis, diagnostic tests were conducted to assess the validity of the statistical assumptions. The results are presented in Table 5.31.

Table 5.31: Regression assumption diagnostics

Assumption	Diagnostic Test/Evidence	Statistic/Output	Interpretation
Normality of residuals	Histogram & Normal P–P Plot	Mean of residuals = 5.52E–16; Std. Dev. = 0.986	Residuals are approximately normally distributed.
Linearity	Scatter plot (ZPRED vs ZRESID)	Random spread around the zero line	The relationship between predictors and outcome is linear.
Homoscedasticity	Visual inspection of the scatter plot	Equal spread of residuals	Variance is constant across predicted values.
Multicollinearity	Tolerance/VIF statistics	VIF range = 1.04–1.45	No multicollinearity.
Independence of errors	Durbin–Watson statistic	DW = 1.189	Slight positive autocorrelation; acceptable for cross-sectional data.
Outliers	Std. residuals & Cook's distance	Std. residuals = –3.05 to +3.06; Cook's D < 1	No influential outliers.

All diagnostic results were within acceptable limits. The residuals were normally distributed, the relationships were linear, and the predictors were independent. The Durbin–Watson value of 1.189, although slightly below the conventional range of 1.5–2.5, is acceptable for cross-sectional data. Therefore, the regression model was deemed valid for interpretation. Model fit and overall significance are discussed next.

5.5.4 Model fit and overall significance

After confirming that the assumptions were met, multiple linear regression was performed to identify the predictors of EPE monitoring among small-scale miners. The model summary is shown in Table 5.32.

Table 5.32: Model summary

Model	R	R^2	Adjusted R^2	Std. Error of Estimate	Durbin–Watson
1	0.539	0.291	0.271	0.339	1.189

The model explained 29.1% of the variance in EPE monitoring ($R^2 = 0.291$). Although this coefficient may appear modest, it is well within the expected range for social and behavioural science models, in which human attitudes, perceptions, and institutional behaviours are influenced by numerous interacting variables beyond those measured in a single study. In such contexts, explanatory powers between 10% and 40% are widely regarded as acceptable (Von Eye & Schuster, 1998). Therefore, the R^2 of 0.291 and adjusted R^2 of 0.271 indicate a moderate and credible level of explanatory power, confirming that the eight predictors collectively provide valuable insights into the factors shaping EPE monitoring among small-scale miners. The Durbin–Watson statistic (1.189) further supports the model's reliability by indicating the absence of problematic autocorrelation. Consequently, the regression results are considered statistically sound and theoretically interpretable within the norms of behavioural and sustainability research. ANOVA results are presented in Table 5.33.

Table 5.33: ANOVA results

Source	Df	F	Sig.
Regression	8	14.361	< .001
Residual	280		
Total	288		

The ANOVA results show that the overall model was statistically significant ($F = 14.361$, $p < .001$), confirming that the eight predictors together have a significant influence on EPE monitoring. The final regression results are presented in the next section.

5.5.5 Regression coefficients and interpretation

Table 5.34 presents the final multiple linear regression results along with their interpretations.

Table 5.34: Regression coefficients for factors influencing EPE monitoring

Predictor	B	Std. Error	B	t	Sig.	Interpretation
(Constant)	2.173	0.318	—	6.844	< .001	—
F1: Limited EPE expertise	0.189	0.038	0.266	5.032	< .001	Significant positive predictor

Predictor	B	Std. Error	B	t	Sig.	Interpretation
F2: Limited financial resources	–0.029	0.038	–0.043	–0.750	0.454	Not significant
F3: Time-consuming EPE process	0.004	0.035	0.007	0.123	0.902	Not significant
F4: Avoiding compliance fines	0.046	0.039	0.061	1.167	0.244	Not significant
F5: Low employee commitment	–0.006	0.038	–0.009	–0.170	0.865	Not significant
F6: Low management commitment	0.171	0.030	0.325	5.619	< .001	Significant positive predictor
F7: Local community pressure	0.123	0.035	0.186	3.560	< .001	Significant positive predictor
F8: Need for ISO certification	–0.087	0.038	–0.119	–2.278	0.023	Significant negative predictor

As shown in Table 5.30, four factors were statistically significant at the 0.05 level as outlined below. Low management commitment ($\beta = 0.325$, $p < .001$) was the strongest positive predictor, highlighting the decisive role of managerial leadership. The limited EPE expertise ($\beta = 0.266$, $p < .001$) also significantly influenced monitoring, underscoring the importance of technical competence. Local community pressure ($\beta = 0.186$, $p < .001$) influenced monitoring positively, suggesting that social accountability drives compliance. Conversely, the need for ISO certification ($\beta = –0.119$, $p = .023$) was negatively associated with indicator monitoring, suggesting that certification burdens can discourage monitoring efforts. The other four factors (financial resources, time constraints, avoidance of fines, and employee commitment) were not significant when the model controlled other variables.

The regression results suggest that both organisational and social dynamics significantly shape how Zimbabwean small-scale miners monitor environmental performance evaluation (EPE) indicators. The most influential predictor, management commitment, underscores the critical role of leadership in embedding environmental values into operational culture. When top management demonstrates environmental responsibility through policy enforcement, budgeting, and continuous supervision, employees tend to prioritise EPE processes more consistently. This finding supports earlier studies that emphasised the centrality of managerial

leadership in driving environmental accountability (Fuchs et al., 2020). In small-scale mining, where operations are often informally structured, management attitudes largely determine whether EPE systems are viewed as a strategic necessity or as an external compliance burden.

The second strongest predictor, limited EPE expertise, validates the assertion that technical capacity underpins the effective monitoring of environmental indicators. Skilled personnel are essential for data collection, interpretation, and the planning of corrective actions. Studies by Kevser et al. (2025) and Ndiweni and Seif (2024) similarly observed that limited environmental management expertise reduces organisations' ability to identify and respond to ecological risks. In Zimbabwe's small-scale mining sector, the absence of qualified environmental officers' results in most monitoring being reactive rather than proactive, undermining sustainable outcomes. The finding therefore reinforces the capacity-building pillar of the sustainability governance framework, suggesting that formal training and knowledge transfer must be institutionalised through both government support and industry partnerships (Zimbabwe Auditor-General, 2015).

The significant positive relationship between local community pressure and EPE monitoring aligns with the institutional isomorphism theory, particularly the normative and coercive pressures (DiMaggio & Powell, 1983). Communities living near mining sites often experience the direct consequences of pollution, land degradation, and water contamination. Their social demands act as informal regulatory mechanisms that compel miners to adopt more responsible environmental practices. Similar patterns have been documented in which community activism and engagement substitute for weak formal enforcement (Dissanayake et al., 2020; Howes et al., 2017). This suggests that in the absence of strong state oversight, social accountability can act as an effective catalyst for environmental compliance.

The negative influence of ISO certification requirements indicates that international environmental standards, while well-intentioned, may be perceived by small-scale miners as financially and administratively unattainable. The high cost of certification audits, documentation requirements, and periodic reviews discourages engagement (Dixon et al., 2024; Khatter et al., 2021). In the current context, ISO certification appears to impose coercive institutional pressure without corresponding technical or financial support, creating a compliance fatigue that undermines rather than promotes sustainability. This outcome suggests a need for context-sensitive adaptation of global environmental standards to the realities of small-scale mining. However, Tura et al. (2018) warn that overreliance on third-party

certifications without demonstrable EPE practices may be dangerous, as it may encourage green-washing tendencies by organisations.

The non-significance of factors such as financial resources, time constraints, avoidance of compliance fines, and employee commitment may appear counterintuitive but reflect underlying structural issues. Financial constraints are pervasive across the small-scale mining sector; therefore, miners may no longer perceive them as a differentiating factor affecting monitoring. Similarly, avoiding fines may not be a strong driver, as enforcement mechanisms are inconsistently applied, thereby reducing deterrence. These non-significant results underscore the broader governance weaknesses highlighted in the literature, where limited institutional pressure reduces compliance motivation (van der Poll, 2022; Zimbabwe Auditor-General, 2015).

Overall, the results point to a configuration where leadership commitment, technical competence, and community oversight operate as mutually reinforcing levers of sustainable environmental monitoring. The results fit well with the conceptual framework, which also identifies technical expertise, governance structures and systems, as well as stakeholder influence and community relations, as critical factors in shaping small-scale mining sustainability. The results integrate well with the stakeholder theory (Freeman, 1984), which posits that sustainable performance emerges when the interests of all stakeholders (management, employees, and the community) are balanced. The results also support the tragedy of the commons theory (Hardin, 1968), which advocates for sustainable exploitation of natural capital for the benefit of all. Strengthening these linkages through structured training programmes, participatory monitoring, and locally adapted environmental governance models could significantly enhance EPE performance among Zimbabwean small-scale miners.

5.6 ANALYSIS OF OBJECTIVE 5: DEVELOPING AN EPE FRAMEWORK THAT CAN PROMOTE SUSTAINABLE OPERATIONS OF ZIMBABWEAN SMALL-SCALE MINERS

The main aim of this study was to propose an EPE framework to promote the sustainable operations of Zimbabwean small-scale miners. The development of the framework mainly involved three steps. First, factor variables were generated from the EFA conducted on the **RO1** dataset. The factor variables were used as predictors in the analysis of **RO3**. Second, company-level composite sustainability indices were calculated to analyse **RO2**, following the fuzzy AHP protocol. The organisational-level composite sustainability index served as the

outcome variable in the multiple linear regression analysis conducted for **RO3**. Third, multiple linear regression was conducted on the **RO3** dataset to select EPE indicators that promote the sustainable operations of the small-scale miners. Basically, the EPE framework emerged from the analysis of the **RO3** dataset. Results from **RO1** and **RO2** fed into the analysis of **RO3** as indicated.

The analysis of **RO3** revealed two (2) factor variables, which were deemed influential in promoting sustainable operations of the small-scale miners. The factors' perceived influences were ranked based on their adjusted beta (**β**) values. Moreover, the significance of each EPE indicator loading onto each factor variable was measured by the indicator's factor loading established through the EFA from the analysis of the **RO1** dataset. Table 5.35 summarises these results to inform the development of the EPE framework.

Table 5.35: Summary of quantitative analysis results informing the EPE framework

Factor Indicator	Factor loading	Factor Indicator Ranking
Environmental Management Control (EMC) (β = .425)		**[Greatest Influence]**
GHG emission levels	.842	**1**
Effectiveness of the environmental performance evaluation process	.834	**2**
Achievements of environmental objectives	.801	**3**
Management commitment to environmental protection	.800	**4**
Effectiveness of environmental risk management	.794	**5**
Employee adherence to environmental management systems	.789	**6**
Water pollution mortality rate	.789	**7**
Air pollution mortality rate	.773	**8**
Compliance with environmental obligations	.751	**9**
Waste recycling levels	.653	**10**
Environmental Quality and Degradation Control (EQDC) (β =.365)		**2nd Greatest Influence**
Water quality	.720	**1**

Factor Indicator	Factor loading	Factor Indicator Ranking
Air quality	.670	**2**
Hazardous waste generation	.662	**3**
Fresh-water depletion	.658	**4**
Soil pollution	.646	**5**
Land degradation	.636	**6**
Noise pollution	.572	**7**
Deforestation rate	.563	**8**
Air pollution	.469	**9**

The EPE framework at this stage emerged from quantitative data analysis. The EPE framework emerging from the quantitative study is presented in Figure 5.1.

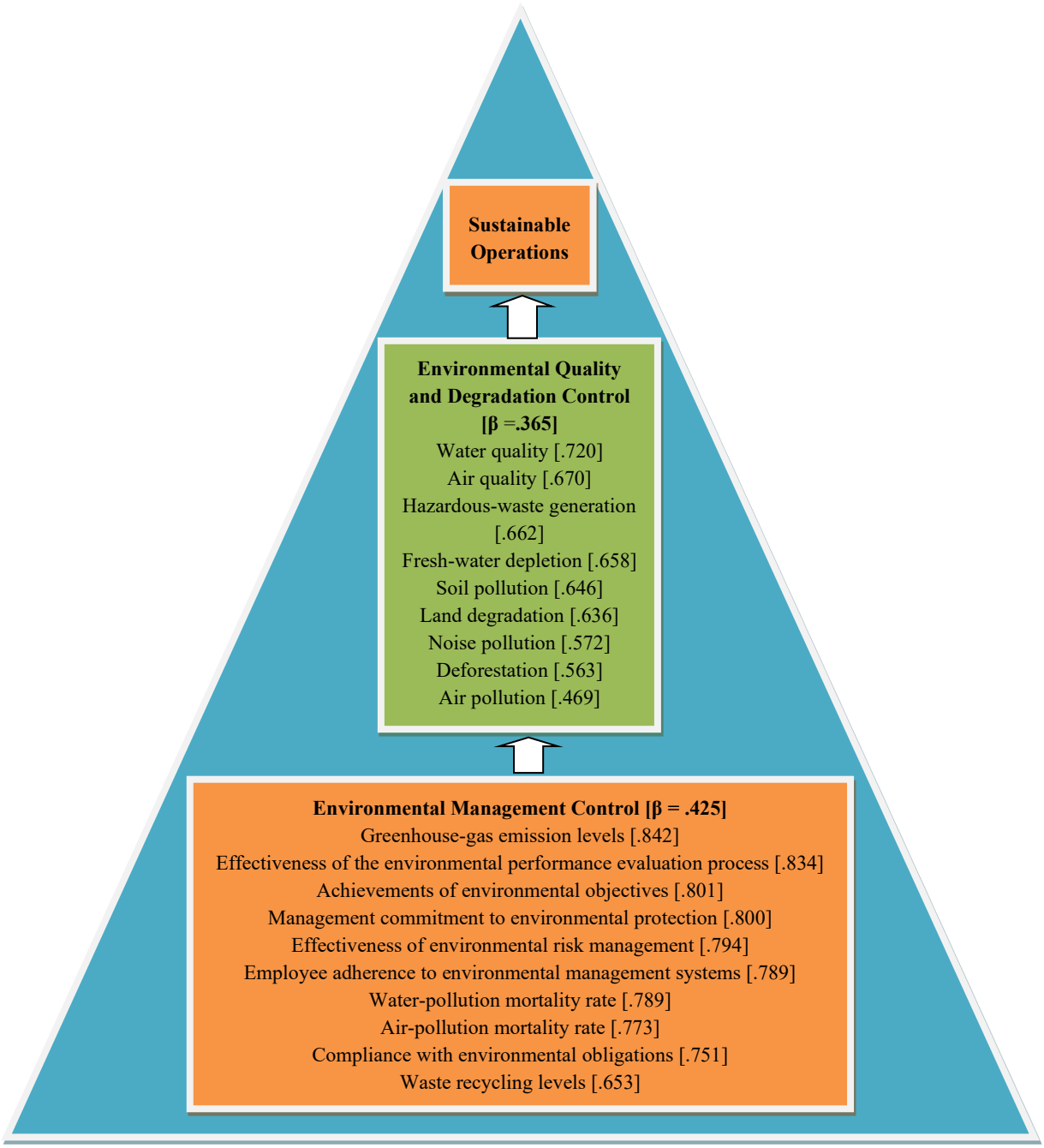


Figure 5.1: EPE Framework Emerging from the Quantitative Study

The proposed EPE framework, derived from the quantitative study, is presented as a pyramid to illustrate the ranked perceived influence of the factors in promoting sustainable operations of the Zimbabwean small-scale miners. The proposed framework comprises two levels of factors that have been quantitatively shown to significantly influence the sustainability of small-scale mining operations. The environmental management control factor is positioned at the bottom of the pyramid, indicating that it has the greatest critical significance and influence

in promoting sustainable operations of small-scale miners, as confirmed by the regression model. Each factor is accompanied by its corresponding EPE indicators, which should be monitored to promote the sustainable operations of small-scale miners. The EPE indicators for each factor are presented in descending order of importance according to their factor loadings.

The indicator listed at the top of each factor is the most important indicator for monitoring by the miners. The arrow connecting the first factor (environmental management control) to the second factor (environmental quality and degradation control) indicates the movement from the first-ranked to the second-ranked factor with respect to their perceived significance and influence in promoting sustainable operations of small-scale miners. The proposed framework at this stage comprises nineteen EPE indicators (first-level factor: 10; second-level factor: 9). The number of indicators was reduced from 26 to 19using multiple linear regression, as presented in the analysis of the **RO3** dataset.

5.7 CHAPTER SUMMARY

The main aim of this chapter was to analyse quantitative data from questionnaires leading to the development of the EPE framework. The EPE framework has been successfully developed after a series of statistical tests and analyses. The quantitative study has statistically confirmed that the indicators presented in the proposed framework can potentially promote sustainable operations of Zimbabwean small-scale miners. However, this proposed framework is not yet the final product of the study, as it needs validation through interviews with selected small-scale miners. The framework validation process is presented in the next chapter.

CHAPTER 6: FRAMEWORK VALIDATION

6.1 INTRODUCTION

This chapter focuses on validating the EPE framework to assess the extent to which the framework is perceived as useful by small-scale miners in promoting sustainable operations. The validation process focused on understanding why certain indicators were considered reasonable and others inapplicable, and on whether any critical indicators should be introduced into the framework. The validation process was not based on the majority view, but on the validity of the views, their consistency and alignment with theory and practice. The proposed EPE framework was presented to the interviewees before the commencement of interviews to orient them to its components and facilitate credible, reliable interviews. The interview transcripts were imported into ATLAS.ti 25 for analysis. The findings of the validation process are discussed in the following subsections.

Section 6.2 discusses indicators merged and reworded for clarity in the final framework. New indicators introduced in the final framework are discussed in Section 6.3. An overview of indicators dropped from the final framework is presented in Section 6.4. The chapter concludes with a summary and conclusion in Section 6.5.

6.2 MERGED AND REWORDED INDICATORS

Some indicators were found to overlap and be somewhat confusing. This could potentially undermine the indicator monitoring process. Indicators should be clear to enable an effective EPE process (ISO 14031, 2021; UN, 2001). The following ad-hoc network diagram, presented in Figure 6.1, summarises the indicators that the miners considered overlapping; these were subsequently merged and reworded to ensure clarity. The network diagram does not include all the quotations and memos involved. Only a selected few quotations and memos to provide evidence for the actual participants' views are shown.

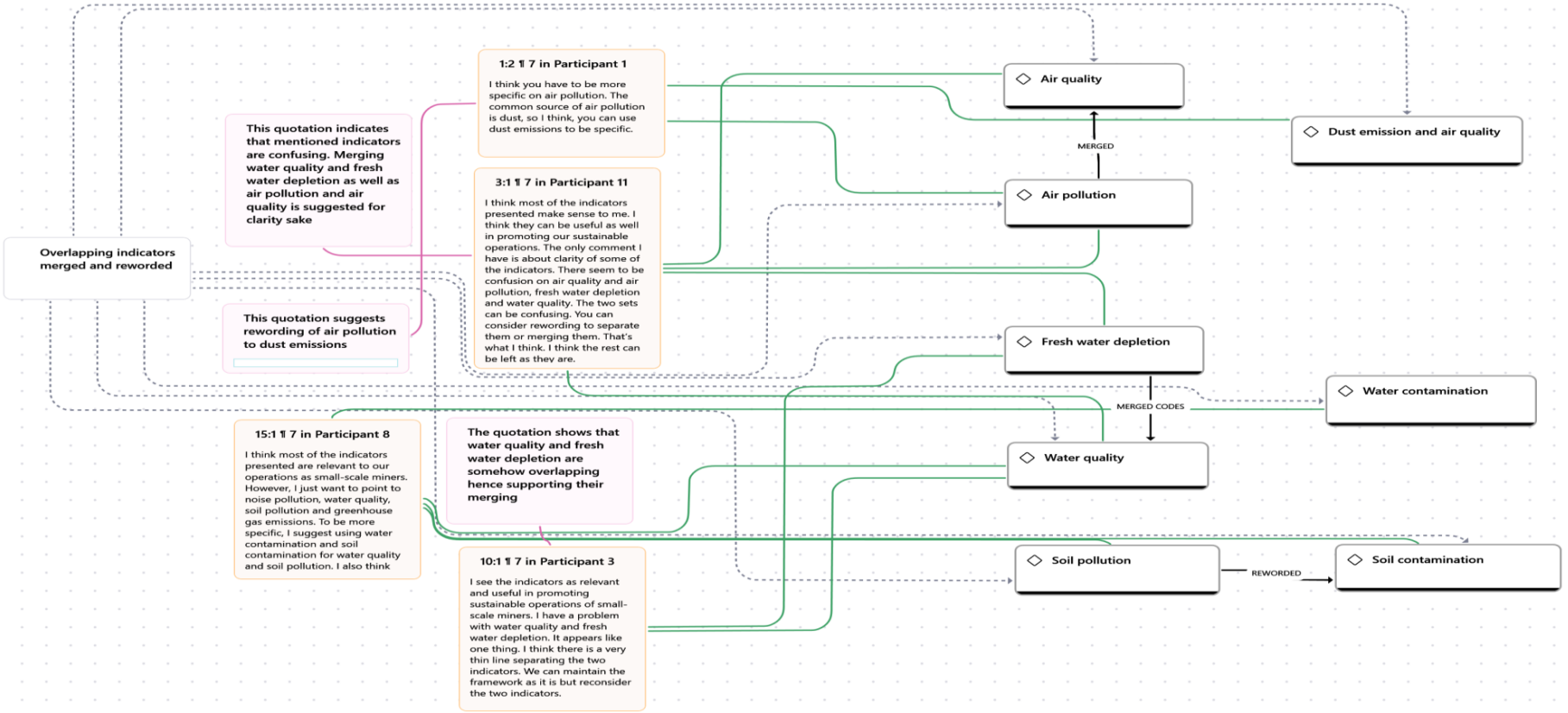


Figure 6.1: Ad-hoc network diagram for merged and reworded indicators

Generally, the miners expressed concerns that water quality and freshwater depletion, as well as air pollution and air quality, were confusing and appeared to overlap. These views suggested that the identified indicators either needed rewording to clarify them or merging to reduce ambiguity. Some participants also reported that, in the context of small-scale mining, dust was the primary source of air pollution. This view suggested rewording "air pollution" as "dust emission" to clarify the indicator. Similarly, some participants expressed concern over the clarity of the term "pollution". They suggested the use of the term "contamination" for "pollution". Therefore, "pollution" was reworded as "contamination".

As literature guides, indicators should not be ambiguous for the EPE process to be effective (ISO 14031, 2021; UN 2001). In view of participants' concerns and the literature, water quality and freshwater depletion were combined into water contamination (see Figure 6.1). Air pollution and air quality were combined into dust emissions and air quality (see Figure 6.1). Similarly, soil pollution was reworded as soil contamination (see Figure 6.1). Furthermore, several new indicators were suggested during the validation process. Section 6.3 presents and discusses the new indicators that emerged from the process.

6.3 NEW INDICATORS INTRODUCED TO THE FRAMEWORK

Participants' new indicator suggestions revolved around environmental training and environmental accidents. An effective indicator framework should try to ensure universality (ISO 14031, 2021; UN 2001). The new indicators which emerged from the validation process could help strengthen the EPE framework. Figure 6.2 summarises the new indicators that were added to the EPE framework and only shows sample quotations, memos and documents for clarity of research evidence.

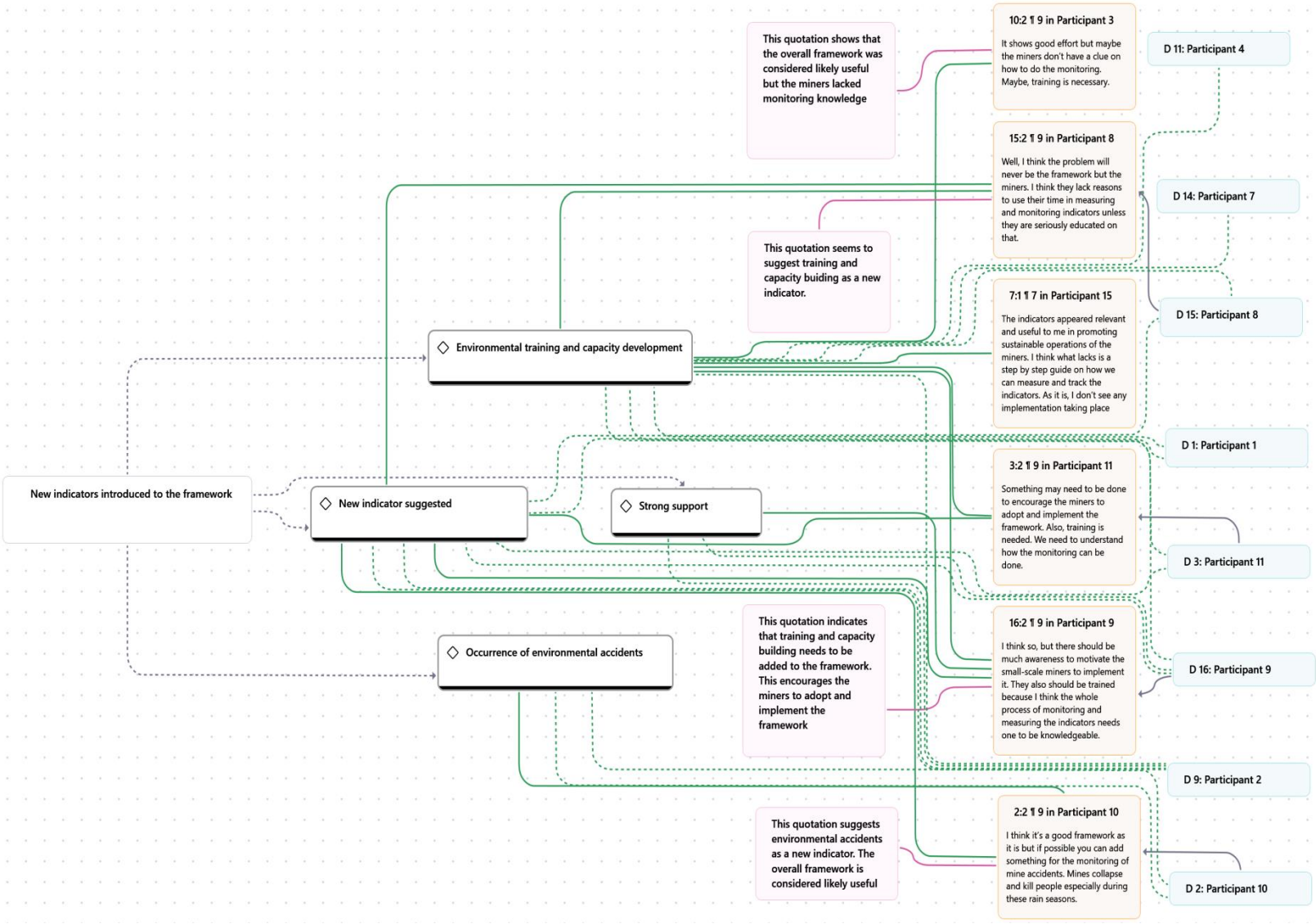


Figure 6.2: New indicators emerging from the validation process

Several participants expressed concerns over the adoption and implementation of the proposed framework. The primary concern cited was a lack of expertise in effectively measuring and monitoring the indicators. Their concerns align with the literature, which reports a general lack of EPE skills among small-scale miners (Kevser et al., 2025; Shahabadi et al., 2017). As literature suggests, indicator monitoring is not a random process; it requires structured guidance and proper expertise to achieve an effective EPE process (ISO 14031, 2021; UN, 2001).

The participants' concerns indicated a strong need to equip miners with the requisite EPE skills. One way to ensure this is to add a specific indicator to the framework that is consistently monitored to verify that miners acquire EPE skills. In light of this, environmental training and capacity building were added as a new indicator to the framework.

Moreover, as indicated by the attached quotations, the miners were concerned with the high rates of mine accidents. Their concerns and suggestions indicated the need to include environmental accidents as an indicator within the framework. Their concerns align with the literature, which reports high rates of environmental accidents among small-scale miners (Ndiweni & Seif, 2024; Moyo et al., 2023; Singo et al., 2022; Mambrey et al., 2020). As researchers have argued, most accidents result from neglect of environmental safety protocols in the small-scale mining sector (Moyo et al., 2023; Singo et al., 2022; Mambrey et al., 2020). In light of the expressed concerns and the literature, the occurrence of environmental accidents was also added to the framework as a new indicator. The next section discusses indicators which were dropped from the framework.

6.4 OVERVIEW OF INDICATORS DROPPED FROM THE FRAMEWORK

Interview participants were asked to comment on the relevance of the framework's indicators to promote their sustainable operations. The comments were based on their small-scale mining contextual realities. Decisions to drop indicators were made after careful consideration of the validity of participants' opinions and theoretical pronouncements. The results are summarised in Figure 6.3 as an ad-hoc network diagram in ATLAS.ti 25. The network diagram does not show all related quotations but rather a selected few to highlight the actual views of the participants who contributed to the removal of the indicators from the framework.

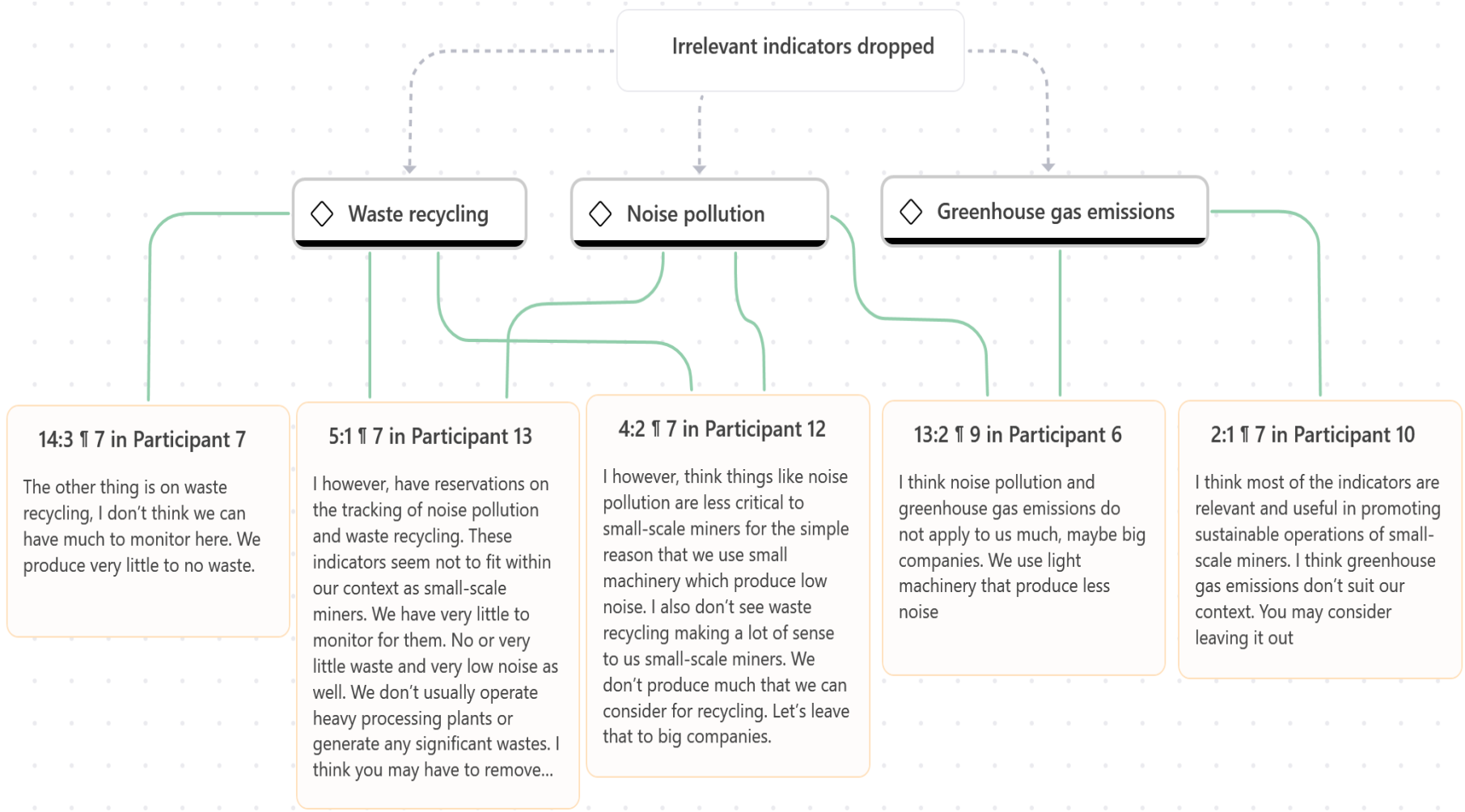


Figure 6.3: Ad-hoc network diagram for dropped indicators

The network diagram in Figure 6.3 shows three indicators which were dropped from the framework. The miners perceived the three indicators as irrelevant to their small-scale mining realities. The indicators are noise pollution, waste recycling, and GHG emissions. As indicated in the attached sample quotations, the miners reported that they relied on light machinery and equipment that did not generate significant noise levels that required monitoring. This implied that noise pollution was not an important indicator to them. Moreover, very little, if any, waste was generated by their mining activities.

The miners also considered GHG emissions very complex to measure and monitor. Because the framework was intended to be basic, GHG emissions were considered unsuitable for small-scale miners. These arguments align with the literature, which specifies that organisations should invest resources to track only indicators that are relevant to their context (ISO 14031, 2021). In light of these justifications, noise pollution, waste recycling, and GHG emissions were excluded from the framework. Table 6.1 presents indicator-based consolidated validation results to provide further evidence justifying validation decisions.

Table 6.1: Consolidated indicator-based validation results

Indicator	Key Participant Quotation	Issue raised	Decision	Reason
Achievements of environmental objectives	"The indicator is acceptable as it is." (P6)	No negative issue	Retain as it is	Acceptable in current form
Compliance with environmental obligations	"I see no issues with this indicator." (P10)	No negative issue	Retain as it is	Acceptable in current form
Employee adherence to environmental management systems	"The indicator seems fine as it is." (P3)	No negative issue	Retain as it is	Acceptable in current form
Management commitment to environmental protection	"The indicator is an important indicator which should be maintained."	No negative issue	Retain as it is	Acceptable in current form

Indicator	Key Participant Quotation	Issue raised	Decision	Reason
Effectiveness of the environmental performance evaluation process	"The indicator should be part of the framework. I do not have anything against it." (P5)	No negative issue	Retain as it is	Acceptable in current form
Effectiveness of environmental risk management	"I think itis good to have this indicator monitored." (P2)	No negative issue	Retain as it is	Acceptable in current form
Waste recycling levels	"Our operations do not produce any significant wastes." (P1)	Indicator irrelevant	Remove	No measurable waste
Greenhouse gas emission levels	"Greenhouse gas emissions are complex to measure and monitor." (P10)	Indicator too complex for small-scale miners	Remove	Very complicated to measure
Water pollution mortality rate	"The indicator should be retained on the framework. It safeguards life." (P9)	No negative issue	Retain as it is	Acceptable in current form
Air pollution mortality rate	"It is a good indicator, it mitigates loss of life again." (P9)	No negative issue	Retain as it is	Acceptable in current form
Hazardous-waste generation		No negative issue	Retain as it is	Acceptable in current form
Air pollution	"I think air pollution overlaps with air quality." (P16). "Our main source of air	Indicator naming is not very context-specific. Also, the indicator overlaps with	Merge with air quality and reword to dust emission and air quality	Indicators overlapping The indicator name is not very specific

Indicator	Key Participant Quotation	Issue raised	Decision	Reason
	pollution is dust." (P1).	another indicator		
Soil pollution	"My view on soil pollution is that you can make it simple to understand. Why don't you use soil contamination?" (P5)	Indicator wording is not very simplified	Reword to soil contamination	To simplify the indicator naming
Noise pollution	"We do not use heavy machines which produce a lot of noise." (P1)	Irrelevant indicator	Remove	No significant noise generated
Air quality	"I think air pollution overlaps with air quality." (P16)	The indicator overlaps with air pollution	Merge with air pollution and reword to dust emission and air quality	Indicators overlapping
Water quality	"I see water quality and freshwater depletion as measuring the same thing." (P4)	The two indicators are overlapping	Merge to water contamination	Indicators overlapping
Deforestation rate	"The indicator is a good component of the framework. Deforestation is a major issue for us." (P13)	No negative issue	Retain as it is	Acceptable in current form
Fresh-water depletion	"I see water quality and freshwater depletion as measuring the	The two indicators are overlapping	Merge to water contamination	Indicators overlapping

Indicator	Key Participant Quotation	Issue raised	Decision	Reason
	same thing." (P4)			
Land degradation	"This indicator measures a key issue. It has to be part of the framework." (P12)	No negative issue	Retain as it is	Acceptable in current form
Occurrence of environmental accidents	"We should be adequately trained as the whole implementation issue requires knowledge. Training is a critical issue." (P9)	The skills gap is a limiting factor. Training was identified as critical	Add environmental training and capacity building as a new indicator	Skills gap identified and training needs are highly recommended
Environmental training and capacity building	"I think you can add something on mine accidents. That is something we cannot ignore. A lot of accidents are happening, leading to deaths and injuries. That is bad." (P2)	High rate of serious mine accidents	Add the occurrence of environmental accidents as a new indicator	High rates of dangerous environmental accidents have been witnessed. The indicator may help mitigate the accidents

The table of results has summarised indicator-based validation results. Table 6.1 presents key participant views for each indicator, which justify validation decisions made. The findings have led to the removal, merging, rewording, and introduction of some indicators. The main changes to the proposed framework, resulting from the validation process, are summarised in Table 6.2.

Table 6.2: Summary of major changes effected

Indicator	Dropped	Reworded	Merged	Added
Waste recycling levels	√			
Greenhouse gas emission levels	√			
Noise pollution	√			
Air pollution and air quality_Dust emission and air quality		√	√	
Soil pollution_soil contamination		√		
Water quality and freshwater depletion_Water contamination		√	√	
Environmental training and capacity building				√
Occurrence of environmental accidents				√

Based on the indicated changes, the EPE framework was refined and presented as the final product of this study. The final validated framework is presented in Figure 6.4.

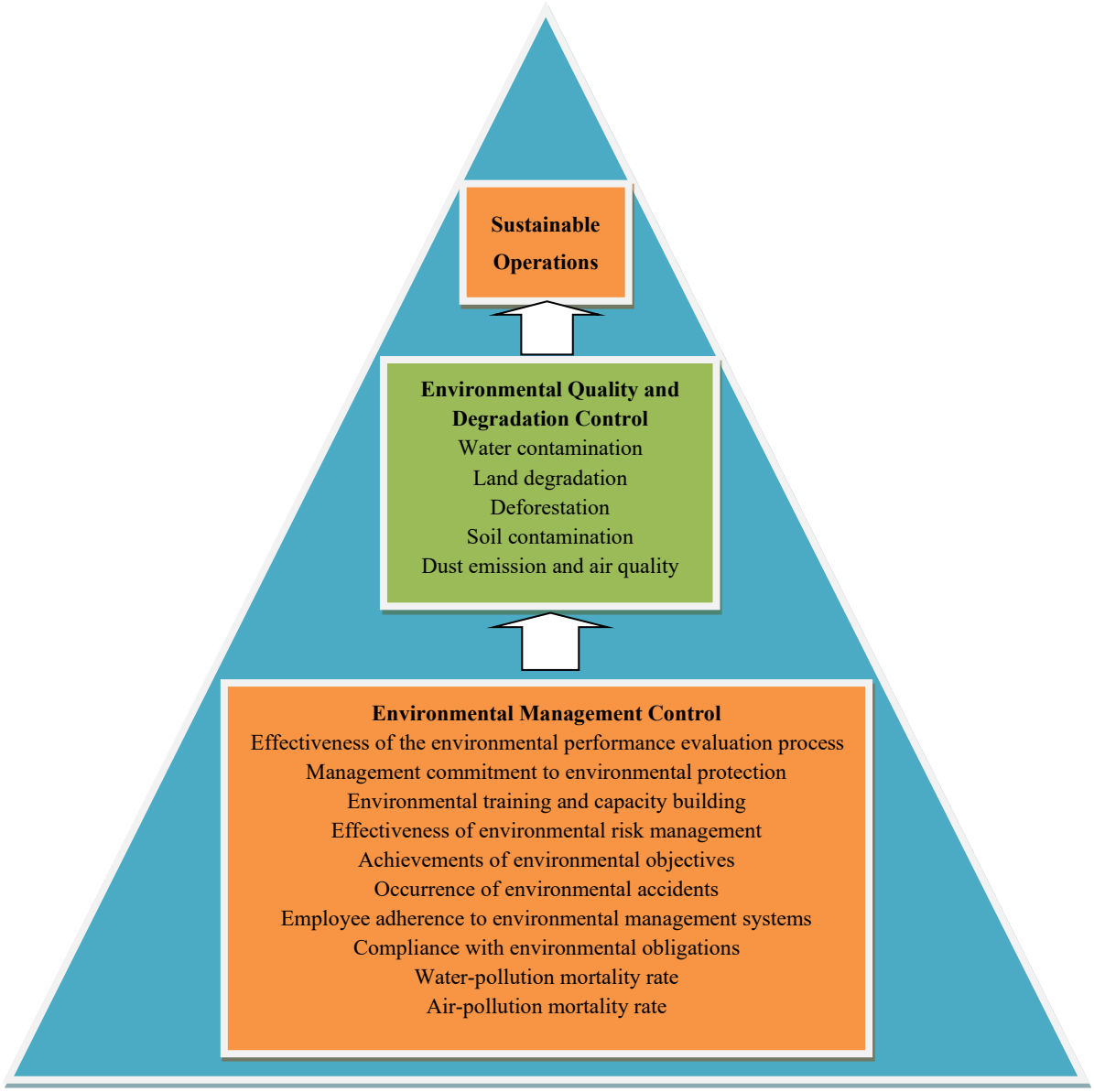


Figure 6.4: Final EPE Framework for Sustainable Operations of Zimbabwean Small-scale Miners

The final validated EPE framework presented is stronger and more credible because it is a product of both quantitative and qualitative analysis. The framework was not developed solely on quantitative data analysis; it was also informed by the realities of small-scale mining in Zimbabwe. Mixed research methods often yield balanced results and findings (Saunders et al., 2023). The final EPE framework now presents fifteen critical EPE indicators that are perceived as capable of promoting sustainable operations of Zimbabwean small-scale miners. The conceptual framework presented in Section 3.8 of Chapter 3 fed into this final EPE framework. The conceptual framework outlines the three (3) sustainability pillars (environmental, economic and social), which were further investigated through the fuzzy AHP approach to

determine the composite sustainability index which served as the dependant variable in determining the environmental performance evaluation indicators which can promote sustainable operations of the small-scale miners.

6.5 CHAPTER SUMMARY

This chapter focused on validating the proposed EPE framework, which emerged from the quantitative study, and presenting the final validated EPE framework. The validated framework has been presented as the final product of this study. The framework is a product of a series of comprehensive tests and analyses. The validation process is considered to have strengthened the framework and enhanced its credibility in promoting sustainable operations of Zimbabwean small-scale miners, owing to the data triangulation employed. However, the use of telephone interviews may have limited the study to some extent as the researcher was unable to capture participants' non-verbal communication. Nevertheless, during the telephone interviews, the researcher paid attention to detail and probed the interviewees for further details to explore critical issues arising that might have added depth to the data. In its current form, the final framework is perceived as having the potential to promote sustainable operations of small-scale miners, if adopted. The next chapter presents the conclusions, and recommendations.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

The main purpose of the study was to propose an environmental performance evaluation (EPE) framework to promote sustainable operations of Zimbabwean small-scale miners. The proposed framework was informed by both quantitative and qualitative data collected through questionnaires and interviews, respectively. This chapter summarises the major results and findings in Section 7.2 for the five research objectives addressed in Chapter 5. Section 7.3 presents conclusions mainly informed by the results and findings. Recommendations are outlined in Section 7.4, in light of the research results and findings. Research contributions are discussed in Section 7.5. The chapter concludes with suggestions for further research in Section 7.6.

7.2 SUMMARY OF MAJOR RESULTS AND FINDINGS

This section summarises the major results and findings for the five research objectives, which are outlined in the following subsections.

7.2.1 Objective 1: Determine the environmental performance evaluation indicators being monitored by Zimbabwean small-scale miners

High indicator monitoring levels were revealed for energy consumption, hazardous waste generation, water consumption, and material consumption. This result concurs with previous results by Feil et al. (2025) and Halkos and Argyropoulou (2021), who revealed the same indicators as critical and widely monitored. The literature argues that intensive monitoring of indicators among small-scale miners is often motivated by the need to advance economic sustainability (Nitschke et al., 2025; Jiménez et al., 2024).

By contrast, low indicator monitoring levels were observed for the effectiveness of the EPE process, employee adherence to environmental management systems, management commitment to environmental protection, GHG emissions, water pollution mortality rates, environmental improvement projects implemented, and environmental audits conducted. Moreover, the results showed very low monitoring of air pollution mortality rates and of environmental training delivered to employees. These results appear to disagree with previous research. Monitoring the same indicators has been found pivotal to the promotion of sustainable

organisational operations, and these indicators are widely monitored (Feil et al., 2025; Wiedmann et al., 2020).

7.2.2 Objective 2: Assess the extent to which small-scale miners in Zimbabwe balance economic, environmental, and social sustainability in their operations

Although not equally balanced, the study revealed a commendable effort by small-scale miners to balance economic, environmental, and social sustainability in their operations. It was found that 73% of small-scale miners' attention was directed toward economic sustainability. Moreover, 18% of their attention was devoted to environmental sustainability, whereas only 9%was devoted to social sustainability. The results appear to support the existing literature arguing that balancing the TBL is not always easy (Qaim et al., 2020; Bhaduri et al., 2016). Kevser et al. (2025) and Yu et al. (2025) postulate that small-scale miners often have constrained financial resources, making it difficult to finance their operations. Their lack of collateral usually worsens this to secure external funding. This may force them to prioritise economic sustainability at the expense of the other sustainability pillars for survival.

7.2.3 Objective 3: Establish the environmental performance evaluation indicators which can promote the sustainable operations of Zimbabwean small-scale miners

The results revealed that Environmental Management Control (EMC) indicators were the most influential in promoting sustainable operations of small-scale miners. The EMC indicators comprised individual EPE indicators, such as management commitment to environmental protection, the effectiveness of EPE processes, compliance with environmental obligations and the effectiveness of environmental risk management, among others. The results suggest that effective control and governance of environmental processes can promote sustainable operations of small-scale miners. This result aligns with previous findings by Fuchs et al. (2020), who found that environmental governance and control structures significantly influence the achievement of sustainable operations in organisations. The results also appear to support van der Poll (2022), who found that weak institutional isomorphic pressures in developing countries often lead to poor environmental management practices by organisations.

The second-strongest predictor of small-scale miners' sustainable operations were Environmental Quality and Degradation Control (EQDC) indicators. EQDC indicators comprised individual EPE indicators, such as hazardous waste generation, air pollution, soil pollution, noise pollution, land degradation, and deforestation. Such indicators generally

resembled the overall quality of the environment. The result appears to fit well within the lens of the tragedy of the commons theory, which advocates protecting the environment to ensure better environmental quality (Hardin, 1968). The literature has lamented an unprecedented trend of unsustainable mining practices by small-scale miners (Ndiweni & Seif, 2024; Moyo et al., 2023; Singo et al., 2022; Mambrey et al., 2020).

7.2.4 Objective 4: Identify factors affecting the monitoring of environmental performance evaluation indicators by Zimbabwean small-scale miners

This study revealed four factors that can significantly affect indicator monitoring. Low management commitment was found to be the strongest factor affecting EPE monitoring practices of small-scale miners. This result supports earlier studies that emphasised the centrality of managerial leadership in shaping environmental accountability (Fuchs et al., 2020). Limited EPE expertise was the second most significant factor affecting monitoring practices. This result supports prior findings that technical capacity underpins effective monitoring of environmental indicators (Kevser et al., 2025; Ndiweni & Seif, 2024). Local community pressure was the third influencing factor. Similar results have been found in past studies, in which community activism and engagement served as substitutes for weak formal enforcement (Dissanayake et al., 2020; Howes et al., 2017).

The last factor was ISO certifications. The high cost of certification audits, documentation requirements, and periodic reviews was also found in previous studies to discourage engagement (Dixon et al., 2024; Khatter et al., 2021). In the current context, ISO certification seems to impose coercive institutional pressure without corresponding technical or financial support, creating a compliance fatigue that undermines rather than promotes sustainability. This result suggests the need for a context-sensitive adaptation of global environmental standards to the realities of small-scale mining. However, as Tura et al. (2018) warn, overreliance on certifications without demonstrable EPE practices may be dangerous, as it may encourage green-washing tendencies by organisations.

7.2.5 Objective 5: Develop an environmental performance evaluation framework to promote sustainable operations of Zimbabwean small-scale miners

The study proposed an EPE framework to promote the sustainable operations of Zimbabwean small-scale miners. The final proposed validated EPE framework comprised15indicators, identified as having the potential to promote sustainable operations of small-scale miners. The

fifteen indicators were presented in their recommended order of priority, ranging from the effectiveness of the environmental performance evaluation process, and management commitment to environmental protection and environmental training and capacity building to dust emission and air quality. The proposed framework makes a valuable contribution to the literature by addressing context-specific EPE needs of Zimbabwean small-scale miners.

7.3 ACHIEVEMENT OF THE RESEARCH OBJECTIVES

Table 7.1 summarises how the research objectives were addressed.

Table 7.1: Achievement of the research objectives

Research Objective		How achieved?
1	Determine the environmental performance evaluation indicators being monitored by Zimbabwean small-scale miners.	• Data was gathered through a questionnaire survey with EPE indicators informed by an extensive literature review. • Data was quantitatively analysed using IBM SPSS 29. • Frequencies and mean scores aided the quantitative analysis. • Exploratory factor analysis identified emerging themes in the EPE monitoring data. • Objective was addressed in Section 5.2.
2	Assess the extent to which small-scale miners in Zimbabwe balance economic, environmental, and social sustainability in their operations.	• Data was gathered through a questionnaire. • The fuzzy analytic hierarchical process (Fuzzy AHP) was employed to determine criteria weights. • Objective was addressed in Section 5.3.
3	Establish the environmental performance evaluation indicators which can promote sustainable operations of Zimbabwean small-scale miners.	• Data was gathered through a questionnaire. • IBM SPSS 29 was used for the quantitative analysis of data. • Multiple linear regression was used for the analysis. • Objective was addressed in Section 5.4.
4	Identify factors affecting the monitoring of environmental performance evaluation indicators by Zimbabwean small-scale miners.	• Data was gathered through a questionnaire. • IBM SPSS 29 was used for the quantitative analysis. • Spearman's rank order correlations aided the analysis.

Research Objective		How achieved?
		• Multiple linear regression analysis was employed to identify the statistically significant factors. • Mean scores from RO1 aided the analysis. • Objective was addressed in Section 5.5.
5	To develop an environmental performance evaluation framework for the sustainable operations of Zimbabwean small-scale miners.	• Data was gathered through a questionnaire. • IBM SPSS 29 was used to analyse quantitative data to establish the components of the framework. • Interview data were used to validate the framework. • Objective was addressed in Section 5.6.

7.4 CONCLUSIONS

The study mainly focused on developing an EPE framework to promote the sustainable operations of Zimbabwean small-scale miners. The framework emerged from the quantitative data analysis phase. Interview data were analysed to validate the framework. The entire study was anchored on the tragedy of the commons, stakeholder, and institutional isomorphism theories. Based on the study's results and findings, the following conclusions were made.

Zimbabwean small-scale miners conducted high-indicator monitoring of energy consumption, hazardous waste generation, water consumption, and material consumption, in accordance with Feil et al. (2025) and Halkos and Argyropoulou (2021). In contrast, Zimbabwean small-scale miners were not prioritising the monitoring of the effectiveness of the EPE process, employee adherence to environmental management systems, level of management commitment to environmental protection, GHG emissions, water pollution mortality rates, environmental improvement projects implemented and environmental audits conducted, as well as air pollution mortality rate and training related to environmental matters delivered to employees. Their indicator monitoring practices appeared not to comply with the call for small-scale miners to operate sustainably (Feil et al., 2025; Nitschke et al., 2025; Wiedmann et al., 2020).

Moreover, Zimbabwean small-scale miners sought to strike an equitable balance among economic, environmental, and social sustainability, although their primary focus was economic sustainability. This may be a result of their typically financially disadvantaged positions (Kevser et al., 2025; Yu et al., 2025). Overall, their attempts to balance the TBL were commendable.

In addition, Zimbabwean small-scale miners can promote sustainable operations by prioritising the monitoring of environmental management control indicators. Such indicators include management commitment to environmental protection, the effectiveness of EPE processes, environmental training and capacity building, compliance with environmental obligations, and the effectiveness of environmental risk management (Fuchs et al., 2020). Their second monitoring priority may focus on indicators of environmental quality and on controlling environmental degradation. The indicators include hazardous waste generation, dust emission and air quality, soil contamination, water contamination, land degradation, and deforestation. Natural capital, as a common resource for all, is protected by monitoring basic indicators (Ndiweni & Seif, 2024; Moyo et al., 2023; Singo et al., 2022; Mambrey et al., 2020; Hardin, 1968).

The small-scale miners' indicator monitoring practices were mainly being affected by low management commitment to environmental protection, in agreement with (Fuchs et al., 2020), limited EPE expertise in line with (Kevser et al., 2025; Ndiweni & Seif, 2024), low local community pressure (Dissanayake et al., 2020; Howes et al., 2017) as well as high costs to meet environmental certification requirements, audits, and periodic reviews.

Finally, the proposed EPE framework has the potential to promote sustainable operations of Zimbabwean small-scale miners. Nevertheless, the adoption and implementation of the framework may be problematic as small-scale miners generally lack the required EPE expertise. Additionally, low management commitment to environmental protection may compound existing implementation challenges.

7.5 RECOMMENDATIONS OF THE STUDY

Given the results and findings, the following recommendations are made:

- Policymakers should establish specific mining laws targeting small-scale miners to streamline mining regulation and enhance clarity of regulatory and compliance processes.
- There is a critical need for policymakers to facilitate deliberate and more frequent trainings and capacity building workshops on sustainability matters for the small-scale miners. They should be educated about the need to consistently strive to balance economic, environmental, and social sustainability. This holistic view of sustainability may lead to sustainable development.

- Management of small-scale miners should play an active role in fostering employee commitment in sustainability matters. Management should recognise that a lack of commitment will distort the entire EPE system.
- The Zimbabwean government should ensure adequate financial support for the small-scale miners and put systems in place to prioritise sustainable development.
- The ministry of mines and mining development may consider assessing the practical utility of the proposed framework and deliberate on the possibilities of integrating it into the national environmental regulatory framework.
- Zimbabwean small-scale miners may adopt the proposed EPE framework and implement it to promote the sustainability of their operations.

7.6 CONTRIBUTIONS OF THE STUDY

The study makes a valuable contribution to the field of accounting. The contributions are highlighted in the following sections.

7.6.1 Contribution to theory

The study contributes to the extant literature by offering new insights into the complex interplay among social, economic, and environmental sustainability. The study presents a conceptual framework for integrating the sustainability pillars to ensure a holistic perspective on sustainability matters. The conceptual framework clarifies the complex interplay among the sustainability pillars as it presents critical factors influencing how the small-scale miners approach sustainability issues within the lens of the tragedy of the commons theory, stakeholder theory and institutional isomorphism theory. Moreover, this study empirically demonstrates that Zimbabwean small-scale miners prioritise economic sustainability over environmental sustainability thereby exemplifying a localised tragedy of the commons theory where rational livelihood decisions externalize environmental costs. This extends the stakeholder theory by showing stakeholder salience is hierarchized by survival imperatives in highly informal economies like Zimbabwe. In addition, by proposing an EPE framework grounded in Zimbabwean small-scale mining realities, the study challenges the institutional isomorphism theory as it argues that regulatory convergence fails when imported institutions (EPE frameworks) lack contextual fit, and lays a validated foundation upon which future, locally resonant institutional frameworks may emerge.

7.6.2 Contribution to literature

The study contributes to the body of knowledge by proposing a research-based, context-specific framework to promote sustainable operations of Zimbabwean small-scale miners. The framework is unique in that it is not generic and addresses the specific needs of Zimbabwean small-scale miners. The framework is validated and presented in a simplified form to facilitate user understanding. This study provides a basis for future research to explore additional phenomena arising from it.

7.6.3 Contribution to practice

The study contributes to practice through the proposed framework. The proposed framework can be adopted by small-scale miners and guide them in identifying the basic EPEIs to monitor to enhance their sustainability. The framework presents the indicators in a hierarchical structure, enabling miners to observe a scale of indicator-monitoring priorities.

7.6.4 Policy implications

The proposed EPE framework can be adopted by national policymakers and made mandatory, either in its current form or following further research-based modifications. It may then be integrated into existing environmental management policy systems to reinforce them and enhance sustainability. The proposed framework may also be adopted and implemented within organisational policy systems. The framework can be enforced through internal regulations at the organisation level. This may make meaningful strides toward promoting sustainable operations in the small-scale mining sector.

7.7 AREAS FOR FURTHER STUDIES

Although the study was conclusive, the following areas are recommended for further research:

- This study only focused on one out of ten geographical provinces of Zimbabwe for data collection. It also focused on gold mining as the province's principal mineral. This may, to some extent, limit the generalisation of the results. The study therefore recommends that future research conduct similar studies but focusing on a wider geographical area and considering the extraction of various minerals to enhance the generalisation of results.

- This study focused on identifying the EPE indicators that can be monitored to promote sustainable operations of the Zimbabwean small-scale miners. However, the indicators have not been presented with a structured research-based monitoring and measurement guidance document. It is therefore recommended that future research explore this area and advance this field by proposing an EPE measurement and monitoring framework, focusing on operationalization, measurement scales, and implementation protocols to enhance the practical utility of the proposed framework.

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APPENDIX A: ETHICS CERTIFICATE

UNISA university of south africa

College of Accounting Sciences_RERC

NHREC Registration # : (If applicable)
Ref #: 2667
Name: Mr Anyway Ngirazi
Student #: 58549781
Staff #:

Date: 11/11/2024

Dear: Mr Anyway Ngirazi

Decision: Ethics Approval from 6 November 2024 to 5 November 2027

Researcher: Mr Anyway Ngirazi

20273 Mutual Park, Harare, Zimbabwe

Harare

58549781@mylife.unisa.ac.za +263775772297

Supervisor: Dr Isaac mabhungu isaac.mabhungu@gmail.com

Co-Supervisor: Prof Hulbrecht Margaretha (Breggie) van der Poll Vdpolhm@unisa.ac.za

Co-Researcher(s):

Email address:

An Environmental Performance Evaluation Framework for Sustainable Operations of Zimbabwean Small-Scale Miners

Qualification: PhD-Accounting Sciences

Thank you for the application for research ethics clearance by the College of Accounting Sciences_RERC for the above mentioned research study Ethics approval is granted for three years.

The **low risk application** was **reviewed** by College of Accounting Sciences_RERC on 6 November 2024 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.

The proposed research may now commence with the provisions that:

1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the College of Accounting Sciences_RERC .
3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.

5. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.

6. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data requires additional ethics clearance.

7. No field work activities may continue after the expiry date (5 November 2027). Submission of a completed research ethics progress report will constitute an application for renewal, for Ethics Research Committee approval.

Additional Conditions

1. Disclosure of data to third parties is prohibited without explicit consent from Unisa.
2. De-identified data must be safely stored on password protected PCs.
3. Care should be taken by the researcher when publishing the results to protect the confidentiality and privacy of the university.
4. Adherence to the National Statement on Ethical Research and Publication practices, principle 7 referring to Social awareness, must be ensured: "Researchers and institutions must be sensitive to the potential impact of their research on society, marginal groups or individuals, and must consider these when weighing the benefits of the research against any harmful effects, with a view to minimising or avoiding the latter where possible." Unisa will not be liable for any failure to comply with this principle.

Note

The reference number 2667 should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.

Kind regards,



Prof Lourens Erasmus
Chair of College of Accounting Sciences_RERC
E-mail: erasmlj1@unisa.ac.za



Executive Dean / By delegation from the Executive Dean of College of Accounting Sciences_RERC
E-mail: chikucn@unisa.ac.za

PARTICIPANT INFORMATION SHEET AND INFORMED CONSENT

PARTICIPANT INFORMATION SHEET

Ethics clearance reference number: **2667**

Date: 14/01/25

Title: An environmental performance evaluation framework for sustainable operations of Zimbabwean small-scale miners

Dear Prospective Participant

I invite you to participate in a study entitled "An environmental performance evaluation framework for sustainable operations of Zimbabwean small-scale miners." My name is Anyway Ngirazi, and I am researching with Dr Isaac Mabhungu, a senior lecturer in the Department of Management Accounting, and Prof. Breggie van der Poll towards a PhD in Accounting Sciences at the University of South Africa.

WHAT IS THE PURPOSE OF THE STUDY?

This study aims to develop an environmental performance evaluation framework to promote sustainable operations of Zimbabwean small-scale miners.

The study seeks to:

i. Determine the environmental performance evaluation indicators being monitored by Zimbabwean small-scale miners.
ii. Assess the extent to which small-scale miners in Zimbabwe balance economic, environmental, and social sustainability in their operations.
iii. Establish environmental performance evaluation indicators which can promote sustainable operations of small-scale miners in Zimbabwe.
iv. Identify factors affecting the monitoring of environmental performance evaluation indicators by Zimbabwean small-scale miners.
v. Develop an environmental performance evaluation framework for sustainable operations of Zimbabwean small-scale miners.

You are being invited as either an environmental performance evaluation or sustainability expert in your company or a key stakeholder of small-scale mines in Zimbabwe. The selection is based on the suitable level of knowledge you are perceived to possess concerning environmental performance evaluation, sustainable development issues and/or environmental

impacts of the Zimbabwe small-scale miners. Your input is valuable in the development of the proposed framework.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

Environmental performance evaluation and sustainable development experts respond to the questionnaire with the aim of establishing the prevailing environmental performance monitoring and sustainability practices of Zimbabwean small-scale miners. The experts are also expected to provide data on factors affecting the prevailing environmental performance monitoring practices of small-scale miners. The key stakeholders are interviewed to establish the extent to which they perceive the proposed framework to be valid in promoting sustainable operations of small-scale miners in Zimbabwe. They participate as theoretical validators of the proposed framework. The final framework incorporates the validation input from the key stakeholders. Validation interviews are expected to last up to 30 minutes each. Questionnaires are expected to be completed in not more than 45 minutes.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participation in this study is voluntary, and there is no penalty or loss of benefit for non-participation. You are under no obligation to consent to participation. If you decide to participate, you will receive this information sheet to keep and be asked to sign a written consent form. Although you are free to withdraw at any time and without a reason, it is impossible to withdraw once the anonymous questionnaire has been collected.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

The framework to be developed is expected to promote the sustainable development of Zimbabwean small-scale miners. In this context, both the social and economic aspects of life are expected to improve for the benefit of everyone. Moreover, the negative environmental impacts of the mining activities are expected to be mitigated, thereby benefiting the immediate mine community and the nation at large.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

The data collection process may consume your productive time. However, questionnaires and interviews are shortened but still serve their intended purposes. This reduces the time burden for you. The other possible inconvenience is that the data collection might invade your privacy by gathering even private and confidential information. However, the information gathered will be kept confidential, and your identity will not be disclosed to anyone.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

Your identity will not be recorded anywhere, and no one can connect you to the responses provided. Fictitious code numbers or pseudonyms will represent your responses and identity. You will be referred to in this way for data publication purposes, research reporting and conference proceedings. Your responses may be reviewed by people bound by the relevant code of ethics. Records that identify you will only be available to people working on the study unless you permit others to see and use the records. Your anonymous data will be used to draft a final research report and may be presented at conferences. A copy of the study report will be submitted for publication, but individual participants will not be identifiable in such a report.

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

The researcher will privately store hard copies of your responses for five years in a locked cupboard/filing cabinet at the researcher's residence for future research or academic purposes. A password will encrypt electronic versions of the information provided and stored on a password-protected computer. Future use of the stored data will be subject to further research ethics review and approval if applicable. The hard copies will be disposed of by shredding. The electronic copies will be permanently deleted from the computer.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

You will not receive any form of payment for taking part in this research.

HAS THE STUDY RECEIVED ETHICS APPROVAL?

This study has received written approval from the Research Ethics Committee of the College of Accounting Sciences at the University of South Africa (UNISA). A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you have any research queries or would like to be informed of the final research findings or results, please contact Anyway Ngirazi at +263775 772 297 or latngirazi@gmail.com. The findings or results are accessible for five years from the completion of the study.

Thank you for taking the time to read this information sheet and for participating in this study.

Thank you.



Anyway Ngirazi

CONSENT TO PARTICIPATE IN THIS STUDY

I, _____ (participant name), confirm that the person asking my consent to participate in this research has informed me about the nature, procedure, potential benefits, and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I can withdraw at any time without penalty (if applicable).

I am aware that this study's findings will be processed into a research report, journal publications, and/or conference proceedings, but my participation will be kept confidential unless otherwise specified.

I agree to the recording of the interview and/or questionnaire.

I have received a signed copy of the informed consent agreement.

Participant Name & Surname: …… (please print)

Participant Signature: …….. Date: …….

Researcher's Name & Surname: Anyway Ngirazi (please print)

Researcher's Signature:  Date 14/01/25

APPENDIX B: QUESTIONNAIRE

QUESTIONNAIRE FOR MINE EMPLOYEES INVOLVED IN ENVIRONMENTAL PERFORMANCE EVALUATION AND SUSTAINABILITY

This questionnaire mainly seeks to explore environmental performance monitoring practices of Zimbabwean small-scale miners in their pursuit of sustainable operations.

SECTION A: SOCIO-DEMOGRAPHIC INFORMATION

Select the appropriate option by marking with an **X** in each case.

1. Department:

Environment related department	
Finance/accounts department	
Other (Specify) ……	

2. Highest level of education:

Secondary qualification	
Mining or environment related tertiary education	
Business related tertiary qualification	
Other qualification (specify) …….	

3. Years of experience in the mining company:

Less than 5 years	
5–10 years	
11–15 years	
Above 15 years	

SECTION B: MINE CHARACTERISTICS

Select the appropriate option by marking with an **X** in each case.

4. Number of years in operation:

Range	**Actual years**
Less than 1 year	
1 – 5 years	
6 – 10 years	
11 – 15 years	
16 + years	

5. Number of employees:

Range	**Actual number**
Less than 10 employees	
10 – 30 employees	
31 – 49 employees	
50 + employees	

6. Major minerals mined:

Gold	
Diamond	
Chrome	
Other (Specify) ……..	

7. Mining methods used:

Open pit mining	
Strip mining	
Tunnelling and shaft mining	
In-situ mining	
Other (Specify) …….....	

SECTION C: ENVIRONMENTAL PERFORMANCE EVALUATION INDICATORS

Using the scale provided, indicate with an **X**, the extent to which your company has been monitoring the following environmental performance measures over the last five years.

1= Never monitored, 2 = Very low, 3 = Low, 4 = Moderate, 5 = High, 6 = Very high

Measure	**Monitoring Extent**					
	1	**2**	**3**	**4**	**5**	**6**
Training related to environmental matters delivered to employees						
Environmental audits conducted						
Environmental improvement projects implemented						
Achievement of environmental objectives and targets						
Occurrence of environmental accidents						
Compliance with environmental obligations						
Employee adherence to environmental management systems						
Level of management commitment to environmental protection						
Effectiveness of the environmental performance evaluation process						
Effectiveness of environmental risk management						
Energy consumption rate						
Water consumption rate						

Measure	Monitoring Extent					
	1	2	3	4	5	6
Waste recycling levels						
Greenhouse gas emission levels						
Material consumption						
Hazardous waste generation						
Air pollution						
Soil pollution						
Noise pollution						
Air quality						
Water quality						
Deforestation rate						
Fresh water depletion						
Land degradation						
Water pollution mortality rate						
Air pollution mortality rate						

SECTION D: FACTORS AFFECTING PREVAILING ENVIRONMENTAL PERFORMANCE EVALUATION PRACTICES

Using a 5-point Likert scale provided, indicate with an **X**, the extent to which the highlighted factors affect the monitoring of environmental performance evaluation indicators in your company.

1 = Not influential at all, 2 = Slightly influential, 3 = Moderately influential, 4 = Highly influential, 5 = Extremely influential

Factor	Extent of influence				
	1	2	3	4	5
Limited environmental performance evaluation expertise					
Limited financial resources					
Time consuming environmental performance evaluation processes					
Avoiding environmental management compliance fines					
Low employee commitment					
Low management commitment					
Pressure from the local community					
Need for ISO and other environmental management certifications					
Other (Specify) ……					

SECTION E: SUSTAINABLE DEVELOPMENT PRIORITIES

This section seeks to explore your company's priorities in pursuing sustainable development in its operations. Sustainable development focuses on three pillars namely, environmental sustainability, economic sustainability, and social sustainability. Environmental sustainability focuses on the company's activities to manage the environment, social sustainability focuses on the company's activities to benefit employees, and the community and economic sustainability focuses on generating and maximising returns for investors.

Instructions for answering this section:

1) Select the sustainability pillar which your company pays more attention to between the two pillars under comparison by ticking (√) in column A or B from (i) to (iii) in the table provided after the Likert scale.
2) Use the 9-point Likert scale below to indicate the extent to which your company pays attention to the chosen pillar over the other pillar.

Attention Likert scale.

1	Equal attention
2	Attention falls somewhere between equal and moderate
3	Moderate attention
4	Attention falls somewhere between moderate and strong
5	Strong attention
6	Attention falls somewhere between strong and very strong
7	Very strong attention
8	Attention falls somewhere between very strong and extremely strong
9	Extremely strong attention

Comparison of Sustainability Pillars

	Sustainability Pillar (I)		**Vs**	**Sustainability Pillar (II)**		**Level of Attention**								
		A			**B**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	Environmental sustainability			Social sustainability										
	Environmental sustainability			Economic sustainability										
	Social sustainability			Economic sustainability										

Thank you

APPENDIX C: INTERVIEW GUIDE

INTERVIEW QUESTIONS FOR SENIOR MINE MANAGEMENT FOR FRAMEWORK VALIDATION

1) What other environmental performance evaluation indicators do you think can be included in the framework to enhance its potential in promoting sustainable operations of small-scale miners in Zimbabwe?
2) Which environmental performance evaluation indicators, if any, do you think may need to be removed from this framework and why?
3) To what extent do you think the environmental performance evaluation indicators disclosed in this proposed framework can promote sustainable operations of small-scale miners in Zimbabwe?
4) Do you have any other suggestions to improve this framework?

APPENDIX D: SYSTEMATIC LITERATURE REVIEW ARTICLE SCREENING

No.	Authors	Year	Document Type	Source	First Screening	Final Screening
1	Tsai et al.	2024	Article	Scopus	1	1
2	Wang et al.	2024	Article	Scopus	2	1
3	Wang et al.	2024	Article	Scopus	0	0
4	Motahari et al.	2024	Article	Scopus	2	1
5	Xu et al.	2024	Article	Scopus	0	0
6	Dağıdır& Özkan	2024	Article	Scopus	2	0
7	Velasco & Gerike	2024	Article	Scopus	2	0
8	Yang et al.	2024	Article	Scopus	0	0
9	Dos Santos et al.	2024	Article	Scopus	0	0
10	Anantadjaya et al.	2024	Article	Scopus	0	0
11	Xu et al.	2024	Article	Scopus	0	0
12	Lin &Lu	2024	Article	Scopus	0	0
13	Zhang et al.	2024	Article	Scopus	0	0
14	Sahu et al.	2024	Article	Scopus	0	0
15	Malah et al.	2023	Article	Scopus	2	1
16	Xian et al.	2023	Article	Scopus	1	1
17	Gonca &Çağdaş	2023	Article	Scopus	0	0
18	Asgari & Noorzai	2023	Article	Scopus	0	0
19	Khan et al.	2023	Article	Scopus	0	0
20	Feng et al.	2023	Article	Scopus	0	0
21	Koc et al.	2023	Article	Scopus	2	0
22	Estupendo et al.	2023	Article	Scopus	0	0
23	Rossi et al.	2023	Article	Scopus	0	0
24	Kuo et al.	2023	Article	Scopus	0	0
25	Lu et al.	2023	Article	Scopus	0	0
26	Sandoval-Gómez et al.	2023	Article	Scopus	0	0

No.	Authors	Year	Document Type	Source	First Screening	Final Screening
27	Ekhtiari et al.	2023	Article	Scopus	0	0
28	Schlickmann & Bortoluzzi	2023	Article	Scopus	0	0
29	Panaro et al.	2023	Article	Scopus	0	0
30	Shao et al.	2023	Article	Scopus	2	0
31	Naghi et al.	2023	Article	Scopus	0	0
32	Coşkun et al.	2022	Article	Scopus	0	0
33	Kostyrko et al.	2022	Article	Scopus	0	0
34	Lalau et al	2022	Article	Scopus	0	0
35	Cristiano	2022	Article	Scopus	0	0
36	Cristiano et al.	2022	Article	Scopus	0	0
37	Negash &Filketu	2022	Article	Scopus	2	0
38	Witkowski et al.	2022	Article	Scopus	0	0
39	Ansari et al.	2022	Article	Scopus	0	0
40	Zhang et al.	2022	Article	Scopus	0	0
41	Daskiran et al.	2022	Article	Scopus	0	0
42	Sardanelli et al.	2022	Article	Scopus	0	0
43	Ali et al.	2022	Article	Scopus	0	0
44	Cheng et al.	2022	Article	Scopus	0	0
45	Ghag et al.	2022	Article	Scopus	2	0
46	Teixeira et al.	2021	Article	Scopus	2	0
47	Ismail &Hanafiah	2021	Article	Scopus	2	1
48	D'Inverno et al.	2021	Article	Scopus	2	1
49	Zhang et al.	2021	Article	Scopus	2	1
50	Lukáč et al.	2021	Article	Scopus	0	0
51	Jacomossi et al.	2021	Article	Scopus	0	0
52	Armengot et al.	2021	Article	Scopus	0	0

No.	Authors	Year	Document Type	Source	First Screening	Final Screening
53	Bianchi et al.	2021	Article	Scopus	0	0
54	Kilic & Yalcin	2021	Article	Scopus	0	0
55	Gavrilescu et al.	2021	Article	Scopus	2	1
56	Cielo et al.	2021	Article	Scopus	0	0
57	Li et al.	2021	Article	Scopus	0	0
58	Turk et al	2020	Article	Scopus	0	0
59	Zhou et al.	2020	Article	Scopus	2	0
60	Kafetzopoulos et al.	2020	Article	Scopus	0	0
61	Cheng et al.	2020	Article	Scopus	1	1
62	Roy et al.	2020	Article	Scopus	2	1
63	Chang et al.	2020	Article	Scopus	0	0
64	Ribarič	2020	Article	Scopus	0	0
65	Neto & Cunha	2020	Article	Scopus	2	0
66	Wang et al.	2020	Article	Scopus	0	0
67	Sahoo &Vijayvargy	2020	Article	Scopus	0	0
68	Kostyuchenko et al.	2020	Article	Scopus	0	0
69	Lin et al.	2020	Article	Scopus	0	0
70	Rajesh	2020	Article	Scopus	0	0
71	Adenuga et al.	2020	Article	Scopus	2	0
72	Aouag et al.	2020	Article	Scopus	2	0
73	Zheng et al.	2020	Article	Scopus	0	0
74	Wollmann &Tortato	2019	Article	Scopus	0	0
75	Bhattacharyya	2019	Article	Scopus	0	0
76	Teerawattana& Yang	2019	Article	Scopus	0	0
77	Coca et al.	2019	Article	Scopus	0	0
78	Rebelato et al.	2019	Article	Scopus	0	0

No.	Authors	Year	Document Type	Source	First Screening	Final Screening
79	Staniškis & Katiliūtė	2019	Article	Scopus	2	0
80	Cetrulo et al.	2018	Article	Scopus	0	0
81	Jradi et al.	2018	Article	Scopus	2	1
82	Nicoletti et al.	2018	Article	Scopus	1	1
83	Cazeri et al.	2018	Article	Scopus	0	0
84	da Silva et al.	2018	Article	Scopus	2	1
85	Vyhmeister et al.	2018	Article	Scopus	2	0
86	How & Lam	2018	Article	Scopus	2	0
87	Mu et al.	2018	Article	Scopus	0	0
88	Lupo & Cusumano	2018	Article	Scopus	0	0
89	Sayed & Lento	2018	Article	Scopus	0	0
90	Li et al.	2018	Article	Scopus	0	0
91	Gong et al.	2018	Article	Scopus	0	0
92	Sen et al.	2018	Article	Scopus	0	0
93	Merli et al.	2018	Article	Scopus	2	1
94	Feng et al.	2018	Article	Scopus	0	0
95	Lo-Iacono-Ferreira et al.	2018	Article	Scopus	1	1
96	Ferreira et al.	2018	Article	Scopus	2	0
97	Wijayasundara et al.	2018	Article	Scopus	0	0
98	Dantas et al.	2017	Article	Scopus	0	0
99	Saeed & Kersten	2017	Article	Scopus	0	0
100	Nimmanterdwong et al.	2017	Article	Scopus	2	1
101	Carrasquer et al.	2017	Article	Scopus	2	1
102	Stindt	2017	Article	Scopus	2	1
103	Santos et al.	2017	Article	Scopus	2	0

No.	Authors	Year	Document Type	Source	First Screening	Final Screening
104	Fang et al.	2017	Article	Scopus	0	0
105	Cheng et al.	2017	Article	Scopus	2	0
106	Chiarini	2017	Article	Scopus	0	0
107	Gogate et al.	2017	Article	Scopus	0	0
108	Siew	2017	Article	Scopus	0	0
109	Genovese et al.	2017	Article	Scopus	0	0
110	Escrig-Olmedo et al.	2017	Article	Scopus	0	0
111	Banasik et al.	2017	Article	Scopus	2	1
112	Grigoroudis	2017	Article	Scopus	1	1
113	Chao et al.	2017	Article	Scopus	0	0
114	Venturelli et al.	2017	Article	Scopus	0	0
115	Lai & Man	2017	Article	Scopus	0	0
116	Shvarts et al.	2016	Article	Scopus	0	0
117	Staniškis & Katiliute	2016	Article	Scopus	0	0
118	Khalil et al.	2016	Article	Scopus	0	0
119	Liu et al.	2016	Article	Scopus	0	0
120	Rahdari	2016	Article	Scopus	2	0
121	Li &Mathiyazhagan	2016	Article	Scopus	2	0
122	Teixeira et al.	2016	Article	Scopus	1	1
123	Uluer et al.	2016	Article	Scopus	2	0
124	Iannone et al.	2016	Article	Scopus	2	0
125	Arampatzis et al.	2016	Article	Scopus	2	1
126	Batocchio et al.	2016	Article	Scopus	0	0
127	Ferreira et al.	2016	Article	Scopus	1	1
128	Silva et al.	2015	Article	Scopus	0	0
129	Pacetti et al.	2015	Article	Scopus	0	0

No.	Authors	Year	Document Type	Source	First Screening	Final Screening
130	Bai et al.	2015	Article	Scopus	0	0
131	Ngacho& Das	2015	Article	Scopus	2	1
132	Noya et al.	2015	Article	Scopus	0	0
133	Issa et al.	2015	Article	Scopus	0	0
134	Morana & Gonzalez-Feliu	2015	Article	Scopus	0	0
135	Ngacho& Das	2014	Article	Scopus	0	0
136	Zhang et al.	2014	Article	Scopus	1	1
137	Nikolaou et al.	2013	Article	Scopus	2	1
138	Parisi	2013	Article	Scopus	0	0
139	Ostad-Ahmad-Ghorabi et al.	2013	Article	Scopus	2	1
140	Ning et al.	2013	Article	Scopus	0	0
141	Wang et al.	2013	Article	Scopus	2	1
142	Lenny et al.	2013	Article	Scopus	0	0
143	Sakalas & Liepe	2013	Article	Scopus	0	0
144	Gregori et al.	2013	Article	Scopus	0	0
145	Guerra-López & Toker	2012	Article	Scopus	0	0
146	Yang et al.	2011	Article	Scopus	1	1
147	Tsolas	2011	Article	Scopus	0	0
148	Feng & Joung	2011	Article	Scopus	0	0
149	Wang et al.	2011	Article	Scopus	0	0
150	Focacci	2011	Article	Scopus	0	0
151	De Figureueirêdo et al.	2010	Article	Scopus	1	1
152	Lundberg et al.	2009	Article	Scopus	1	1
153	Ramos et al.	2009	Article	Scopus	2	0
154	van Berkel et al.	2008	Article	Scopus	2	0

No.	Authors	Year	Document Type	Source	First Screening	Final Screening
155	Craig & Lemon	2008	Article	Scopus	0	0
156	Stripple et al.	2008	Article	Scopus	0	0
157	Perotto et al.	2008	Article	Scopus	1	1
158	Costa Dos Santos & Rodrigues	2008	Article	Scopus	0	0
159	Xie & Hayase	2007	Article	Scopus	1	1
160	van Gerven et al.	2007	Article	Scopus	0	0
161	Romero & Piñeiro	2006	Article	Scopus	2	1
162	Anand et al.	2005	Article	Scopus	0	0
163	Lindgreen & Hingley	2003	Article	Scopus	0	0
164	Machado & Moy	2003	Article	Scopus	2	1
165	Moore et al.	2003	Article	Scopus	0	0
166	Ward et al.	2002	Article	Scopus	0	0
167	Zobel et al.	2002	Article	Scopus	0	0
168	Leslie	2001	Article	Scopus	0	0
169	Thoresen	1999	Article	Scopus	0	0
170	Johnson	1996	Article	Scopus	0	0

APPENDIX E: LANGUAGE CERTIFICATE

Certification of language editing

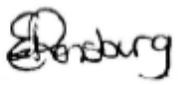
This is to certify that the paper titled

An environmental performance evaluation framework for sustainable operations of Zimbabwean small-scale miners

by **Anyway Ngirazi**

has been edited for language by Erika Janse van Rensburg holding a BIS(Hons) in Publishing studies. Neither the research content nor the author's intensions were altered.

Issued by Erika Janse van Rensburg



23-02-2026

APPENDIX F: SIMILARITY REPORT

Similarity Report

PAPER NAME

Turnitin All-inclusive Document _Anyway Ngirazi_58549781_PhD_Accounting Sciences .docx

AUTHOR

ANYWAY NGIRAZI

WORD COUNT

48833 Words

CHARACTER COUNT

303226 Characters

PAGE COUNT

180 Pages

FILE SIZE

2.2MB

SUBMISSION DATE

Feb 24, 2026 10:05 AM GMT+2

REPORT DATE

Feb 24, 2026 10:12 AM GMT+2

22% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

- 13% Internet database
- 14% Publications database
- Crossref database
- Crossref Posted Content database
- 16% Submitted Works database

Excluded from Similarity Report

- Manually excluded sources

The manually excluded sources are all the candidate's own work. Documents were saved in error to the repository when a new repository was created by Unisa.



Similarity Report

22% Overall Similarity

Top sources found in the following databases:

- 13% Internet database
- 14% Publications database
- Crossref database
- Crossref Posted Content database
- 16% Submitted Works database



The 4% is when the student submitted his thesis to his workplace instead of Unisa

TOP SOURCES

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	Midlands State University on 2021-07-16 Submitted works	4%
2	uir.unisa.ac.za Internet	3%
3	ir.unisa.ac.za Internet	<1%
4	UNICAF on 2026-01-22 Submitted works	<1%
5	University of South Africa on 2025-12-18 Submitted works	<1%
6	vital.seals.ac.za:8080 Internet	<1%
7	citcglobal.com Internet	<1%
8	jssidoi.org Internet	<1%

Sources overview