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A Conceptual Framework for Greener Goldmining through Environmental Management Accounting Practices (EMAPs): The Case of Zimbabwe

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Abstract: Goldmining contributes substantially to the Gross Domestic Product (GDP) of the Zimbabwean economy through revenue generated from exports, however it also incurred numerous challenges to the environment. Amongst others, these challenges embody ecological degradation; water and air pollution; and depletion of natural resources. In this paper, we establish the effects of mining operations on the environment through a comprehensive literature review, and how the integration of environmental management accounting practices (EMAPs) such as material flow cost accounting (MFCA), life cycle costing (LCC), and activity-based costing (ABC) could be integrated into a conceptual framework to address environmental challenges. EMAPs were chosen as they generate both physical and monetary data, which could promote transparency in material usage within the goldmining sector. Our analyses revealed a substantial body of literature on separate and individual EMAPs, yet very little was found on the integration of EMAPs. The main contribution of this work is the development of an integrated conceptual EMAPs framework on the strength of sets of qualitative propositions, aimed at promoting green goldmining for Zimbabwe as a developing economy. Future work would involve the validation of the framework among key stakeholders in the Zimbabwean goldmining industry.

Keywords: activity-based costing (ABC); environmental management accounting (EMA); environmental management accounting practices (EMAPS); green goldmining; life cycle costing (LCC); material flow cost accounting (MFCA); sustainability

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1. Introduction

According to the Chamber of Mines Report, Zimbabwe, being a goldmining country, produced an average of 27 tonnes of gold per annum at its peak in 1999. Although opportunities for expansion do exist, lately production averages 15 tonnes per annum [1]. In Zimbabwe, the mining sector is a major driver of foreign direct investment (FDI) [2]. Despite the positive contribution of the mining sector to economic development, the sector has also brought about hardship in local communities through pollution of water and air; lost grazing and agricultural land; the creation of unprotected mining pits; exploitation and depletion of natural resources; as well as forced eviction and relocation of communities without fair compensation [2,3].

The impact of goldmining is not confined to Zimbabwe as a developing economy but is of global concern. Ref. [4] explains, in Figure 1, how gold is produced, and how the processes from the open pit to a piece of jewellery have an impact on the environment and host communities. To produce gold costs the environment much more than what a golden ring, for instance, is worth.

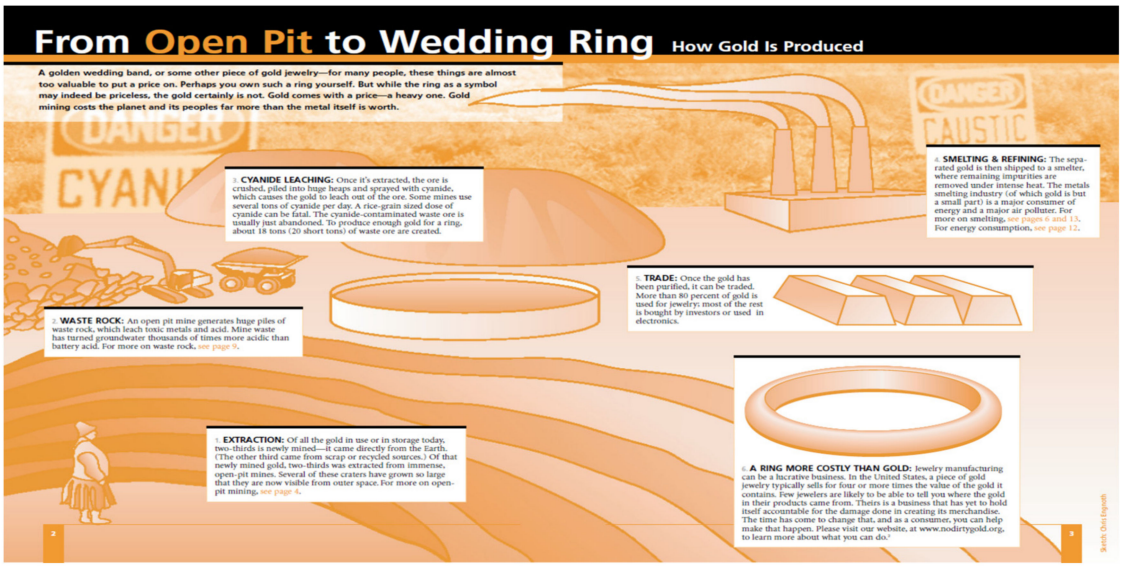

Figure 1. How gold is produced [4] (reproduced with permission).

Following Figure 1, extraction from open pit mines leaves craters large enough to be visible from space. The second process entails waste rock, containing toxic metals which turn water to be more acidic than battery acid. Cyanide leaching occurs when the ore is sprayed with cyanide to release the gold from the rock. During the next phase, gold is heated to be smelted at high temperatures, and refined through a process using substantial amounts of energy. Once a piece of jewellery is made, it is sold at almost four times the cost of production, and this may lead to the jewellery industry being just as responsible for a negative environmental footprint [4]. This is where LCC (Section 2.4.2) may also play an important role to elicit these effects.

An area that needs to be further researched in surface goldmining, as is practised in Zimbabwe, is how it impacts local livelihoods. Conflicts regarding the use of land escalate to conflicts at a local, national, and ultimately a global level, with surface goldmining being one of the main sources of conflict. Western Ghana was identified as one of the leading goldmining regions, and a study by [5] assessed the land cover due to gold surface mining. They reported deforestation (58%), a substantial loss of farmland (45%), and relocation of farmers who then expand farmland into forests, as concerns. It is clear, therefore, that the effects of goldmining on the natural environment expands to the African continent, and not only Zimbabwe.

Owing to the population growth and humanity's growing need for fuel, freshwater, fibres, and lumber, natural resources are consumed faster and more extensively during past decades, hence our natural habitat is over-exploited [6]. Consequently, ref. [6] argues for the transition towards green growth as a key to sustainable development and prosperity. Sustainability which is based on proactive decision making and innovation minimises the negative impact and maintains balance between environmental management, economic growth, political justice, and cultural aspects to work towards a desirable planet for all species [7]. The United Nations Environmental Programme [8] provides that when these pillars are integrated into a green economy framework; decision makers would be able to define policies based on a more complete picture. The major challenge in corporate sustainability is the development of a management framework to systematically follow the integration of sustainability in business strategy [9]. Sustainability has become important for each organisation and human being when the Sustainable Development Goals (SDGs) were proposed in 2015. Goals of importance for the mining industry are: good health and well-being (3), clean water and sanitation (6), responsible consumption and production (12), and climate action (13) [10]. In the same vein, the African Union developed *Agenda 2063: The Africa we want* with the following goals: healthy and well-nourished citizens (3) and

environmentally sustainable and climate resilient economies and communities (7) which are aligned to the SDGs mentioned before [11].

Figure 2 presents all the Sustainable Development Goals (SDGs) developed in 2015.

Figure 2. The Sustainable Development Goals [12] (reproduced with permission: The content of this publication has not been approved by the United Nations and does not reflect the views of the United Nations or its officials or Member States).

In the light of the importance of sustainability based on the SDGs and Agenda 2063, it is apparent that the goldmining industry also need to decrease their environmental footprint. In adherence, the World Gold Council reported in 2019 that they launched the Responsible Gold Mining Principles (RGMPs) to ensure all stakeholders are aware how responsible goldmining is defined [13]. In this research, we propose that the goldmining sector incorporate environmental management accounting (EMA) into their operations. EMA has different practices to measure the flow of material (physical units) as well as money (monetary units). These are called environmental management accounting practices (EMAPs) which include, amongst others, activity-based costing (ABC), Life Cycle Costing (LCC), and material flow cost accounting (MFCA) [14]. These practices may enable the goldmining industry to identify and decrease waste and, at the same time, decrease costs, thereby increasing their profitability.

The aim of the article is to present corporate greening through the lens of sustainability and illustrate how EMAPs can assist goldmining organisations to become greener. Goldmining organisations may have to adhere to a number of environmental regulations, the most recognised regulation being "The OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High Risk Areas" [13]. In addition, EMAPs could assist these organisations to decrease their environmental footprint by following the flow of materials and money through their operations to reduce waste and wasteful expenditure. The conceptual EMAPs framework developed in this article aims to address some of these concerns by providing valuable insights to decision-makers on ways of integrating environmental issues into the core industrial competitiveness. The research on goldmining was motivated by [15].

The layout of the rest of the article is as follows: The introduction is followed by the research questions this article aims to address, as well as our objective of this research in Section 1.1. The use of qualitative propositions in developing the conceptual framework is presented in Section 1.2. Background to a greener goldmining approach with respect to corporate activities is presented in Section 1.3. Section 2 provides a literature review. The materials and methods, including the research methodology are discussed in Section 3, followed by the qualitative findings presenting a summary of the propositions, which are

defined throughout the article, and the framework in Section 4 with a theoretical validation thereof in Section 5. Conclusions and directions for future work in this area are presented in Section 6. A list of references concludes the article.

1.1. The Use of Propositions

The instrument in our work is in the form of propositions synthesised from the literature and serving as guidelines for developing the framework to address challenges of goldmining as unpacked in this article. The propositions embody three sets around elements of entities in the framework, and associations among these, as follows:

- Content propositions, labelled as C*p*i, i = 1, 2, 3, . . . , of which the purpose is to identify the various content related building elements of our framework;
- Association propositions, indicated by *Ap*j, j = 1, 2, 3, . . . , used to define associations among the building blocks of the framework;
- General propositions, denoted as *Gp*k, k = 1, 2, 3, . . . , used to capture information that may be more generic to the development of the framework.

1.2. Background for the Development of Corporate Greening

Ref. [16] explains that the 1980s mark a period in the development of corporate greening when corporates attempted to integrate economic and environmental objectives of their chemicals and waste atmosphere, land, freshwater, bio-diversity, and biotechnology as phenomena that collectively gave rise to their greening and were viewed as challenges faced [17]. The strategic advantage of environmental management has been recognised in recent years when dealing with environmental challenges [16,18]. Ref. [19] claims that organisations increasingly devote time and resources to environmental management practices with the objective of contributing to sustainable development. The use of EMAPs in addressing environmental challenges may be key, and to this end [20] defines EMAPs as strategic systems of integrated environmental processes for monitoring and controlling environmental impacts; training of personnel; and summarising, integrating and reporting environmental performance.

Researchers have grouped drivers of environmental management into internal and external forces and these create pressure on corporates to pursue greener environmental practices [17,18]. Organisational context, learning design, individual or managerial level, managerial attitudes, and leadership values are classified as internal factors, while competitive forces, regulations, and other stakeholder influences, for example from NGOs, are classified as external forces [18,20,21].

Consequently, we arrive at our first two content propositions.

- **Proposition C*p*1:** Employees, who are internal to a mining environment, and the media, who are external stakeholders, may likewise exert pressure that motivate mining organisations to adopt strategies for greener goldmining;
- **Proposition C*p*2:** NGOs and other essential pressure groups assist in the diffusion of ideas among mining organisations, thereby acting as motivators for them to adopt environmental management initiatives. Environmental-related regulations are an essential external driver of environmental management and have received much attention early on [22,23]. For compliance to improved environmental management practices, stringent environmental regulations ought to be effected, as these can direct attention to resource inefficiencies, potential technological improvements, motivate innovation, reduce uncertainty in investments, and improve corporate awareness through information gathering [24]. Early environmental practitioners paid attention to regulatory requirements [25]; consequently, government regulation has been identified as the key source of pressure on organisations to consider environmental issues [23]—the forces identified above create a need for organisations to respond to the challenge of environmental issues in different ways [17]. Many organisations have moved from command and control laws to voluntary and market-based approaches [17], motivating the need for regulatory aspects to be embedded in a framework for greener goldmining.

The discussions in this section lead to a number of content propositions:

- **Proposition C*p*3:** Government, together with other key stakeholders, may adopt legislation that may accelerate the rate at which organisations comply with environmental regulations;
- **Proposition C*p*4:** Government, and other regulatory bodies with rich resources, could exert numerous forces on mining organisations to adopt greener initiative practices and avoid penalties that come with failing to comply (refer C*p*2);
- **Proposition C*p*5:** Stakeholder engagement helps build lasting beneficial relationships, and stakeholder mapping and identification of their needs are an essential strategy for mining organisations.

An observation about internal and external stakeholders leads to a further content proposition:

- **Proposition C*p*6:** Social order within the mining sector may essentially be based on a shared social reality. (Note that this may be a general proposition in other spheres of life.)

According to ref. [26] sustainability entails a scenario whereby organisations combine their economic goals aimed at taking care of human beings and their impact on ecosystems. Hence, sustainable development is enhanced when an organisation's activities are aligned to sustainable development, and take into consideration its obligation to society [27]. Taking it a step further, ref. [28] (p. 1) states that "You can't manage what you don't measure", whilst ref. [29] (p. 517) postulates that " ... you are what you measure!" It follows that organisations wanting to promote sustainable development should have a performance measurement system (PMS) in place to measure sustainability performance [30]. Given the limitations of natural resources, current production needs to be changed to enable global sustainable development [31]. An important aspect that has been noted on existing frameworks is the lack of common ground and definitions that reconcile the major segments of sustainability development [32], giving further impetus to the goal of this article, namely, the development of a framework that acts as a base in the pursuit of sustainable greener goldmining.

Ref. [33] postulates that potential stakeholders need access to readily available data relating to environmental activities of organisations to make informed decisions. Organisations should carefully consider environmental impacts of their actions, and where there is wasteful consumption of raw materials and energy, ways of reducing these should be investigated [34]—there is a need for the mining sector to conduct an extensive overview of its current mining practices and investigate ways of cleaning-up to facilitate sustainable growth and remain profitable [35]. For example, mining activities impact on food security owing to the loss of fertile soils resulting in desertification [34]. Ref. [34] reiterates that sustainable development leads to sustainability, as it assists in establishing activities and processes that should be highlighted by organisations, such as addressing environmental degradation, as well as social and financial performance.

There has been an increase of late in environmental responsibilities in mining, and many organisations within the mining sector are cognisant of this [36,37]. Ref. [38] argues that, though a country's system of national accounts is used to derive key indicators of economic performance, it does not capture the depletion of the environmental base, and hence there is a need for a framework to promote greening of the environment with respect to goldmining in the Zimbabwean economy.

The above motivations inform the following research questions (RQs):

1.3. Research Questions and Objective

The questions which we aim to find answers for are:

- What are the effects of goldmining operations on the environment? (RQ1)
- How can the integration of EMAPs into a framework address the gaps identified? (RQ2)

- How can the government and other key stakeholders facilitate greener goldmining activities? (RQ3)

Our research objective in response to the RQS is:

- Develop an integrated conceptual framework of EMAPs to promote greener goldmining in Zimbabwe. (RO)

2. Literature Review

As discussed in the introductory part of this work, goldmining operations, especially in developing economies, have an adverse impact on the physical environment and communities in the vicinity in which they operate. Some of these impacts are discussed in the introduction and Section 1.1, thereby partially addressing the first research question (RQ1).

The following section further unpacks the adverse environmental effects of mining operations.

2.1. Environmental Impacts

Ref. [39] did a study in Zimbabwe on abandoned goldmines, regarding the surrounding soil of a tailings dam, and found that a low pH (acidity), electrical conductivity, potentially toxic elements (PTEs), and sulphate in the soil holds a threat to communities and the environment. To safeguard the environmental integrity and public health, they suggest stricter legislation, environmental stewardship, and environmental impact assessments. Their findings support our propositions Cp1 and Cp4 above.

Mineral production has a direct economic impact on surrounding communities, leading to poor health and wellbeing of local residents [40,41], and [42] argues that mineral development has severe negative social and economic impacts on multiple scales, ranging from local to global measurements. Industrial accidents, violation of human rights, health and safety issues, environmental degradation, and impact on livelihood of local communities are examples of some of the extreme negative social and environmental impacts of the mining sector [43], plausibly, therefore, goldmining in developing economies as well, leading to:

- **Proposition Cp7:** Goldmining activities have adverse effects on the natural environment, as they leave a strong footprint on the environment, arguably more than any other industrial activity.

Mining operations have a finite lifespan, hence humanity's dependence on non-renewable resources cannot continue indefinitely [44]. Environmental impacts caused by mining range from destruction of habitat including fauna and flora; land disturbance which includes change of land use and land forms; natural watersheds and drainage patterns; adverse chemical impacts of improperly treated wastes, which include air pollution, waste dumps, and effluents, for example acid mine drainage (AMD); and noise and vibration due to blasting [45]. Hence, noise and dust pollution generated during the excavation process would affect surrounding plants and animals [46]. Ref. [47] concurs that mining can destroy the ecosystems, thereby resulting in the loss of the service values of the surrounding ecosystem. If not carefully managed, goldmining activities may destroy the environment, as their activities have an influence on adjacent ecosystem services, plausibly more for a developing economy, which may lack the resources to put remedial measures in place.

Figure 3 indicates global mining hotspots and their impact on the environment, as well as communities.

Figure 3 highlights release of toxic pollutants, displacement of people, destroying of forests, substantial water usage, and groundwater and river contamination as a few of the impacts of mining. Ref. [25] reports that corporate scandals and the escalation of corporate power and influence call for more corporate responsibility on issues regarding the social and environmental impacts of organisations. Environmental disasters such as the Fukushima nuclear disaster caused by a tsunami, the Exxon Valdez oil spill, and the Bhopal gas leak, among others, have drawn increased public and media attention over their

harmful impact on the environment and society, calling for organisations to be accountable by putting in place environmental management strategies [17]. Again, these calls support, amongst others, Proposition C*p*1. Above.

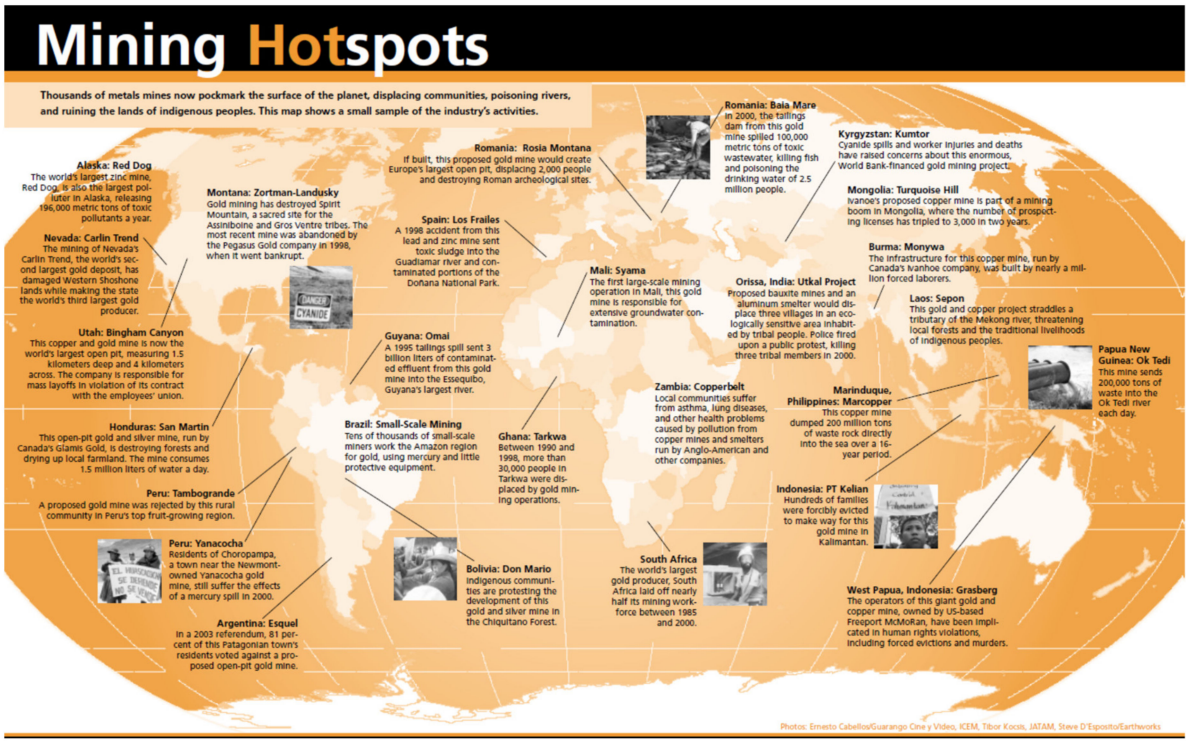

Figure 3. Mining hotspots and their impact [4] (reproduced with permission).

Additional triggering factors that have caused increased attention of organisations to the greening of the environment include climate change, deforestation, erosion, nuclear waste, and routine pollutants, which have expanded and become common place over the past decades [48]. These factors have worsened owing to the accelerated growth and scope of human activities [17]. The author adds that previous research has focused on the drivers of environmental management practices, and strategies, highlights the role of accounting in managing information, and concludes there is limited guidance on how accounting can be integrated with environmental developmental stages when pursuing environmental management strategies. Based on these challenges, the researchers postulate the need for an integrated conceptual framework embedding EMAPs to facilitate a greener environment for the Zimbabwean goldmining sector, to amongst others, provide a guide to related organisations for decreasing their environmental impacts.

According to ref. [49], neglect and exploitation of the weaknesses of current legislation and regulation is an important cause of environmental degradation in the Zimbabwean mining sector, as many argue that environmental compliance increases production costs, thereby making some projects uneconomic, supporting proposition C*p*4. Humans in pursuit of a more comfortable life have over exploited natural resources, damaged the natural ecological environments, and accumulated large amounts of waste, all of which have resulted in extreme climates [50]. The environment is harmed through polluting groundwater, emitting carbon, and contaminating rivers that drain into the sea [51], further leading to global warming as on ongoing problem of the 21st century and beyond. Ref. [50] adds that threats posed by extreme weather to humankind are visible everywhere, and ideas to solve over exploitation of natural resources and environmental protection are the essential challenges now. Ref. [50] views mining, as a sector, extremely improper in terms of the potential environmental impacts. That said, the researchers note the value of,

particularly, goldmining with respect to economic growth, which provides employment for large parts of the population.

Ref. [13] views the management of the environmental impacts of operations as an important step towards responsible goldmining. To guard the well-being of people and mitigate environmental impacts, *the International Cyanide Management Code* was developed in 2000. Voluntary codes and standards are incorporated by the goldmining industry, such as the ISO 14001 Environmental Management System and the International Council on Mining and Metals Sustainable Development Framework. In the ISO 14001 family, EMA is defined, and one of the major tools, MFCA, focuses on information for internal decision making [52]. MFCA is one of our EMAPs identified for a greener goldmining industry, and is discussed in Section 2.4.1. Additional environmental impacts of mining are discussed in Section 2.4.3 on Activity Based Costing (ABC).

Above discussions lead to a preliminary version of a content proposition and an association proposition:

- **Proposition C*p*8a:** ISO standards play an essential role in the governance of environmental regulations with respect to goldmining and the development of EMAPs;
- **Proposition A*p*1:** There is an association needed between applying EMAPs and meeting the objectives and goals of a mining enterprise.

Proposition C*p*8a is enhanced further on in this article.

2.2. Economic Impacts

Local livelihoods rarely profit sufficiently from mining activities, as mining has widespread and invasive environmental and social effects on these communities [53]. Ref. [54] advocates that the mining industry, owing to their environmental impacts, does not necessarily have direct links to the growth of the local economy, hence it does not contribute fully to the diversified sustainable development of a local, developing economy. It may, however, be a dominant industry in terms of providing for employment and generating income.

2.3. Impact on Society

Mineral extracting industries often cause conflicts between goals of the mining venture, the needs of the host community, and government policies [55]. Specifically, governments of developing countries have been observed to lacking the political will to effectively address the impacts of mining, for example, social injustice and inequality [56], leading to our next content proposition:

- **Proposition C*p*9:** To be granted a social licence to operate (SLO), goldmining organisations should consider the societal needs of communities in which they operate.

We furthermore observe our second association proposition:

- **Proposition A*p*2:** There is an association between meeting objectives/goals of a mining company and expected results with respect to cost savings and minimising environmental impacts.

In most cases, mining development has been observed to cause an influx in the population, with employees from outside of the region moving closer to work [57], leading to an increase in demand for accommodation, resulting in an increase in rentals in communities with insufficient housing supply [58], in turn causing an increase in property prices. The population influx has been observed to further result in an increased cost of living [57] and to cause displacement from local towns of the most vulnerable groups in society [58], as well as exerting financial and societal pressures on local residents, which has been linked to psychological and health problems [59]. Therefore, if not carefully managed via a framework or guidelines to address the conflicts between the mining company and the surrounding community, goldmining activities can adversely impact communities with respect to housing, financial aspects, and health problems.

The neglect of the welfare of people in host communities in the mining regions has been attributed to the lack of defensive measurement of the impacts of mining on host communities [42]. Ref. [60] reports that goldmining activities taking place underneath the town in Zaruma, Ecuador, resulted in an elementary school being swallowed by a collapse in the ground just before Christmas 2016.

The observations in this section lead to a general proposition that holds in most walks of life:

- **Proposition G*p*1:** Communication and engagement are essential among stakeholders to create common vision.

The foregoing discussion in (this) Section 2.3 provide an answer to our first research question, namely: What are the effects of mining operations on the environment? (RQ1). The rest of the research questions are addressed in the sections that follow in the solutions proposed in this article, namely, the use of EMA and its subsidiaries as core aspects of the proposed framework.

Next, we move to the tools of this article, namely, a discussion of environmental management accountings and its underlying sub tools.

2.4. Environmental Management Accounting (EMA)

The traditional way environmental-related costs have been accounted for indicates there has been little effort to reduce such costs, even though these costs could have been reduced if appropriate information had been provided for these [61]. According to ref. [62] and ref. [61] if, for example, material waste is included as part of total raw material costs and not as waste, opportunities to reduce waste might go amiss owing to a lack of information about the presence of waste. Environmental-related costs became increasingly essential to improve on waste management [63], and as a result a number of accounting methodologies such as EMA, carbon management accounting (CMA), and greenhouse-gas accounting (GHGA) have been developed [51]. Traditional methods that were in use did not consider environmental protection costs as well as integrated technologies [64,65], hence a more structured approach to costing environmental impacts had to be developed [33]. EMA therefore, encompasses a wide range of accounting tools given the diversity of management decisions [66], leading to:

- **Proposition C*p*10:** Goldmining systems should have a management accounting system that determines wasteful activities and enhances cost optimisation.

Proposition *Cp10* is a complementary proposition as it supports many other propositions in this article.

Ref. [67] defines EMA as a generic term that includes both monetary and physical EMA. Monetary environmental management accounting (MEMA) addresses environmental aspects of organisational activities expressed in monetary terms [67]. It provides the basis for most internal management decisions as it addresses aspects about tracing and treating costs and revenues incurred resulting from the company's impact on the environment [68]. Physical environmental management accounting (PEMA) focuses on an organisation's impact on the natural environment expressed in physical units [67]. Environmental measurement aspects and information are becoming vital, as stakeholders now pay increased attention to environmental performance [69]. Therefore, techniques that accurately measure environmental aspects should be used by organisations [20], and consequently a growing interest in accounting for the environment was sparked [70]. EMA as a response to environmental challenges can play an essential role in fostering an integrated approach to environmental management [17], hence the following content propositions:

- **Proposition C*p*11:** EMA may hold much promise to be employed to manage the various challenges facing the goldmining sector;
- **Proposition C*p*12:** EMA divisions of PEMA and MEMA, together with carbon management accounting (CMA) and greenhouse-gas accounting (GHGA), may provide essential information for the sustainable management of the challenges facing goldmining.

Ref. [71] promotes EMA as the most developed subset of sustainability accounting which, therefore, generates physical as well as monetary data through the use of various accounting techniques or methods. Material flow cost accounting (MFCA), life cycle costing (LCC) and activity-based costing (ABC) are methods to cost environmental impacts [33]. Therefore, this research aims to contribute to this body of knowledge by defining an integrated conceptual framework embedding MFCA, LCC, and ABC.

The following section discusses MFCA.

2.4.1. Material Flow Cost Accounting (MFCA)

According to ref. [72], managing material flows will assist in increasing efficiency of inputs, leading to cost reductions and thereby positively impacting on the environment. To this end, MFCA is used to provide information describing material flows (inventories and movements) in physical and monetary terms to assist in environmental management evaluation decisions [73,74]. Consequently, the main aim of MFCA is to treat undesired outputs (losses) as desired outputs when it comes to cost assignment [75].

MFCA is an accounting method that aims to categorise the costs of the products and wastes based on material flow, with the intention of improving resource efficiency [33,76,77]. MFCA can be a powerful tool for the implementation of cleaner production by identifying potential areas for improving the economic and environmental performance of the flow system [52,78]. Identification of potentials for money savings by avoiding unnecessary wastes, residual substances, and emissions is, therefore, an important objective of MFCA [52]. MFCA is useful in manufacturing as costing is crucial to the manufacturing sector and potential savings are expressed in monetary terms [79]. With its relationship to cost accounting and covering cost of goods sold (COGS), MFCA [52] breaks costs into material, energy, waste management, and systems costs (positive and negative products) [80,81].

The above exposition and possibilities of MFCA lead to three content propositions, one (C*p*14) an enhanced version of an earlier proposition:

- **Proposition C*p*13:** MFCA, as an EMAP, supports eco-efficiency decisions that enhance resource efficiency to improve the economic and environmental performance of a mining organisation;
- **Proposition C*p*8:** ISO standards play an essential role in the governance of environmental regulations and the development of EMAPs such as MFCA;
- **Proposition C*p*14:** MFCA assists in achieving resource and energy efficiency, as it facilitates speedy availability of waste information.

Research indicates that environmental and economic benefits can be, and in fact have been, achieved with MFCA [82]. Therefore, the quantification of the economic effects of production losses is hoped to motivate managers and engineers to innovate ways to reduce such losses and thereby increase production efficiency. Ultimately, when the goldmining sector is concerned, MFCA is likely to assist decision-makers with waste management, as well as improving environmental management by highlighting costs which would be saved by reworking inefficient activities and processes.

This leads to an important preliminary MFCA proposition related to waste management:

- **Proposition C*p*15a:** MFCA can assist the goldmining organisations in working towards reduction in waste to enhance both the economic and environmental performance of the goldmining sector.

Proposition C*p*15a is enhanced further in this article.

Organisations have continuously been seeking opportunities to generate financial benefits by reducing costs whilst at the same time reducing adverse environmental impacts through material efficiency improvements [83]. An increase in the production of goods, when not effectively managed, has the potential to result in waste or financial leakage that will impact the financial bottom line of an organisation [84,85], hence MFCA focuses on sharing costs to waste streams [86]. According to ref. [62], a considerable percentage of production costs consist of material costs, and a large share of these costs comes as

material losses within production systems. The major aim of manufacturing organisations is for material inputs to end up as products [85], and output that becomes non-product is considered as waste, which is a cost to an organisation [87]. Waste is what has prompted organisations to seek cost efficient ways to prevent revenue losses [88]. It may become necessary, therefore, for management accounting tools to promote greener goldmining to be integrated strategically in a conceptual framework to reduce waste.

The optimal use of material and energy by different industries has become a topical issue owing to limited energy resources worldwide, and MFCA has been suggested as a new management system that can facilitate waste management and provide an estimation of actual values of losses [89]. According to ref. [90], global pressure to achieve higher productivity with reduced environmental impacts has necessitated organisations to investigate practices that enable them to account for all inputs to and outputs from their operations, with a view to support eco-efficient decisions that improve economic and environmental performance. MFCA has been put forward as one such practice that can support eco-efficient decisions [66], and has been chronicled as among the most fundamental EMAPs [91].

MFCA is based on the premise that all material procured by a business must eventually leave, either as part of a final product or non-product (waste) [87]. MFCA is an EMAP that can lead organisations to an improved understanding and mitigation of potential environmental and financial consequences of their energy and material use practices. It can further identify opportunities to achieve both environmental and financial improvements on those practices [52,76]. MFCA is applicable to every type of organisation, irrespective of their product, services, size, structure, location, and existing management and accounting systems [52,87]. Consequently, MFCA may equally be applied to the goldmining sector.

Unlike traditional accounting systems that do not provide sufficient information on the environment systematically [79], MFCA examines the relationship among accounting, the environment, and information management to achieve improved decision-making accountability [92]. Hence, by extending the scope of traditional accounting, MFCA makes goal management more systematic and scientific.

The additional motivations for the use of MFCA in this section lead to an enhancement of a previous proposition:

- **Proposition C*p*15:** MFCA can assist goldmining organisations in economic and environmental performance through:
  - ➢ reduction in waste;
  - ➢ improved energy usage;
  - ➢ improved decision making and accountability.

It should be noted that there are disadvantages to the use of MFCA. Ref. [87] states that MFCA only assists in calculating the costs of product and waste, however does not calculate total environmental costs (waste and emission treatments, prevention, and environmental costs) incurred by an organisation. Based on this weakness of failing to measure total environmental costs, MFCA should be applied together with other methods to measure total costs of environmental impacts [33], hence the need for an integrated conceptual framework so that its weaknesses can be mitigated by other practices.

Amongst the complementary methods mentioned above is life-cycle costing (LCC), discussed in the following section.

2.4.2. Life Cycle Costing (LCC)

Waste managers need to gauge the complete cost of a waste management system and not just assess a treatment method [93], leading to the idea of life-cycle costing (LCC). Ref. [94] considers LCC as a system-wide analysis practice. Likewise, ref. [33] describes LCC as a practice to estimate and accumulate costs for a product over its entire life cycle. Consequently, LCC is used to assess the anticipated economic performance of a project through its life cycle [95].

The development of the environmental life cycle cost (ELCC) framework by a working group from the Society of Environmental Toxicology and Chemistry (SETAC), incorporated multiple stakeholders and better accompanies a traditional LCA goal and scope [94]. Using LCC, profits generated during the manufacturing phases of the underlying life cycle cover expenses occurring during the pre- and post-manufacturing phases of the product [96]. It is a requirement in the mining sector to conduct life cycle assessments (LSAs) to assess the environmental and economic performance of mining organisations [33]. Therefore, having LCC within the integrated conceptual framework may assist the goldmining industry to gauge the complete cost of waste management over the entire life of a goldmining project, leading to a preliminary version of a proposition:

- **Proposition C*p*16a:** LCC may be implemented in conjunction with MFCA by the goldmining sector in accordance with the principles of sustainable development, thereby considering the economic, social, and environmental aspects of an investment project.

There is a need for the industry to have an appreciation that better value, and not lower price, has to be the focus for early stage project evaluation of an investment [97]. As LCC is a practice used to gauge the complete cost of a waste management system within a project [94], it monetises metrics in the LCA of a project over its lifetime by discounting it to the current values [98]. Ref. [99] identified energy consumption, carbon footprint, and pollutant emissions, as well as other factors, leading to adverse environmental impact as the metrics in a project. Barriers to the application of LCC in projects stem from a lack of reliable life cycle cost input data, uncertainty associated with LCC assumptions, poor perceptions of LCC benefits by project owners, and an imperfect understanding of LCC methodology and application [95,100,101].

The additional information in this section allows us to enhance an earlier proposition:

- **Proposition C*p*16:** LCC may be implemented in conjunction with MFCA by the goldmining sector to facilitate:
  - ➢ principles of sustainable development;
  - ➢ economic, social, and environmental aspects of an investment project;
  - ➢ feasibility of environmental management strategies;
  - ➢ cost savings;
  - ➢ enhanced decision making.

In conjunction with MFCA and LCC, the goldmining industry may usefully embark on the use of activity-based costing (ABC), discussed next, to facilitate a greener industry.

2.4.3. Activity-Based Costing

Environmental issues have become the primary concern of corporate management, as production and consumption activities have been generating negative impacts on the environment through use, disposal, and production [102]. Environmental issues have become the focus of a pressing concern for humanity and a common emphasis has been on how to improve economic benefits without negatively impacting on the environment [103]. The concern of corporate managers over the environment also manifested owing to pressure from stakeholders on organisations to be environmentally responsible [102]. New green manufacturing technologies (GMTs) have been widely considered for entities to maintain a competitive advantage [104], coping with pressure groups [63] (supporting propositions C*p*2 and C*p*4), enhancing production skills [105] and solutions to these should be sought in ABC [102]. Ref. [51] confirms that ABC is an effective way of estimating production costs whilst considering environmental issues. ABC was developed to counter the traditional costing methods which had failed to accurately address the growing need of organisations to allocate overhead costs to products or services [33]. Consequently, various industries such as aviation, metal manufacturing, and construction have adopted ABC [106] due to its ability to calculate the various costs of labour and resources [107].

The way a mining projects are being costed should be reviewed, as a flawed costing system may inform an incorrect decision on a project, thereby leading to losses in the

long run [108]. Ref. [108] adds that making accurate costs are essential as they impact on the budget of an organisation. Organisations are constantly challenged in the rapidly changing environment to apply scarce resources effectively and efficiently to bring about an improvement in revenues and execution of strategies [109]. Organisations need inter-company cost accounting practices [110], as these enable them to assess costs based on a set of standards and, therefore, facilitate rational and objective decision making [111]. A detailed assessment at every level of the supply chain allows the equal distribution of costs and benefits along said supply chain, leading to an optimal configuration of the chain network [112]. ABC embodies cost accumulation that uses activities and cost drivers in assigning costs to products or services [96], and as a result assists manufacturing organisations in identifying production costs associated with each activity within the production process [33]. Ref. [113] and [114] suggest that the implementation of ABC in organisations has resulted in improved strategic decision making as it has granted a better understanding of how resources are used within organisations. Therefore, having a framework in place that provides accurate costing should assist decision makers in the goldmining sector.

ABC implementation requires skills, knowledge, and capital [115], which the mining sector ought to be able to source [33]. ABC holds several benefits when measuring environmental costs as, for example, they enable management to gain a better understanding of why costs do arise, enabling them to implement appropriate management approaches of managing costs such as activity-based management (ABM) [113,116]. Understanding cost behaviours and reasons why they occur may well assist management in the identification of areas needing improvement within the production flow [33]. The use of ABC assists in revealing where value is added and where it is being compromised within the organisation [33]. They argue that ABC allows for environmental analyses to be conducted after each stage of mining and would assist in the identification of stages with the largest impact on the environment, as well as the cost structure, which can be managed to facilitate more efficient and sustainable mining. Hence, having ABC within the framework may assist the goldmining sector to accurately measure environmental costs and identify activities where value is being added and being lost, leading to:

- **Proposition C*p*17:** ABC may be used in conjunction with the aforementioned accounting strategies to assist with product-related decision making for the goldmining sector, as it focuses on accurate cost assignment of overhead costs to products.

The following section considers how all the accounting strategies and methods mentioned above may be integrated to facilitate greener goldmining for a developing economy such as Zimbabwe.

2.5. Integration of Techniques and Methods

The literature identified MFCA, ABC, and LCC as important EMAPs. According to [117], EMAPs such as ABC and MFCA need to be employed by organisations, and will play a key role in trying to minimise the use of natural resources, waste, and emissions. The literature also identified the triple bottom line (TBL) as an essential principle to achieve sustainable development by simultaneous dealing with the economic, environmental, and social segments [118]. While there is a substantial body of literature on separate EMAPs, environmental management, and stakeholder influence, there is limited literature available on the relationships among these, and for the improvement of sustainable performance. Hence, there is a need for EMAPs to be linked and managed in a systematic manner [119]. The contribution made by this article is the development of an integrated conceptual framework for EMAPs in the goldmining industry.

Following the discussions throughout this article about the internal and external drivers of environmental management, the MEMA and PEMA aspects of EMA, and the EMAPs around MFCA, LCC, and ABC, we can establish an important association proposition:

- **Proposition A*p*3:** There is an association between accounting subject matter, EMA, and EMAPs such as LCC, ABC, and MFCA.

Organisations play an essential role in the promotion of green growth [120], and, therefore, ought to be aware of the role they play in sustaining its growth and ways of safeguarding natural resources, achievable through use of management accounting tools [117]. Ref. [121] observed organisations that employed integrated environmental accounting and reporting for the past 20 years were outperforming their competitors. It is, therefore, essential for management to develop and implement EMAPs, as it would facilitate the elicitation of hidden information [122].

Ref. [123] notes the importance of organisations using integrated management systems to increase their sustainability. Sustainability can be achieved through the amalgamation of economic, environmental, and social resources [124], and of the tangible or intangible qualities of the activities that organisations perform to achieve environmental conservation and social justice, together with a balanced economic performance [123]. Bearing in mind that manufacturers are always searching for opportunities to generate financial benefits by reducing costs, as well as the adverse environmental impacts, through material efficiency improvement [83], EMAPs which are strategically aligned to this purpose should be adopted [85]. Therefore, in a bid for a more integrated approach to corporate economic and environmental activities MFCA, LCC, and ABC were integrated into a framework (refer to Proposition C*p*18 below).

A combination of methods should be applied in order to measure environmental costs more accurately [87,125]. According to ref. [126], when, for example, ABC is used with LCC, it can improve productivity and efficiency, thereby leading to higher net margins. Therefore, when material flows are traced within organisations and allocated back to the cost centre responsible for environmental impact [33], it will improve environmental performance and ultimately profitability [87]. According to ref. [117], the contribution of an organisation's activities to green development and growth need to be established, as establishing a monetary value for sustainability will assist in the identification of polluting activities. For example, activity-based management (ABM) identifies activities which may not be adding value, and which can be reduced or eliminated [127]. Organisations are increasingly becoming interested in reducing the environmental footprint of their activities and products [128]. ABC can, for example, identify environmental cost drivers, which in the end allocate environmental costs to certain products, resulting in correct cost assignment to objects [117]. Therefore, adding ABC to the set of integrated tools should assist the goldmining sector in the identification of non-value adding activities, resulting in their elimination and cost saving.

The discussions in this section lead, respectively, to a content proposition and an association proposition:

- **Proposition C*p*18:** The goldmining industry in a developing economy with limited resources may benefit through the adoption and integration of various EMA strategies, notably MFCA, LCC, and ABC;
- **Proposition A*p*4a:** There is an association between aspects around social responsibility with respect to sustainability and the expected results of a goldmining company.

Proposition A*p*4a is later combined with proposition **A*p*4b** to define a comprehensive association, **Proposition A*p*4** (refer to Section 2.6).

Further, the earlier discussions on the environmental impact of goldmining on the environment, and how EMA and its associated tools of MFCA, LCC, and ABC may facilitate such impact, lead to:

- **Proposition A*p*5:** There is an association EMAPs with respect to the EMA tools MFCA, LCC, and ABC and environmental impacts of goldmining.

Ref. [129] accuses the accounting profession of not having played an essential role in the development and implementation of environmental cost management systems. Ref. [130] found UK accountants to have low levels of involvement in their organisations' environmental activities. This was the same in Australia, were ref. [129] found that environmental managers are more active participants in environmental management issues

than accountants. Research identified environmental costs to be important as shown by The World Resource Institute (WRI), which found environmental cost to be significant in nine US corporations [131]. Environmental costs were found to represent 19% of the total cost of manufacturing an agricultural pesticide in the Du Pont Plant studies, and 22% of the cost of refining at Amoco's Yorktown refinery [131,132]. Hence, the development of an integrated framework of EMAPs by the accounting profession will go a long way in the development and implementation of environmental management systems to assist the goldmining sector in becoming greener.

Ref. [133] provides that when an organisation establishes its environmental costing systems two (2) sets of decisions are to be made: the functional set of environmental cost categories that suit the organisation's operations, and strategic environmental emphases (minimum compliance, compliance, and compliance plus) that require the identification and overall scope of costing. In addition, its mode of implementation must be determined. The author states that LCC, cradle-to-grave costing, full costing, and ABC have been advocated as green costing-strategy alternatives that can be employed by an organisation. Ref. [134] states that a lack of a comprehensive framework on which to map existing EMAPs acts as an obstacle towards widespread use and adoption, as there would be no clear guidance on essential tools for business-decision contexts and actors to be involved. Therefore, an integrated framework would assist organisations wishing to introduce EMAPs for greening.

The above discussions lead to:

- **Proposition A*p6*:** There is an association between stakeholder pressure and environmental management (involving EMAPs) strategy adoption.

The above discussions provide and answer to RQ2, namely: How can the integration of EMAPs into a framework address the gaps identified?

2.6. Role of Government and Other Stakeholders in Sustainable Development

As we live in a connected world, sustainability concerns the global, long-term impact of our practices, relationships, and institutions [135]. Further, government and sustainable development are intricately aligned, in the sense that government is the key actor for initiatives surrounding sustainable development [136]. Sustainability, which should not be seen as the effort to maximise just a singular goal, has received attention owing to failing states, climate change, and depletion of natural resources [136], and requires an integrated and balanced response to ecological health, economic, and social issues [135]. Governments should, therefore, act as a catalyst for change [136] by taking on new roles that typically comprise a modern state [137]. Ref. [137] states that governments should work towards striking a balance between environmental protection and economic growth. This is due to the fact that a growing economy would allow the government to fulfil the needs of its citizens [136] and if this is not balanced with environmental protection it follows the citizens will not have a healthy and safe living environment as they would not have access to clean water and air or fertile soil [138]. Naturally, the demand for natural resources and infrastructure is a result of growing populations and economies [136], making it essential for governments to manage these efficiently [139] by ensuring that its executive branch of civil service is adequately competent, skilled, and capacitated to address sustainability issues [140], even though saving the environment with environmental resources being depleted should be the essential target of every organisation [117].

According to ref. [141], stakeholders view the adoption of sustainable practices as being proper and appropriate, and thereby giving legitimacy to the operations of an organisation. Organisations now seek ways to minimise their exposure to environmental risks and take a proactive approach to environmental management owing to increased environmental impact of their actions and increased attention [142]. Key stakeholders, for example, regulatory bodies, and media coverage on environmental issues have exerted pressure on organisations to improve their environmental management [61] (c.f. Proposition C*p*4). Furthermore, local communities can also exert pressures on organisations

through their vote in local and national elections via environmental activism and by filing citizen lawsuits [143]. Therefore, this calls for an organisation to take good care of relationships with the environment and stakeholders, besides the profit maximisation goal [144]. Ref. [145] argues for the need to understand when stakeholder pressures are effective in driving organisations to become more sustainable. Formal guidelines (such as laws, regulations, and constitutions), as well as informal guidelines (e.g., norms, values, and shared beliefs), have been observed to influence organisational social behaviours over time [145,146], thereby supporting earlier propositions on social responsibility (Proposition C*p*6) and legislation (Proposition A*p*4—below).

In line with stakeholder pressure and expectation, it is essential for the goldmining sector to proactively manage the environment to legitimate their practices, leading to:

- **Proposition A*p*4b:** There is a shared association between institutional forces, environment, and governance systems and rules and legislation of a country.

Combining propositions **A*p*4a** and **A*p*4b** gives:

- **Proposition A*p*4:** There is a shared association among:
  - ➢ Corporate governance systems and structures (social responsibility) with respect to
    - Rules;
    - Legislation.
  - ➢ Expected results of a goldmining company with respect to
    - Sustainability strategy.

The sections that follow present our research methodology coupled with the above literature review, leading up to the integrated conceptual EMAPs framework for promoting green goldmining in a developing economy, in this case, Zimbabwe.

The discussion in this section provides an answer to RQ3, namely: How can the government and other key stakeholders facilitate greener goldmining activities?

3. Materials and Methods

The research methodology depicted in this article follows the layers of Saunders et al.'s research onion [147] in Figure 4.

Following the onion from the outer layer, an interpretivist philosophy was adopted, which assumes that reality as we know it is construed intersubjectively through the meanings and understandings garnered from our social world [148]. Concepts and understandings from scholarly literature were interpreted, thereby following an interpretive philosophy. Moving to the second layer, an inductive research approach was chosen for this study, which started at specifics in the literature and moved towards the development of an integrated EMAP framework on the strength of three sets of propositions defined throughout. As a theoretical validation of the framework is undertaken in this article, our research approach was, therefore, deductive as well. The research strategy in the third layer was survey driven in the form of a comprehensive literature review in Section 2. This is in line with ref. [149], who stated that qualitative researchers normally take an inductive approach to the object of study, beginning with an immersion in the natural setting, and hence, reporting on findings observed, lead to the development of second order constructs. A qualitative research choice in layer four through the analysis of the available literature of scholarly work was followed for this study. Following the abridged literature review in the introduction and the subsequent comprehensive literature review, the researchers developed an integrated conceptual framework to address environmental challenges and promote greener goldmining. A conceptual framework according to ref. [150] is a framework which is the outcome of qualitative processes of theorisation. As indicated, the framework is based on three sets of qualitative propositions formulated from the literature.

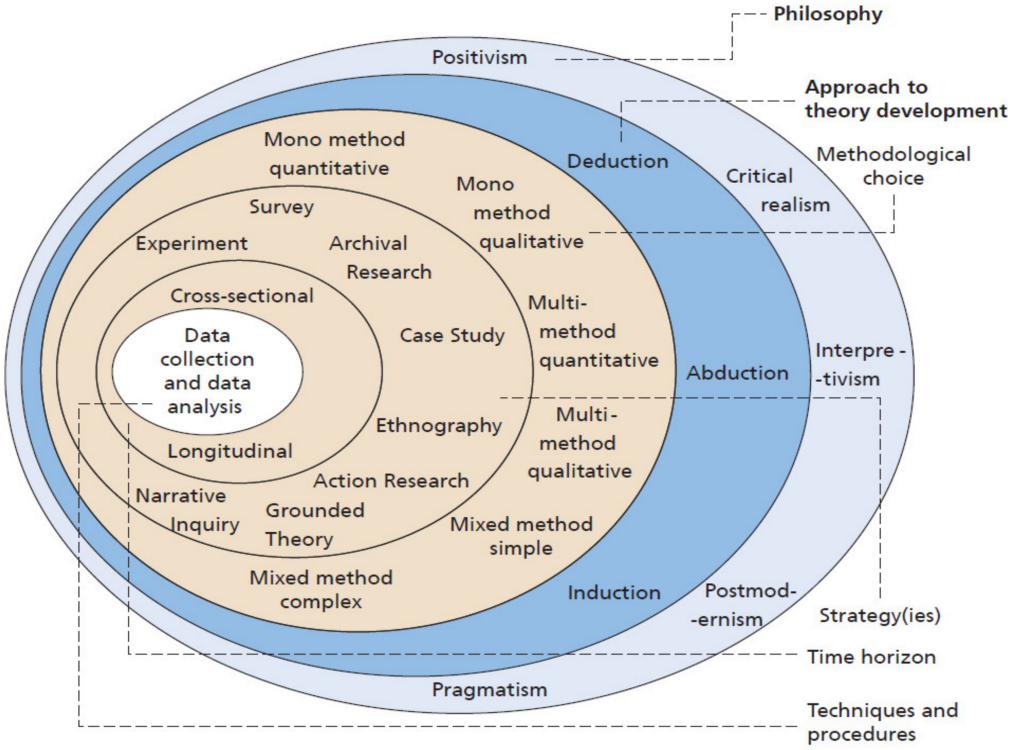

Figure 4. The research onion [147], p. 130, (The research onion diagram is ©2018 Mark Saunders, Philip Lewis, and Adrian Thornhill and is reproduced in this article with their written permission).

The study was cross-sectional at level five, and considered EMAPs at a given time, which is akin to a sequence of snapshots of scholarly articles at a given point in time. Looking at the inner (sixth) layer of the research onion, the data collection technique and analysis was through a comprehensive literature review, which was followed by a narrative analysis and integrated framework building.

Qualitative Propositions

As indicated in Section 1.1, three sets of qualitative propositions, namely, content propositions, associations, and general propositions were formulated on the strength of observations and findings in the literature. The framework depicted in Section 4 was developed from these propositions.

4. Results

Our conceptual framework, informed by the three sets of propositions and additional observations from the discussions, is presented in Table 1. It centres around the EMAPs discussed above to facilitate green goldmining in Zimbabwe in response to the research objective (RO).

A summary of the three sets of propositions is presented in Table 1.

The content of each entity (block) in the framework was derived from the content propositions. The links among the blocks depict the association propositions as indicated. Our framework is depicted in Figure 5.

Table 1. Summary of propositions.

Proposition Number	Proposition Description
	Content Propositions
Proposition C*p*1	Employees, who are internal to a mining environment, and the media, who are external stakeholders, may likewise exert pressure that motivate mining organisations to adopt strategies for greener goldmining.
Proposition C*p*2	NGOs and other essential pressure groups assist in the diffusion of ideas among mining organisations, thereby acting as motivators for them to adopt environmental management initiatives.
Proposition C*p*3	Government, together with other key stakeholders, may adopt legislation that may accelerate the rate at which organisations comply with environmental regulations.
Proposition C*p*4	Government, and other regulatory bodies with rich resources, could exert numerous forces on mining organisations to adopt greener initiative practices and avoid penalties that come with failing to comply (refer C*p*2).
Proposition C*p*5	Stakeholder engagement helps build lasting beneficial relationships, and stakeholder mapping and identification of their needs are an essential strategy for mining organisations.
Proposition C*p*6	Social order within the mining sector may essentially be based on a shared social reality. (Note that this may be a general proposition in other spheres of life.)
Proposition C*p*7	Goldmining activities have adverse effects on the natural environment, as they leave a strong footprint on the environment, arguably more than any other industrial activity.
Proposition C*p*8a	ISO standards play an essential role in the governance of environmental regulations with respect to goldmining and the development of EMAPs.
Proposition C*p*8	ISO standards play an essential role in the governance of environmental regulations and the development of EMAPs such as MFCA.
Proposition C*p*9	To be granted a social licence to operate (SLO), goldmining organisations should consider the societal needs of communities in which they operate.
Proposition C*p*10	Goldmining systems should have a management accounting system that determines wasteful activities and enhances cost optimisation.
Proposition C*p*11	EMA may hold much promise to be employed to manage the various challenges facing the goldmining sector.
Proposition C*p*12	EMA divisions of PEMA and MEMA, together with carbon management accounting (CMA) and greenhouse-gas accounting (GHGA), may provide essential information for the sustainable management of the challenges facing goldmining.
Proposition C*p*13	MFCA, as an EMAP, supports eco-efficiency decisions that enhance resource efficiency to improve the economic and environmental performance of a mining organisation.
Proposition C*p*14	MFCA assists in achieving resource and energy efficiency, as it facilitates speedy availability of waste information.
Proposition C*p*15a	MFCA can assist the goldmining organisations in working towards reduction in waste to enhance both the economic and environmental performance of the goldmining sector.
Proposition C*p*15	**Proposition C*p*15**: MFCA can assist goldmining organisations in economic and environmental performance through: ➢ reduction in waste; ➢ improved energy usage; ➢ improved decision making and accountability.

Table 1. *Cont.*

Proposition Number	Proposition Description
	Content Propositions
Proposition C*p*16a	LCC may be implemented in conjunction with MFCA by the goldmining sector in accordance with the principles of sustainable development, thereby considering the economic, social, and environmental aspects of an investment project.
Proposition C*p*16	**Proposition C*p*16**: LCC may be implemented in conjunction with MFCA by the goldmining sector to facilitate: ➢ principles of sustainable development; ➢ economic, social, and environmental aspects of an investment project; ➢ feasibility of environmental management strategies; ➢ cost savings; ➢ enhanced decision making.
PropositionC*p*17	ABC may be used in conjunction with the aforementioned accounting strategies to assist with product-related decision making for the goldmining sector, as it focuses on accurate cost assignment of overhead costs to products.
Proposition C*p*18	The goldmining industry in a developing economy with limited resources may benefit through the adoption and integration of various EMA strategies, notably MFCA, LCC, and ABC.
Association propositions	
Proposition A*p*1	There is an association needed between applying EMAPs and meeting the objectives and goals of a mining enterprise.
Proposition A*p*2	There is an association between meeting objectives/goals of a mining company and expected results with respect to cost savings and minimising environmental impacts.
Proposition A*p*3	There is an association between accounting subject matter, EMA, and EMAPs such as LCC, ABC, and MFCA
Proposition A*p*4a	There is an association between aspects around social responsibility with respect to sustainability and the expected results of a goldmining company.
Proposition A*p*4b	There is a shared association between institutional forces, environment, and governance systems and rules and legislation of a country.
Proposition A*p*4	There is a shared association among: ➢ Corporate governance systems and structures (social responsibility) with respect to ○ Rules; ○ Legislation. ➢ Expected results of a goldmining company with respect to ○ Sustainability strategy.
Proposition A*p*5:	There is an association between EMAPs with respect to the EMA tools MFCA, LCC, and ABC and environmental impacts of goldmining.
Proposition A*p*6	There is an association between stakeholder pressure and environmental management (involving EMAPs) strategy adoption.
General propositions	
Proposition G*p*1	Communication and engagement are essential among stakeholders to create common vision.

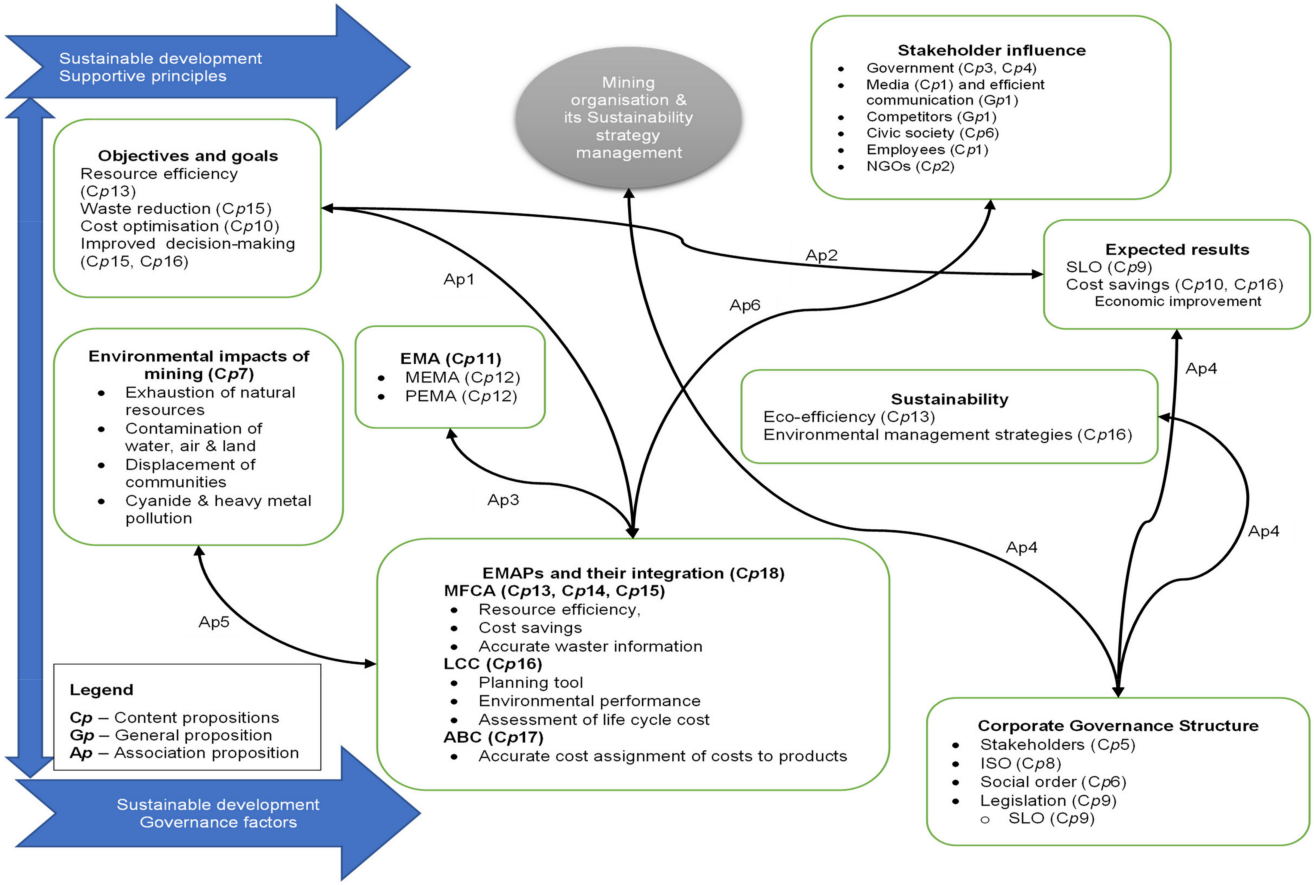

Figure 5. Conceptual framework (Synthesised by researchers).

5. Validation of the Framework

Our Figure 5 framework was synthesised through the application of the three sets of propositions. Content propositions indicating related aspects are placed in the same entity (block) in the framework. Different entity contents are labelled appropriately through the content propositions defined in the article. Associations identified are indicated through the links among the entities.

The framework recognises that EMA through the application of EMAPs play an essential role in the drive for an integrated approach in promoting greener goldmining as it generates both physical and monetary data through various accounting techniques such as MFCA, LCC, and ABC. Within the framework, MFCA has the objective of reducing or eliminating wastage, thereby supporting eco-efficiency within the goldmining sector. LCC has the objective of ensuring that profits generated over the life cycle of the mining project can cover the expenses incurred during all the life cycle phases, while ABC's objective is to estimate production costs whilst considering environmental issues, which can result in improved environmental management and an increase in profits through lower costs and the elimination of waste.

Stakeholder influence and various regulations are furthermore essential to achieving sustainable development. Environmental management is an essential component of this study and cannot be left to a few individuals; it should be the responsibility of all stakeholders.

In addition, governments are key initiators of sustainability development and should be seen to play an equally active role. Government regulations were identified as the key source of pressure for the goldmining organisations to consider the adoption of EMA. Pressure on organisations by stakeholders has been noted to have improved organisations' response to environmental management. The researchers postulate that if there is no guiding framework on EMA adoption and implementation, ecological degradation will

persist, as goldmining organisations will merely work towards compliance, and not play an active role in sustaining their surrounding environments.

Figure 5's framework, together with the above validation, meet the objective of this article, namely: Develop an integrated conceptual framework of EMAPs to promote greener goldmining in Zimbabwe.

6. Conclusions and Future Work

In this paper, we analysed challenges of the goldmining industry with reference to a developing economy such as Zimbabwe.

The literature revealed that, although the goldmining sector is a major driver of FDI, particularly for developing economies, it is also a major threat to environmental sustainability. Key environmental challenges noted include waste generation; water and air pollution; creation of unprotected pits; exploitation and depletion of natural resources; loss of fertile soils for farming; destruction of the ecosystems; and violation of human rights.

It was further noted that the drivers of environmental management can be grouped into internal forces (such as managerial level, leadership values, and organisational context) and external forces (such as regulation and competitive forces). Existing frameworks have been noted in lacking common ground that reconcile the major segments of sustainability development. We elucidated that an integrated conceptual framework to facilitate greener goldmining should, therefore, be developed within the context of EMA. Analyses of EMA revealed that this can be divided into two (2) aspects: Monetary environmental management accounting (MEMA) and Physical environmental management accounting (PEMA). EMA has been observed from the literature review to have come as a response to environmental challenges and is essential in fostering an integrated approach.

The discussion of EMAPs established that MFCA can be used in addressing material wastage and supporting eco-efficient decisions. LCC can be used in gauging the complete cost of waste management over the complete life cycle of a mining project. Further, ABC can be used in providing accurate environmental cost assignment to the mining sector, besides revealing where value is being added and where it is being lost. It was further noted that EMA plays an essential role in fostering an integrated approach of environmental management and carbon management accounting (CMA), greenhouse gas accounting (GHGA), MFCA, LCC, and ABC were identified as EMA variants and EMAPs.

We observed that sustainability could be improved using integrated management accounting systems that would integrate economic and social resources, supporting the view that the aforementioned methods should be combined to measure environmental costs more accurately. Whilst the adoption of EMA was noted to be voluntary and motivated by social structural inspirations and institutional theory in other countries, its adoption in Zimbabwe was observed to be a result of the need to comply to regulations and pressures from law enforcement agents [151].

Throughout the analyses we systematically developed three sets of propositions around content-, association-, and general propositions. These propositions were instrumental in the development of an integrated conceptual framework EMAPs framework aimed at promoting green goldmining for Zimbabwe as a developing economy.

Future research in this area could be pursued along several avenues. The Figure 5 framework is conceptual, and could be taken through the usual validation steps, thereby strengthening our deductive research approach (refer to Figure 4). Validations among stakeholders in the goldmining industry could be conducted in the form of interviews, focus groups, or case studies in one or more gold mines.

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