

**Corporate sustainability: paradoxical cognitive framing of mining sustainability
tensions and environmental outcome**

Student number: 26472369

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Abstract

Corporate sustainability (CS) has challenged the traditional approach to measuring business success and introduced a broader definition of success that encompasses integrated sustainability across social, environmental, and economic domains. However, this has not been without tensions, such as conflict between short-term profit generation and investment into long-term sustainability. The paradoxical cognitive frame has been proposed as a foundation for navigating these tensions fairly, without prioritising one element of sustainability over the other.

The majority of the literature focuses on Europe and North America and has taken a qualitative approach to analyse the nature of these tensions and the effect of a paradoxical cognitive frame on the relationship between perceived experience of sustainability tensions and sustainability outcomes. Furthermore, the antecedents of paradoxical cognitive framing, such as management roles and situational ability training, have received little research attention. As such, the current research study examined how paradoxical cognitive framing modulates the relationship between perceived experience of sustainability tensions (PEST) (efficiency versus resilience) and environmental sustainability outcome (ESO). It also investigated the influence of strategic role and training variation on paradoxical cognitive frame.

The study was a cross-sectional, quantitative study of a sample of 123 management team members, which included executives, middle, and senior management, within the South African mining industry. Structural equations and correlation analyses were applied to analyse the data. The study results diagnosed a negative relationship between PEST and ESO. The influence of paradoxical cognitive frame between the PEST and ESO was not detected and the influence of training variation on paradoxical cognitive frame was also not proven to exist. However, the study showed a partial influence of the senior management role on the paradoxical cognitive frame.

KEYWORDS :

Corporate sustainability, Paradox theory, Paradoxical cognitive frames, efficiency, resilience, South Africa, Mining, training, management teams.

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1. INTRODUCTION

1.1 Background of the study

Corporate sustainability (CS) has emerged as a vital aspect of modern business management. In the past, companies were mainly assessed on their ability to maximise shareholder value through profitability and growth (Lou et al., 2020). For instance, Friedman (1970) argued that the only role of the business that justifies its existence is to generate profit. Nonetheless, today, in an interconnected and environmentally constrained global economy, organisations are also judged on their contribution to environmental protection and social well-being (Wannangs & Gold, 2020). This shift has been captured in the Triple Bottom Line and value co-creation frameworks, which require businesses to balance economic, social, and environmental objectives (Freudenreich et al., 2020). As Wannags and Gold (2020) noted, a company's legitimacy increasingly depends on how effectively it integrates these three dimensions into its strategy and operations. However, embedding sustainability into corporate practice is complex. One of the main challenges is the rise of paradoxical tensions, where businesses face competing demands that cannot be resolved by simple prioritisation. For example, actions taken to increase short-term efficiency may compromise long-term environmental resilience, while measures to mitigate ecological impacts may increase operational costs (Bianchi & Testa, 2022). Tensions like these cannot be resolved through traditional approaches, such as trade-offs, but require a paradoxical cognitive framing (Ivory & Brooks, 2017). Rather than ignoring or eliminating the tension in favour of the other side of the pole, the paradoxical cognitive approach brings the tensions to salience, accepting their inherent conflicting nature of demands.

The mining industry in South Africa embodies this paradox perfectly. The gross domestic product (GPD) contribution that is attributable to mining is about 6% as recorded in 2023. Thereby generating R451 billion economic output (Energy Capital & Power, 2025). The industry is responsible for 25% of export earnings and provides employment to 450000 people, with millions more direct and indirect reliance on mining-related operations (Campbell, 2025). Independent Energy Agency (2024) noted that South Africa was one significant contributor to the emission of greenhouse gases. The agency further noted that of the 38% emitted by the country, the largest contribution was attributed to coal mining and energy generation. Globally, mining is resource-intensive and linked to serious environmental and social impacts such as greenhouse gas emissions, water pollution, and

community displacement (Bihkongnyuy Beri, 2023). Nonetheless, mining is a key driver of economic development, particularly in developing and emerging economies. The industry fuels economic growth through job creation and the provision of raw materials to support manufacturing. South Africa, like any emerging economy, is still highly dependent on coal despite the promise by the government to slowly transition to clean and greener energy sources (Ramluckun et al., 2024). This dual reality, which perpetuates the growth and compromises resilience, provides the mining sector with the right environment to consider the ways in which paradoxical cognitive framing can be leveraged to overcome these sustainability tensions by organisations.

1.2 Problem statement

In the modern global economy, companies are no longer judged solely on financial growth and profitability but are also evaluated based on their ability to incorporate the social, environmental, and economic aspects of sustainability, collectively known as CS (Wannags & Gold, 2020). Although some researchers, including Lee and Kwon (2019), believe that integrating sustainability into the corporate strategy would improve the reputation and profitability in the long term, it is bound to create tensions. The existence of these tensions is due to the necessity to meet competing priorities between the three pillars of sustainability: economic, environmental, and social, without giving priority to one of the dimensions over the others (Carmine & De Marchi, 2022). Although these issues have been acknowledged, a significant portion of the current literature has dealt with them in a trade-off fashion, viewing tensions as dilemmas that can be overcome by prioritising one objective over another. This methodology is, however, prone to simplifying the long-standing and mutually sustaining tone of sustainability tensions (Lou et al., 2020). Paradox theory, in turn, suggests a different framing, one that is more tolerant and accommodating of conflicting demands at the same time, and more subtle in its foundation of making a decision (Bianchi & Testa, 2022). However, the empirical studies examining the personal and organisational conditions that facilitate paradoxical framing are sparse, which has caused a major gap in theoretical understanding (Carmine & De Marchi, 2023). Additionally, a significant part of the literature fails to mention the influence of cultural, institutional, and regional contexts on how organisations make sense of and respond to sustainability paradoxes.

The South African mining industry is an epitome of the dilemma. It has a positive impact on growth and employment creation, but it is very sensitive to non-renewable energy

(Igogo et al., 2021). Meanwhile, South Africa opted to reduce greenhouse gas emissions as part of the world climate commitments (Weldegiorgis, 2023). There is a need to provide structures that can help businesses navigate paradoxical sustainability-related challenges by making sustainability a strategic aspect. Companies that do so not only gain reputational legitimacy, but profitability and sustainability as well (Zou et al., 2025). This paper, therefore, aims to fill the gap identified through empirical research on the role of cognitive framing paradox in shaping environmental sustainability tensions and environmental performance in the South African mining sector.

1.3 Theoretical need

The theoretical contribution of this study is in the development of a theory of paradox to the field of CS research. Traditional models like the win-win model or the business case approach are still dominant but not sufficient. While the win-win logic assumes convergence between economic, social, and environmental objectives, it fails to appreciate the contradictory tensions inherent in the dominant CS discourse (Lou et al., 2020). Similarly, the business case perspective privileges economic returns, treating sustainability as valuable only when it enhances profitability (Carmine & De Marchi, 2022). These perspectives oversimplify the complexity of CS, offering little guidance in contexts where tensions are unavoidable. Paradox theory provides a more nuanced framework by recognising tensions as contradictory yet interdependent (Lewis & Smith, 2022). It emphasises paradoxical cognitive framing, which enables organisations to interpret and respond to opposing demands without eliminating one pole of the tension. While existing research has illustrated this theoretically, empirical studies remain limited and geographically narrow. Carmine and De Marchi (2022) demonstrated the moderating effect of paradoxical framing but only within Italian firms. There is limited evidence on how this operates in resource-intensive industries or in emerging economies. By focusing on the South African mining sector, this study extends paradox theory across contexts, using quantitative methods to validate its applicability in a high-stakes environment.

1.4 Business need

The business significance of this study is rooted in the strategic importance of mining to South Africa's economy and its vulnerability to sustainability tensions. Mining contributes 7.5% of the country's GDP, provides substantial employment opportunities, and secures export revenue (Invest SA, n.d.). However, the sector is heavily dependent on coal and

other non-renewable resources, creating a contradiction between economic reliance and environmental responsibility (Igogo et al., 2021). At the same time, South Africa faces global and domestic pressures to reduce carbon emissions and align with climate commitments (Weldegiorgis, 2023). This paradox poses a threat and an opportunity to businesses. Companies that take a defensive stance on sustainability, that is., acting solely to meet the sustainability requirements, may be subject to a damaged reputation or penalties by regulators, or lose competitiveness. In contrast, companies employing paradoxical cognitive framing will be able to transform sustainability into their strategic value and create an efficient and resilient balance between short-term performance and long-term survival (Zou et al., 2025). Such framing not only underpins the environmental outcomes but also leads to innovation, trust by the stakeholders, and positive financial performance in the long run. In this regard, the research provides practical advice to mining executives and management to enable them to navigate sustainability tensions. Finally, it shows that sustainability is not a compliance cost but rather a source of resilience and competitive advantage.

1.5 Aim and objectives

1.5.1 Aim

This study aims to examine how executive leaders and management (top management team) in the South African mining industry perceive sustainability tensions between efficiency (cost and production) and resilience (environmental protection and long-term resource stewardship), with a focus on environmental sustainability over time. It also aims to determine whether paradoxical cognitive framing, TMT functions, and sustainability training moderate the effects of these perceived tensions.

1.5.2 Objectives

To attain this purpose, this study attempts to fulfil the objectives as follows:

1. To investigate the relationship between the perceived experience of sustainability tensions, specifically efficiency versus resilience and environmental sustainability outcomes in the South African mining sector.
2. To assess the moderating effect of paradoxical cognitive framing on the relationship between perceived experience of sustainability tensions and environmental sustainability outcomes.
3. In organisational contexts:

- a) To assess the influence of the strategic role (executive committee members, senior management and middle management) on cognitive framing.
- b) To examine the impact of sustainability training exposure, including informal or formal training, on paradoxical cognitive framing.
- c) To assess the interaction between the effect of strategic managerial role and sustainability training on paradoxical cognitive framing.

1.6 Significance

This study has conceptual and practical importance, particularly in the mining industry, where the pressure of sustainability is alarmingly high. In theory, it considers the moderation of the interrelation of perceived experienced environmental outcomes and sustainability tensions by paradoxical framing. Although past research suggests that a positive effect of paradoxical framing can lead to positive outcomes (Carmine & De Marchi, 2022; Wu et al., 2024), there is scant research on whether the same dynamic can be relevant to some of the most resource-intensive industries. This innovative work fills a vital gap in the literature, which should contribute to the sustainability transition in extractive industries by applying a rigorous measurement procedure in settings where sustainability issues are most pressing.

The conflicting demands of sustainability transition, the necessity to extract environmental resources needed to sustain the development of green technologies and reduce the environmental impact, are issues that more and more scholars focus on (Boafo & Arthur-Holmes, 2025). The example is mining, which is economically central and ecologically important to South Africa, therefore illustrating this dilemma. Unlawful mining activities, as witnessed in Zama-Zama, represent extreme threats to the environment (Madonsela et al., 2025). The lessons gained due to this exploration can thus be used by companies and regulators to take more subtle readings of the angina of sustainability.

The findings can have managerial and political applications, whereby leadership training can be encouraged to inculcate paradoxical attitudes and aid a policy framework that promotes two efficiencies and not binary trade-offs. Furthermore, by linking the study to the changing nature of institutional environments, including those in South Africa in terms of resources (South African Government, 2025), climate-related risks, and financial risks (United Nations Environmental Programme Finance Initiative, 2024), the study provides a timely and practical contribution.

1.7 Structure

The dissertation is structured into six chapters that logically progress from theory to findings, providing a clear and coherent narrative throughout. Chapter one presents the research problem, background, and rationale, and it discusses the aims, objectives, scope, significance, and structure. Chapter two provides a critical literature review of the concept of sustainability contradictions, the cognitive frame, and environmental performance. Chapter three presents the hypotheses, and conceptual framing. Chapter four elaborates the approach, which includes design, sampling, collection, validity, reliability, and ethics. Chapter five presents the findings in terms of statistical analyses, including regression and analysis of variance (ANOVA). Chapter six focuses on the discussion of the results in connection with the literature and Chapter seven outlines the theoretical and practical implications, limitations, and future research directions.

2. LITERATURE REVIEW

2.1 Introduction to the literature review

This literature review aims to critically analyse the academic discussions, theories, and empirical research that connect to the concept of corporate sustainability (CS) and the paradoxes it poses in organisational practice. A literature review is the foundation of scholarly inquiry, which synthesises available knowledge, identifies uncertainties, and includes gaps that support the need to conduct additional research (Saunders & Lewis, 2018). In this study, the review is central because it sets the context in which the paradoxical cognitive framing would assist the South African mining industry in solving the sustainability tensions.

The research problem reveals that although CS is viewed as a strategic approach, its implementation often leads to conflicts between economic, social, and environmental objectives (Sasse-Werhahn, Bachmann, & Habisch, 2020). As discussed in Chapter one, past literature tends to treat these tensions as trade-offs without considering the paradox theory as a more holistic perspective. Consequently, to develop the theory and practice of paradoxical framing, it is necessary to investigate how paradoxical framing can help reinvent sustainability decision-making, particularly in the mining industry, where tensions are intense. This chapter is divided into four sections. The first section presents the theoretical underpinnings of the paradox theory. The second section discusses CS and the strains it entails. The third section examines the context of the mining industry, with particular reference to South Africa. The final section, concludes with a summary of the critical literature gaps and an explanation of how the reviewed research relates to the research hypotheses presented in Chapter three.

2.2 Theoretical foundations: paradox theory

A paradox theory provides an effective way of defining complex organisational behaviour, particularly when companies have conflicting or competing demands that are interdependent (Cunha & Putnam, 2017b). It recognises that contradictions do not have to be eliminated but may exist in each other, and need to be managed continuously as opposed to being resolved, as is the case with traditional linear problem-solving models (Carmine & Smith, 2024). The theory is based on three pillars: contradictions, interdependence, and persistence (Lewis & Smith, 2022). Contradictions reflect the forces that are antagonistic to each other, including the motivation to achieve efficiency in short-

term goals and long-term endurance (Waldman et al., 2019). Interdependence demonstrates how the choice that benefits one goal cannot help but influence the other, whereas persistence makes us aware that these conflicts are not only persistent but also recurrent. Such a theoretical premise is the core of Research Objective 1, which aims to investigate the relationship between perceived experience of sustainability tensions, specifically efficiency versus resilience and environmental sustainability outcomes in the South African mining industry, where economic pressures and sustainability ambitions often conflict with each other.

Some empirical research indicates that paradoxical reasoning enhances flexibility and creativity (Le & Phi, 2020). Liu et al. (2019) found that paradoxical leadership helps employees overcome conflicting expectations, thereby enhancing creativity and problem-solving. Similarly, Ingram (2024) demonstrated that paradoxical strategies in dynamic industries enable organisations to adopt both exploration and exploitation strategies, thereby enhancing resilience; however, excessive paradox thinking can inhibit organisational resilience. Sibanda & Mkumatela (2025) found that companies that integrate green logistics in their operational model benefit from enhanced operational efficiencies and build market competitiveness. These results confirm Research Objective 2, which aims to test the correlation between sustainability tensions and environmental sustainability outcomes through the paradoxical cognitive framing. Seidemann (2024) cautioned, however, that paradox theory is excessively idealistic; real-world considerations, such as the fluidity or scarcity of resources, policy constraints, and power imbalances, tend to force companies to focus on one half of the paradox (Waldman et al., 2019).

Applying to the issue of CS, the paradox theory does not involve the common trade-offs and win-win approaches (Lewis & Smith, 2022). The trade-off paradigm considers economic, social, and environmental objectives to be mutually exclusive, which makes it possible to justify environmental degradation in the name of economic benefits (Carmine & De Marchi, 2022). As an illustration, South African mining accounts for approximately 7.1% of the national GDP, employing more than 457,698 individuals, but it also generates 38% of all carbon emissions in the country (Leshoele & Gumede, 2021). By comparison, the win-win model presupposes that sustainability efforts have the potential to yield both financial and environmental benefits, such as the economic benefits of energy savings

(Goldsmith et al., 2022). This is too optimistic, according to critics such as Cox (2019), and overlooks existing tensions.

South African mining companies experience these contradictions in an attempt to harmonise profitability and environmental responsibility (Fraser, 2021). Research Objective 3 thus investigates how strategic roles particularly top management team level (managerial and executive roles) and sustainability training affect paradoxical framing, based on this theory, by examining how leadership exposure and education enhance the capacity to integrate conflicting sustainability objectives.

The paradox theory is situated between these extremes. It recognises that the tensions of sustainability are unavoidable and long-term in nature, but proposes that such tensions can be addressed using acceptance and integration approaches (Waldman et al., 2019). The framework is more subtle: conflict is not denied, although interdependence is leveraged to find creative solutions (Bianchi & Testa, 2022). One major criticism, is that the paradox theory is largely conceptual. There is a paucity of empirical data, particularly in quantitative research beyond Europe and North America (Cunha & Putnam, 2017). Thus, although paradox theory broadens scholarly discussion beyond reductionist perspectives, it remains to be proven in various industries and cultural settings.

One main process in the paradox theory is cognitive framing, which involves taking in or perceiving the paradoxical tensions and the way individuals and organisations respond to them (Lewis & Smith, 2022). Paradoxical framing consists of accepting contradictions, justification of the co-existence of contradictions, and sense-making processes with which players are able to work constructively with conflicting demands (Shu, 2021). For instance, management with paradoxical training can view sustainability trade-offs as opportunities rather than problems to be resolved, and create innovative solutions that balance efficiency and resilience (Fahimnia et al., 2025). However, critics like Leung et al. (2018) found that the constructive framing of paradox is both cognitively and emotionally challenging and may result in defensive responses, such as denial, suppression, or compartmentalisation. Furthermore, the adoption of paradoxical frames by an individual can be subject to contextual influences such as organisational culture, institutional support, and leadership style (Ivory & Brooks, 2017).

2.3 Corporate sustainability (CS) and tensions

The concept of CS has emerged as a prevailing paradigm of business research and business practice, focusing on embedding the economic, social, and environmental goals into the organisational strategy (Pazienza et al., 2022). The discourse on sustainability has predominantly advocated for business models such as triple bottom line and value co-creation (Freudenreich et al., 2020) and challenged the historical institutional logic by Friedman on profit being the main role of business (Friedman, 1970).

Fundamentally, CS aims to achieve a balance between profit generation and societal or environmental obligations, going beyond compliance to adopt long-term resilience and legitimate stakeholder interests. Frameworks like the triple bottom line and the Sustainable Development Goals (SDGs) have offered conceptual anchors in the discourse of organisations (Wannagags & Gold, 2020). However, researchers suggested that these models promote an idealised image of how organisations should operate in terms of sustainability, which does not accurately reflect the reality of the contradictions that organisations experience (Aalborg Universitet & Hoffmann, 2018)

Recent research suggests that CS is not a smooth convergence of objectives, but rather a research area of contradictions and complexities. Over the years, the academic discourse on sustainability has developed extensively. Kitsios et al. (2020) argued that there is still a gap in the practical implementation of CS strategies due to limited existing operational guidelines that integrate decision-making, strategy management and CS.

Another aspect of sustainability is the inherent tensions between goals and commitments. As Nogueira (2019) noted, tension arises when conflicting economic, social, and environmental goals coexist. For example, the company may invest in cleaner technologies, which will increase short-term expenses; this is contrary to shareholders' expectations of generating profits, and social initiatives may compromise operational performance (Freudenreich et al., n.d.). These tensions are part of sustainability as structural characteristics and require a constant negotiation of conflicting priorities (Oyetoro, 2024). Research Objective 1 addresses the issue of the perceived experience of sustainability tensions' impact on the environmental performance of South African mining companies.

The efficiency and resilience tension is one of sustainability tensions in mining CS. Efficiency is aimed at minimising costs and maximising resource utilisation (Haffar & Searcy, 2015), and resilience focuses on adaptive ability and sustainable stability (Mao et al., 2023). Empirical data revealed that excessively efficiency-driven companies are more exposed to environmental and market shocks, whilst companies that balance efficiency and resilience perform better in terms of sustainability (Van Staveren, 2023).

The mining industry in South Africa accounts for 7.1% of GDP and 15 % of the national carbon emission (Leshoele & Gumede, 2021; Khan et al., 2021), as presented in Figure 1, the year-on-year change of carbon emission. Sibande et al. (2024) found that small and medium enterprises (SMEs) that opted for green logistics solutions not only realised environmental mitigatory benefits, such as waste reduction, but also enhanced energy efficiency. These contradictions highlight the ironic equilibrium that is at the core of Research Objective 2 on cognitive framing.

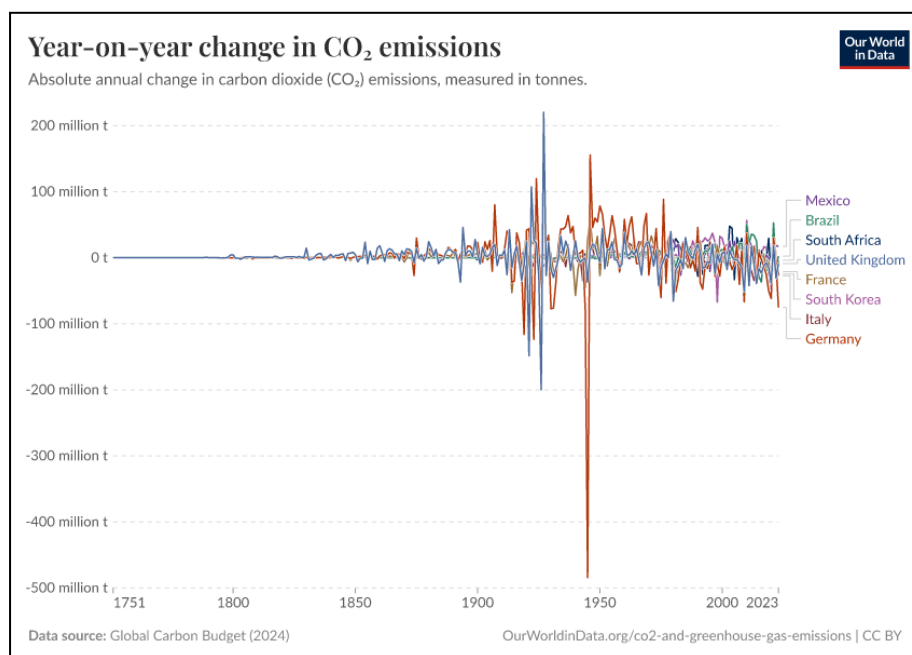


Figure 1: South Africa: Year-on-year change CO₂ emissions (Ritchie & Roser, 2020)

Old methods of dealing with these tensions either apply a trade-off logic or a win-win logic. The trade-off perspective is that conflicts can only be resolved by sacrificing one ambition in favour of the other, with economic ambitions often taking precedence (Haffar & Searcy, 2015). Rezaee (2021) indicated that this strengthens a parochial shareholder-focused concept of sustainability that compromises change at the system level. For instance, if mining companies

prioritise cost efficiency over environmental stewardship, they may gain in the short term but exacerbate long-term ecological harm (Susanna, 2025).

In contrast, the win-win perspective assumes that economic and sustainability objectives are compatible, such that investments in sustainability are inherently expected to produce business benefits (Ariztia & Araneda, 2022). Empirical research provides examples of energy efficiency reducing costs or social investment increasing broad access to financing for growth projects (Irianto et al., 2025). However, critics noted that such synergies are context-specific and not generalised in situations where no integrative solutions are found (Dunlop, 2019). In reality, a good deal of sustainability dilemmas prove to be win-lose situations, which are inconsistent with the positive assumptions of the win-win model (Martinez et al., 2019).

Paradoxical approaches attempt to live within the boundaries of troubling situations as normal and unresolved, rather than as anomalies to be eliminated (Hameiri et al., 2017). Instead of solving the contradictions through trade-offs or assuming that synergy exists, paradox theory encourages organisations to live with and dynamically work through tensions. It has been demonstrated that paradox management during crises can be embraced to drive innovation in ways that compel management to find alternative solutions that combine conflicting demands (Tabesh & Vera, 2020). In fact, some companies that understand the conflict between efficiency and resilience might invest in flexible technologies that enhance cost performance and adaptability. However, critics cautioned that paradoxical methods are cognitively challenging and may paralyse decision-makers. In the absence of adequate institutional support, paradox management can be unclear or paralysing (Fairhurst, 2018).

The key to addressing sustainability tensions is effective leadership. It has been demonstrated that leaders who accept paradoxical reasoning can convert contradictions into positive frames, justifying all the side of a tensions and encouraging stakeholder participation in decision-making processed. (Sajjad et al., 2023). For example, sustainability-oriented CEOs can influence organisational culture in a way that fosters long-term resilience and ensures efficiency (Bao et al., 2022). However, leadership does not work everywhere. Institutional logics that support financial performance in lieu of commitment to sustainability may undermine commitment and lead to symbolic actions (Wu et al., 2023).

Training and capacity building also play a role in organisations' response to sustainability tensions. Structured sustainability training provides management with the tools to detect and understand paradoxes and respond more positively to them (Siqueira, 2023). Furthermore, the effectiveness of training is relative to the organisational context. Even trained management

may not have the autonomy to employ paradoxical approaches, especially in hierarchical cultures or situations with limited resources (Berti & Simpson, 2021).

2.4 Mining industry context

The mining industry is in a kind of paradox in the world economy. On the one hand, it provides raw materials that form the basis of the modern infrastructure, energy and technological developments. On the other hand, it is among the worst-affected industries on the environment, causing depletion of resources, pollution, and socio-economic distortion (Amir Nurmagomedov, 2025). With the world becoming more sustainable through the adoption of global sustainability agendas like the Paris Agreement and SDGs, the mining industry is under more scrutiny to ensure that its economic benefits are balanced with its adverse externalities (Buckup, 2025). This contradiction is connected with the Research Objective 1, which examines the effects of sustainability tensions, such as the trade-off between environmental responsibility and economic performance, on the environmental outcomes in the mining industry.

In addition, mining companies are faced with pressure in all three dimensions of sustainability globally being social, environment and economic dimensions. Mining has been found to be the top emitter of greenhouse gases, contributor to water pollutants, and destroyer of biodiversity (Famiyeh et al., 2021). In spite of increasing decarbonisation pledges, the use of coal and other non-renewables is still deeply rooted, particularly in the emerging economies (Hu et al., 2021). According to Laing & Pinto (2023), mining is also critical to the low-carbon transition, since renewable technologies require minerals such as cobalt, lithium, and rare-earth elements. Critics expressed concern that this twofold aspect may allow firms to recast extractive mining as green mining that may rationalise unsustainable mining in the name of climate necessity (Sovacool et al., 2019).

Mining is at the heart of national and regional economic development, supplying jobs, tax revenue, and exports. In South Africa, the industry contributes approximately 7.5 % of the GDP, and it is among the largest employers in the country (O'Neill, 2024). Proponents cited the fact that mining has helped to alleviate poverty and develop infrastructure, and that sustainability efforts can be financed by growth through mining (Beri, 2023). However, facts revealed that mining-driven development is usually more likely to increase inequality and expose economies to fluctuating commodity prices (Carvalho, 2017). The resource curse theory proposes that when nations depend heavily on mining income, it can delay long-standing economic diversification and trap nations in cycles of boom and bust (Harvey et al.,

2025). Coal reliance in South Africa not only stabilises the economy, but also prevents the movement towards carbon reduction.

Furthermore, mining has its advantages and disadvantages on a social level. It creates employment, supports community initiatives, however, people are displaced, health is damaged, and disputes over land and resources is incited (Mancini & Sala, 2018). The legacy of inequality and exploitation of the apartheid regime in South Africa also complicates the social contract of mining. Although corporate social responsibility (CSR) programmes focus on counterbalancing these evils, critics believed that they are not always transformative but are usually symbolic (Brueckner et al., 2021).

Moreover, there is the sustainability paradox in the mining sector, which is depicted by specific tensions. One of the main contradictions is the exploitation of resources and the commitment to the climate. Liu & Song (2024) identified that South Africa is one of the largest coal consumers of globally, along with the United States of America and consumes coal in power generation. The government has promised a Just Energy Transition, but there is still strong political and economic pressure to maintain coal production (Ntumba, 2022). The leaders of the industry have said that a rapid elimination of coal may lead to an economic collapse and loss of employment (Beri, 2023). Conversely, postponing decarbonisation negatively affects the reputation of the entire South African nation and increases the risk of climate change (Biber et al., 2017). Such tension demonstrated the lack of connection between the short-term economic needs and the long-term environmental objectives (Parfait, 2023).

As investigated by Bora (2024), the other conflict is between efficiency and resilience. There is a pressure of constantly increased efficiency by mining companies, and this is particularly observed when the company is facing fluctuating prices of the commodities it deals with and pressure on investors (Hosseinzadeh et al., 2017). However, in the process, it tends to waste resources and decrease flexibility. Ultra-efficient systems can be ill-equipped to react to disruptions in climate, highlighting the trade-off between short-term profitability and long-term resilience. Supporters like Jasiūnas et al. (2021) said resilience measures, such as hoarding of supplies or investing in renewable-energy systems, cushioned the long-term outlook of the industry. Critics claimed that such strategies increase expenses, create the possibility of losing investors, and increase the tension between corporate and social demands (Bhardwaj et al., 2018).

According to Mnwana & Bowman (2021), South Africa provided some vivid reflections of paradoxical mining tensions. The country's reliance on mining revealed the conflict between

economic stability and social responsibility. Companies have to balance between automation to reduce the cost and the necessity to retain employment in a country with a high rate of unemployment. These paradoxes are further developed by institutional and cultural influences. Although the European setting has adopted the paradox theory, the socio-political environment of South Africa, which is characterised by inequality, poor governance, and unpredictable regulations, complicate the process of dealing with sustainability contradictions further (Herrfahrdt-Pähle et al., 2020).

2.5 Perceived experience of sustainability tensions and environmental sustainability outcomes

Sustainability tensions in the mining sector are multifaceted and difficult to resolve, as they are associated with the mutual pursuit of economic, social, and environmental goals, which are typically conflicting. The tensions are not incidental but rather structural, indicating underlying contradictions in CS. In the mining industry, Audi & Yu (2024) cited that firms are pressured to maximise efficiency, profitability, and shareholder expectations and reduce environmental effects, safeguard community wellbeing, and implement long-term resource management. According to Berti & Cunha (2022), these conflicting priorities led to paradoxical scenarios whereby any activity that favours one motivator can ultimately undermine another, forcing management and organisations to play at the crossroads of trade-offs and ambiguities. The definition of sustainability tensions, in this case, entails acknowledging the continuous, interconnected, and even conflicting requirements placed on mining companies as they endeavour to reconcile economic growth, ecological conservation, and social accountability. This part directly responds to Research Objective 1, which aims to investigate the relationship between perceived sustainability tensions (efficiency vs. resilience) and environmental sustainability outcomes in the South African mining sector. It investigates the mediation of environmental performance through management's experiential perceptions of these tensions, which conceptualises why the unresolved efficiency-resilience conflicts promise to misuse the concept of sustainability. Resilience emphasises an organisation's or system's capacity to reorganise, survive, and sustain its function amid crises, placing a predominant reliance on buffers, boundary institutions, and diversity in governance (Van Staveren, 2023). However, this study focused on buffer level as a precondition for resilience, the slack capacity available for the organisation to absorb any adverse effects of a shock. Academic literature in the mining environmental sustainability has explored the concept of resilience from the lens of ecological systems, climate change risk, and supply chain (Akbari-kasgari et al., 2022) amongst others, arguing that mining activities pose a pronounced threat to the resilience of ecological systems (Xiao et al., 2019).

One of the critical dimensions of grasping sustainability tensions is the correlation between efficiency and resilience. Efficiency, as pointed out by Saviom (2024), focuses on efficient operation, minimisation of costs, and utilising resources optimally, which align with short-term economic goals closely. Zhai & Lee (2024) added that resilience includes adaptive capacity, redundancy, and readiness to respond to long-term disruptions, such as climate change, regulatory change, or community conflict, alongside other forms of resilience. Practically, the two imperatives are at odds. As an illustration, Smith et al. (2022) pointed out that a mining company can apply highly efficient extraction techniques to lower the costs and produce more output, yet this approach can lead to the loss of the system to accommodate shocks, including unexpected environmental events, labour conflicts, or changing prices of commodities. Similarly, Wu et al. (2025) hypothesised that resilience investments (such as environmental buffer maintenance or energy source diversification) can increase operational expenses and decrease short-term profitability. This trade-off between efficiency and resilience is thus one of the primary contributors to environmental sustainability performance, as well as how organisations allocate resources, react to disruptions, and strategise to achieve long-term sustainability.

Sustainability tensions have serious effects on mining environmental outcomes. Singh et al. (2024) highlighted that mining activities are inherently landscape-disturbing, greenhouse gas-emitting, and biodiversity-impacting, and they tend to aggravate environmental degradation in the name of economic goals. Most organisations are found to have been induced to focus more on efficiency, but in this regard, short-term gains have the potential to increase ecological damage, yet resilience-oriented strategies may mitigate adverse environmental effects and enhance sustainability performance over the long term (Fraser, 2021). According to Bassetti et al., (2020), mining enterprises that recognise the tensions between efficiency and resilience and proactively address them through environmental planning, adaptive technologies, and engagement with the stakeholders demonstrate better environmental performance in the long run than those that neglect such contradictions. However, these results are contextual, meaning they are affected by regulatory frameworks, resource availability, and socio-political pressures, indicating that environmental sustainability is not the sole dependent of organisational intent, but it is also shaped by external circumstances (López-Arceiz et al., 2020).

According to Appolloni et al. (2022), sustainability tensions in resource industries were reported, meaning that these issues are common and enduring across settings. In industries like oil and gas, forestry, and mining, Okeke (2024) argued that organisations fail to strike a

balance between profitability and environmental responsibility, and, in many cases, tension is reflected in trade-offs between operational efficiency, social equity, and ecological stewardship. Some organisations seek win-win solutions, yet many paradoxes still exist, which necessitate constant negotiation and adaptation strategies.

These results highlight the importance of incorporating paradoxical cognitive framing into sustainability management. The traditional method of focusing on efficiency or resilience is inadequate in managing the complexity of the environmental sustainability outcomes of resource-intensive industries. The subject of efficiencies in coal mining has been explored over the years; however, the interplay between efficiency and resilience remains sparse, particularly when dealing with aspects of climate change and other macro-environmental factors (Sinaga et al., 2024). This supports the necessity for research to advance resilience and efficiency as two connected and interrelated tensions that are at play through the lens of the paradox theory. Additionally, scholars have predominantly investigated the term tension from a generic term, such as economic versus social domain or environmental versus economic (Miron-Spektor et al., 2022). Research that considers the specific details of tensions (resilience versus efficiency) and their salience is required to bring diversity of thought in the discourse of CS tensions and cognitive framing.

2.6 The role of paradoxical cognitive framing in sustainability tensions

The concept of paradoxical cognitive framing is based on the paradox theory, which focuses on how individuals and organisations understand, interpret, and act upon inherently incompatible demands (Carmin & Marchi, 2022). As Fayezi (2022) emphasised, it consists of acknowledging that tensions are not exceptions that can be resolved, but interdependent contradictions that must be managed dynamically. Gesiot et al. (2025) found that paradoxical framing involves acknowledging the coexistence of conflicting goals, rationalising their existence, and integrating sense-making mechanisms that enable their constructive engagement rather than evasion or simplification. This mental approach offers a mental toolkit that management can use to reformulate dilemmas as openings to innovation and strategic adaptation rather than as problems with single-best-answer solutions.

In the framework of sustainability, Edwards (2021) assumed that paradoxical thinking becomes especially pertinent, with organisations commonly experiencing the tension between economic growth, environmental preservation, and social responsibility. Traditional solutions, including trade-off logic or win-win strategies, are often unable to reflect the persistence and interdependence of these tensions (Rietdijk et al., 2024). Paradoxical thinking, on the contrary,

invites management to see these conflicts as both, rather than as either. For example, a mining company can concurrently seek efficiency and resilience through investing in flexible technologies that can improve operational performance and minimise environmental impact. Correspondingly, Wang & Zheng (2024) found that trade-offs associated with sustainability, such as resource extraction versus ecological preservation, can be redesigned as a chance to create innovative practices that meet various goals in the long term. This mental shift allows organisations to transcend short-term problem-solving and develop a long-term adaptability and value-creating capacity.

Cognitive framing plays a vital role in organisational decision-making as it determines how leaders view risks, analyse choices, and rank conflicting demands. According to Cihan (2025), management whose cognitive framing skills are strong in paradoxical framing tend to identify interdependency and predict the impact of their decisions across various areas. This consciousness enables more complex and adaptable strategies that are responsive to the complexity and uncertainty of sustainability settings. As an example, Annesi et al. (2024) reported that a paradoxically minded CEO can integrate both environmental considerations and operational decisions without sacrificing financial goals, thus creating a culture where innovation and responsible practices do not contradict each other. In addition, cognitive framing influences organisational communication, the way the sustainability tensions are debated with stakeholders, and how the organisational goals and resource allocation correlate.

Paradoxical cognitive framing is also a mediating factor in sustainability tensions, assisting organisations in finding a middle ground between competing goals without falling into zero-sum results. Empirical and conceptual investigations indicated that such framing allows management to identify and exploit synergies when they exist and to be ready to make trade-offs that they cannot avoid (Carmine & De Marchi, 2022). In mining, De Klerk & Swart (2023) found that leaders using paradoxical frames might recognise the tension between efficiency and resilience as an opportunity to meet their objectives and thus invest in adaptive technologies and environmental protection that can enhance both profitability and long-term sustainability. In the same manner, Nonet et al. (2022) found that framing of social and environmental goals with economic goals entices stakeholders to tolerate short-term contradictions as components of a larger strategy, which facilitates engagement, trust, and institutional alignment. However, studies indicated that paradoxical framing is cognitively challenging and situation specific; its success depends on organisational culture, leader dedication, and the presence of resources to assist in integrative decision-making (Leung et al., 2018).

Paradoxical cognitive framing can act as a reliable way of navigating sustainability tensions by reframing conflicts as opportunities instead of threats. It allows organisations to interact dynamically with competing demands, improve the quality of decision-making, and balance the adverse effects of trade-offs through acceptance, justification, and sense-making. Its implementation in the context of sustainability, especially in resource-intensive sectors such as mining, offers a route to a reconciliation of economic, social, and environmental goals within a complex and uncertain world. Research Objective 2 is addressed, which assesses the moderating role of paradoxical cognitive framing in the relationship between perceived experience of sustainability tensions and environmental sustainability outcomes.

2.7. Strategic roles in sustainability and their impact on paradoxical; cognitive framing

Sustainability is impossible without the concerted action of various strategic actors of the organisation. CEOs influence the sustainability strategic vision and explain its significance, both internally and in the external environment. Findings indicated that top-level leadership plays a critical role in defining sustainability not as a compliance mechanism but as a strategic asset (Sajjad et al., 2023). CEOs establish an example of paradoxical framing and make the organisation pursue both economic performance and environmental responsibility at the same time (Carmine & De Marchi, 2022).

The senior management takes the bridging role, interpreting the strategic vision of the CEO into policies, processes, and quantifiable goals. They make sure that the sustainability objective is incorporated into corporate functioning and is connected with performance measurement schemes (Famiyeh et al., 2021). Middle management are at the operational frontline, where sustainability tensions are the most visible in day-to-day decisions. According to Leung et al. (2018), this level of paradoxical framing is conducive to creativity because management must balance conflicting forces with limited resources. As much as the sustainability agenda cannot work without TMT (CEOs and senior management) to provide direction, middle management contribute to the success of turnaround strategies in the organisation, as they have direct contact with employees and instil paradoxical thinking into the routine system. The role of leadership is still critical in the conceptualisation and implementation of sustainability strategies (Bao et al., 2022). According to Sajjad et al. (2023), sustainability leadership incorporates the economic, environmental, and social demands by creating a culture of tolerating ambiguity and paradox. At the CEO tier, leadership puts a premium on legitimacy and long-term expansion, frequently conceptualising sustainability as

a reputational and market necessity (Henry et al., 2019). Operationalisation of strategies is the concern of senior management, yet their task is frequently to go through trade-offs, including the necessity to balance cost-efficiency with long-term resilience (Fahimnia et al., 2025). Middle management add a relational aspect, which shapes the engagement of employees, the adoption of a team, and the integration of paradoxical frames into the daily work (Leung et al., 2018).

Nevertheless, the leadership is not just a top-down cascade, but it is decentralised and distributed over several levels, with every actor perceiving sustainability tensions in different ways. As an example, the CEOs might be focused on global competitiveness, whereas the middle management are focused on the local community issues (Mnwana & Bowman, 2021). This level distinction presents opportunities and threats: on the one hand, it provides a chance to take different visions, whereas on the other hand, it may lead to disjointure when the roles are not aligned. Bojica & Martínez-Del-Río (2023) postulated that the integrated cognitive frame enables management to integrate both the threat and the opportunity in a response model, thereby formulating proactive strategies. In contrast, management with a balancing cognitive frame strive for a balance between the two conflicting views of the external environment, addressing the economic and social elements of the conflict independently. However, the two models proposed by Bojica & Martínez-Del-Río (2023) depend on the context in which they are applied. For instance, companies aiming to explore new markets and technologies may benefit from integrative cognitive framing, while companies founded on stability may employ balanced cognitive framing. Fundamentally, scholars model cognitive framing as a mental processing framework that governs how management or individuals identify and process conflicting demands of related and nested logics within an organisation (Waldman et al., 2019).

Paradoxical cognitive framing is the capacity of leaders to explain tensions as interdependent instead of mutually exclusive. At the CEO level, paradoxical framing is usually focused on strategic legitimacy and resilience. Waldman et al. (2019) highlighted that the paradox theory assists the leader in making no simplistic trade-offs but rather incorporates competing demands within the strategy. Senior management have a systems perspective, which guarantees that the paradoxical thinking is institutionalised in monitoring, reporting, and compliance (Mancini & Sala, 2018). By contrast, middle management use paradoxical framing in their micro-level practices, balancing operational efficiency with social or environmental responsibility. Liu et al. (2019) demonstrated that the paradox mindset at this level promotes innovative behaviours, which allows organisations to be more adaptable. However, there are obstacles: organisational silos, insufficient training, and conflicting interests can weaken paradoxical framing (Seidemann, 2024). Although CEOs can recommend paradoxical

strategies, when the senior management are focused on efficiency and leave the middle management without resources, sustainability tensions may fall back on trade-offs. Therefore, horizontal alignment is necessary.

2.8 Sustainability training exposure and its effect on paradoxical cognitive framing

Equipping people with knowledge and information through training to ensure sustainability change within the organisation is essential. Manzhynski et al. (2024) proposed that for the tensions to be made salient, the organisation should explore the balanced application of information sharing and cognitive development. Therefore, sustainability tension can be latent depending on the level of cognition, information sharing, and the manner in which information is shared within the organisation.

Training is one of the approaches leveraged to enhance and develop organisational and individual cognition (Manzhynski et al., 2024). The influence of sustainability training is significantly essential in developing managerial perceptions and behaviours in terms of competing sustainability demands, as well as contributing to the cognitive framing prone to paradoxes rather than being simplified and trade-off based (Hahn et al., 2014). Formal, tailored training programs and assessments with practical examples geared towards embedding sustainability knowledge and skills are essential to TMT and lower level employees in organisations that integrate sustainability in their strategy and practices (Draghici et al., 2021). The study posits that people learn best when theory is combined with real-life examples and practical application through projects. Hahn et al., (2014) distinguished two different types of sustainability training. First, is formal training that entails designed trainings like workshops, courses, and certification schemes. Second, is informal training through on-the-job education, workgroups, and sharing experience. New dominant codifications, quantitative measures, and normative rationality are passed on by formal training. Whilst contextual knowledge and adaptive disposition, which promote structurability and responsiveness in relation to sustainability issues, are embedded through informal training. These two forms of training are complementary, and both have different impacts on the development of managerial thinking.

According to empirical studies, sustainability-oriented training is observed to improve environmental performance, satisfaction with environmental objectives, and standards of environmental knowledge. Schröder et al., (2023) found that human resource management practices that include formal and informal training program was fundamental in developing employee action competency for sustainability in SMEs. The structure of the training program

includes workshops, practical or experiential learning, and reflections through group discussion and journals (Schröder et al., 2023).

Nevertheless, being involved in training is not a sure way of developing paradoxical cognitive frame, institutional pressures and norms shape cognitive framing, moderated by the level of experience and the role of an individual in the organisation as argued by Szabo & Ruotsalainen (2022). Another important argument presented by Sasse-Werhahn et al. (2018) is that companies that harness practical wisdom manage sustainability through integrating all three elements of sustainability in their strategy. Practical wisdom acknowledges the life requirements of accepting conflicting logics and goes beyond an academic approach, encompassing values and social practices when dealing with sustainability and its tensions (Sasse-Werhahn et al., 2018).

There is also an aspect of manager value judgement which is subjective and informed by the manager's ethical subscription, which shapes cognitive frames and determines what is deemed significant, particularly when faced with tensions of sustainability (Benkert, 2020). Stronger sustainability values are found to be linked to holistic and integrated manager's approach to sustainability and the comprehensive understanding of the systematic nature of sustainability, including its paradoxes (Benkert, 2020). Integrated sustainability training that includes formal and informal training, however, has dominantly been emphasised through many scholarly discourses as a foundation of awareness to sustainability implementation and identifying sustainability issues (Sult et al., 2023).

Sustainability training that includes paradoxical thinking can be efficiently designed so that it helps management to both invest in resilience-related strategies (for example, redundancy and stakeholder dialogue and environmental buffers) and invest in efficiency-related innovations, thus preventing the efficiency traps where over-optimisation leads to increased exposure to disruption (Carmine & De Marchi, 2022). Additionally, individuals who train in paradoxical cognition are empowered to adopt hybrid strategies and maintain the sustenance of adaptive decisions in the long term (Carmine & De Marchi, 2022). However, research has identified that the success of such training relies on the backing of leaders. Studies have found that cognitive frames are dynamic and change over time; as a result, the TMT learning mindset is fundamental in embedding these changes (Bianchi & Testa, 2022).

2.9 Conceptual framework

The paradigm of this study is the paradox theory that views sustainability as a continuous process of interaction among competing but related demands instead of making opposing decisions. Conventional models of corporate sustainability often resolve these tensions through a trade-off or win-win logic, prioritising one aspect (typically profit) over the environment or the social aspect. The paradox theory, on the contrary, states that these tensions are natural and unchanging; they ought to be controlled rather than eliminated (Lewis & Smith, 2022).

The tensions are particularly evident in the South African mining environment between operational efficiency, which is motivated by the desire to maximise production and reduce waste, and resilience, the capacity to change and continue the operations under the influence of environmental and regulatory changes. The perceived experience of sustainability tensions is considered as the independent variable in this research, and the hypothesis is that a perceived experience of sustainability tensions can affect the results of environmental sustainability, the dependent variable.

The key to this relationship is paradoxical cognitive framing, which mediates the effect. This construct is used to explain how individuals and organisations identify, integrate and settle conflicting objectives (Benkert, 2020). It is believed that management and firms that know how to frame paradoxes are likely to transform sustainability contradictions into creative opportunities, and the tensions will have less dire effects on environmental performance.

In addition, managerial role (executive, senior, or middle manager) and sustainability training (formal, informal, or none) are thought to have an effect on the capabilities of an individual or an organisation to be involved in paradoxical framing (Draghici et al., 2021; Sasse-Werhahn et al., 2018). The more they have decision-making authority or exposure to sustainability, the more leaders may develop more advanced framing skills and thus, are able to cope with tensions in a successful manner (Sasse-Werhahn et al., 2018).

Figure 2 presents a conceptual framework that demonstrates and summarises the relationships among the constructs presented by the study. Fundamentally, the framework shows a direct relationship (H1) between the perceived experience of sustainability tension and environmental sustainability outcome. This suggests that leaders (middle management, senior management and executive committee members) who perceive sustainability tensions positively are associated with positive environmental outcomes. The model also demonstrates the moderating effect of paradoxical cognitive framing (H2) on the relationship between perceived experience of sustainability tension and environmental sustainability

outcomes. The hypothesis postulates that leaders who approach sustainability tensions through a paradoxical cognitive frame, through sensemaking that generates solutions that contribute to environmental sustainability outcomes. Hypothesis H3a suggests that assigning a strategic leadership role influences an individual's cognitive framing, in that the individual's cognitive framing will be shaped to identify and manage the paradoxes of sustainability. Hypothesis H3b suggests that training influences the shaping of cognitive framing towards paradoxical cognitive framing. Lastly, H3c demonstrates the integrated influence of training and strategic approaches towards sharpening paradoxical cognitive framing.

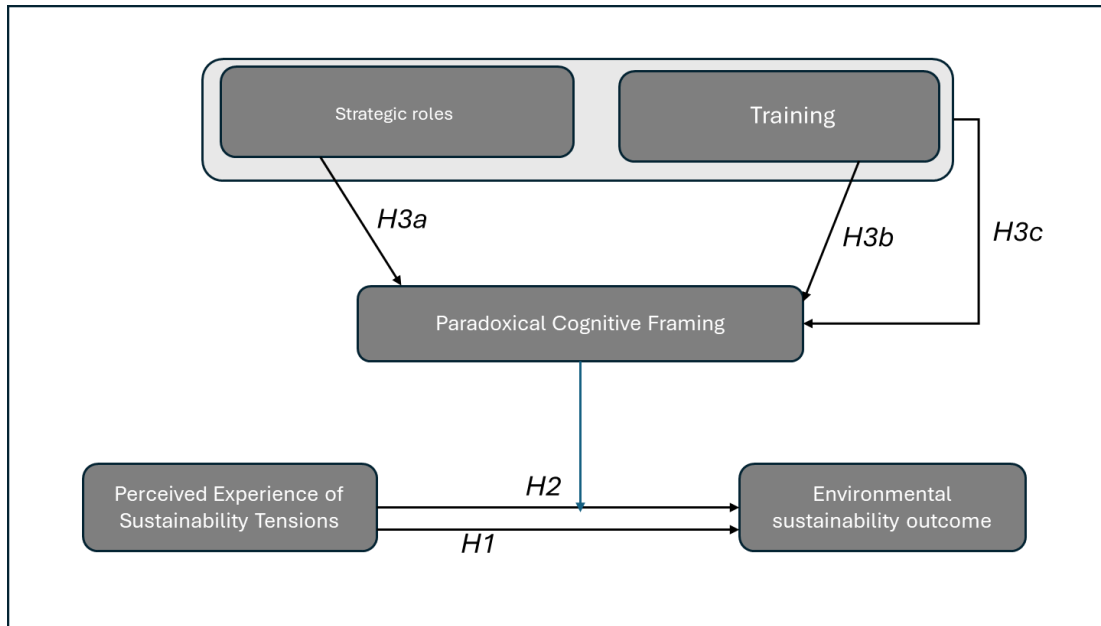


Figure 1 Conceptual Framework

Thus, the conceptual model positions:

- **Independent Variable (IV):** Perceived experience of sustainability tensions
- **Dependent Variable (DV):** environmental sustainability outcomes
- **Moderating Variable (MV):** Paradoxical cognitive framing influenced by managerial role and training

The framework assumes that paradoxical cognitive framing mitigates the negative relationship between perceived experience of sustainability tensions and environmental performance. By empirically testing this interaction, the study advances the application of the paradox theory within the mining industry, an area where such quantitative validation remains limited. Appendix Four provides a consistency matrix, which summarises the hypotheses and literature that support the generated hypothesis.

2.10 Gaps in literature

Notwithstanding the increasing number of scholarly interest, some of the major gaps in the research on CS and paradoxical framing still exist. First, little is known about the cognitive aspects of paradox management. Although the current literature mentions framing paradoxes occurring within organisations as a means to justify and manage tension, the literature does not focus on how executives at various levels interpret and put framing paradoxes into practice (Roth et al., 2021). This restricts knowledge to the psychology and behavioural processes of paradox responses.

Second, the majority of the literature are conceptual or qualitative case studies, which offer deep understanding, but low levels of generalisability. Little empirical research exists on the moderating effect of paradoxical framing on sustainability tensions and results, which creates an informational gap on the quantifiable effects.

Third, studies focus on Europe and North America, where institutional settings are vastly different to those of emerging economies. African settings and South Africa, in particular, are underrepresented despite the fact that the tensions of sustainability in the mining context are the most acute in those settings.

Lastly, the study of how managerial roles and training influence paradoxical framing has received little research. Gaining insight into the potential differences in the responses of CEOs, senior management, and middle management and the impact of formal or informal sustainability training on them presents an attractive approach to both theoretical and practical development.

2.11 Conclusion

This chapter has critically examined the theoretical and empirical foundations of CS and the paradox theory, highlighting their relevance to the mining sector. The traditional strategies of trade-off and win-win partially address and are insufficient to reflect the complexity of persistent contradictions, particularly in the mining industry. The use of the paradox theory offers a more subtle approach that highlights contradictions, interdependence, and persistence, but is more conceptual in nature, and there is limited empirical evidence to support it. In addition, existing studies are limited geographically and do not consider African contexts in which the tensions of sustainability are the most

significant. This study addresses the gaps in literature about paradoxical cognitive framing in the mining industry of South Africa. Chapter four sets out the research objectives, hypotheses and conceptual framing.

3. RESEARCH HYPOTHESES AND CONCEPTUAL FRAMING

3.1 Introduction

This chapter is based on the conceptual underpinning developed in the literature review to present the formal hypotheses of the study. It expresses the theoretical assumptions concerning the sustainability tension, paradoxical cognitive framing, managerial roles, and training exposure into empirically testable propositions. Based on the paradox theory and sustainability performance literature, and utilising the literature on managerial cognition, this framework combines both theoretical logic and quantifiable constructs. The purpose is to determine the exact interrelationships that are expected to exist between the perceived experience of tensions within sustainability, the results of environmental performance, and the paradoxical cognition that the South African mining industry faces in balancing conflicting demands between effectiveness and ecologically resilience.

3.2 Theoretical rationale and hypothesis development

Hypothesis 1: The relationship between perceived experience of sustainability tensions and environmental outcomes

H1: Environmental sustainability outcomes have a negative correlation with the perceived experience of sustainability tensions.

H0: There is no correlation between environmental sustainability outcomes and perceived experience of sustainability tensions.

The hypothesis is based on the sustainability literature that argues that managerial perceptions of trade-offs between efficiency (such as productivity, profitability) and resilience (such as environmental protection, responsible resource use) would lead to suboptimal sustainability outcomes in the event that one of the sustainability imperatives is prioritise for the other. Those that embrace the tensions between the two opposing demands may realise desirable environmental outcomes and long-term business performance (Fraser, 2021).

The literature review identified a gap in developing an understanding of conflicting demands that are underpinned by dualities in decision-making, such as the tensions of sustainability between environmental outcomes and economic outcomes. Another common application of these dual demands faced by management in high-context cultures is within the mining industry of South Africa. Management encounter two well-intentioned, yet interconnected, situations, which force them to prioritise short-term

efficiency over long-term resilience (Sinaga et al., 2024). Under the economic imperative as the primary driver of firms, investment in environmental stewardship is often reduced, thereby lowering the firm's capacity in terms of innovation and creative solutions steered towards improving environmental performance outcomes (Wu et al., 2025).

Carmine & De Marchi (2022) demonstrate that this type of imbalance triggers the so-called efficiency traps, where over-optimisation of costs and productivity makes it more likely to become prone and vulnerable to environmental and social hazards. Similarly, Boemelburg et al. (2023) emphasise the idea of the sustainability tensions in question that, when unaddressed, may increase organisational strain and erode the ecological goals. This supports the argument that perceived experienced tensions, if not controlled, are associated with poor outcomes in environmental dilemmas. H1 therefore suggests that, in a dichotomous form of experiencing perceived sustainability tensions, environmental performance erode, among those firms that do not have integrative mechanisms to managing the tensions.

Hypothesis 2: The moderating effect of paradoxical cognitive framing

H2: Paradoxical cognitive framing moderates the relationship between the perceived experience of sustainability tension and environmental outcomes, such that higher levels of paradoxical cognitive framing enhances the relationship.

H0: Paradoxical cognitive framing has no moderating influence on the perception of the experience of the sustainability tension on the environmental outcomes relationship.

This assumption is based on the paradox theory, which highlights that the ability to allow and resolve conflicting demands helps organisations to work successfully in a tension situation (Carmine & De Marchi, 2022; Boemelburg et al., 2023).

The structure of cognitive framing that enables management to identify tensions and reframe them as not contradictory but as interdependent and mutually reinforcing is known as paradoxical cognitive framing (Annesi et al., 2024). This moderating effect is supported by empirical studies on sustainability training and paradox framing research. Draghici et al., (2021) demonstrated experimentally that management who were trained in paradoxical framing make more balanced sustainability decisions; they do not prioritise economic or environmental arguments but are integrative.

Thus, when management have strong quality paradoxical framing, the perceived tensions are higher than the perceived hindrances, and the conflicting needs are transformed into

resilience and innovation (De Klerk & Swart, 2023). When this is the case, the negative relationship postulated in H1 is expected to direct or possibly invert. The intermediate appropriation of paradoxical cognition is therefore theoretically aligned with organisational learning viewpoints, stating an inherent association of high adaptive attitudes to sustainability performance excellence (Boemelburg et al., 2023).

Hypothesis 3a: The role-based variation in paradoxical cognitive framing

H3a: There is an effect of strategic position (CEO, senior management, middle management) on paradoxical cognitive framing.

H0: Paradoxical cognitive framing differences across strategic roles do not exist.

Cognitive framing, according to the literature on leadership, varies based on the hierarchical level or level of responsibility depending on differences in experience, decision-making scope, and responsibility issues in strategies (Boemelburg et al., 2023). Complex trade-offs, conflicts among stakeholders, and long-term sustainability pressures are more apparent to senior leaders, especially CEOs, resulting in the emergence of paradoxical cognition (Sajjad et al., 2022). By contrast, middle management who often have an operational and efficiency-driven perspective may have either/or mindsets in line with short-term results (Carmine & De Marchi, 2022).

Carmine & De Marchi (2022) also believe that leadership roles have effects on how tensions are defined throughout the organisation; the paradoxical reasoning is usually centrally initiated at the top and spreads through the organisational culture and decision structures (Henry et al., 2019). As such, H3a is set to reveal a large dissimilarity in the paradoxical cognitive framing processes at managerial levels, with different cognitive exposure to paradoxical circumstances.

Hypothesis 3b: Training exposure and paradoxical cognitive framing

H3b: There are variations in paradoxical cognitive framing level of sustainability training exposure (none, informal, formal).

H0: Paradoxical cognitive framing is not different at the levels of training exposure.

It is alleged that this hypothesis is based on literature on sustainability training, which makes a distinction between formal and informal learning modalities (Draghici et al., 2021). Codified sustainability principles are transferred through formal training, which may take place through workshops or certification programmes, and systemic reasoning is promoted (Hahn et al., 2014). Local adaptation and experiential learning are promoted

through informal training, including peer coaching or learning through solving problems (Hahn et al., 2014). Both of them, when done effectively, can develop paradoxical thinking, allowing for the tolerance of contradictions and the use of integrative problem-solving (Schröder et al., 2023).

The results of the research carried out by empiricists suggest that topics on sustainability training led to increased environmental awareness, satisfaction, and commitment (Schröder et al., 2023). Nevertheless, not every training comes with cognitive transformations; it is not possible that compliance-biased or technical training leads to the creation of paradoxical cognition, as individual ethics and societal norm may at times shape paradoxical cognitive framing, as argued by Sasse-Werhahn et al. (2018). Therefore, H3b anticipates a quantifiable difference in paradoxical thinking between different types of training, and formal or paradox-mindfulness-based training should produce higher paradoxical thinking scores.

Hypothesis 3c: Interaction between strategic role and training exposure with paradoxical framing

H3c: Strategic role and training exposure interact to influence paradoxical cognitive framing.

H0: Role and training exposure have no interactive effect on paradoxical cognitive framing.

This hypothesis combines both previous propositions (H3a and H3b) with the theory of organisational learning, that cognitive development is the outcome of both structural (role-based) and experiential (training-based) influences. The position leadership quadrant determines the exposure to paradoxical contexts of decisions, and the instruments to process such complexity are determined based on the training question quadrant (Henry et al., 2019). Sasse-Werhahn et al.,(2018) can observe that variation is quite suspicious when the paradoxical thinking is supported by the institutionalised systems of learning.

Boemelburg et al. (2023) also demonstrate that, as a leader at the level with structured sustainability training, learners not only internalise paradoxical cognition but also distribute it throughout the entire organisation. Localisation of benefits may occur when middle management receive training, particularly when higher authorities reinforce it. H3c, therefore, states that the interplay between hierarchical role and training exposure will result in some degree of synergies whereby the cognitive framing fruits of training will be intensified at a higher level of strategic competitive advantage.

3.3 Conclusion

The hypotheses formulated in this chapter will be constructs that express the theoretical discussions of the perceived experience of tensions of sustainability and paradoxical cognition in empirical terms. H1 and H2 in combination are used to prove the underlying relationship between the perceived experience of sustainability tensions and the environmental performance and buffering effect of paradoxical cognition, whereas H3a, H3c develop the relationship to organisational contingencies, the leadership role, and training exposure, which form the cognitive framing. These hypotheses are informed by the existing research literature on sustainability and paradox theory directly, and in combination with each other, they lead to the following empirical analysis.

4. RESEARCH METHODOLOGY

4.1 Introduction

The chapter describes the research methodology employed to implement the objectives of the research and test the hypotheses. It describes the general research design, philosophy and methodology applied in the examination of the relationships of paradoxical cognitive framing on the relationship between sustainability tensions and environmental performance in the South African mining industry. The methodological choices, research strategy, data collection methods, sampling procedures as well as techniques of data analysis are described in the chapter to address the accuracy as well as reliability of the findings. Lastly, the chapter discusses ethical issues during the research process. Figure 3, is the layer of decision path that the research employed to derive the methodology for the study.

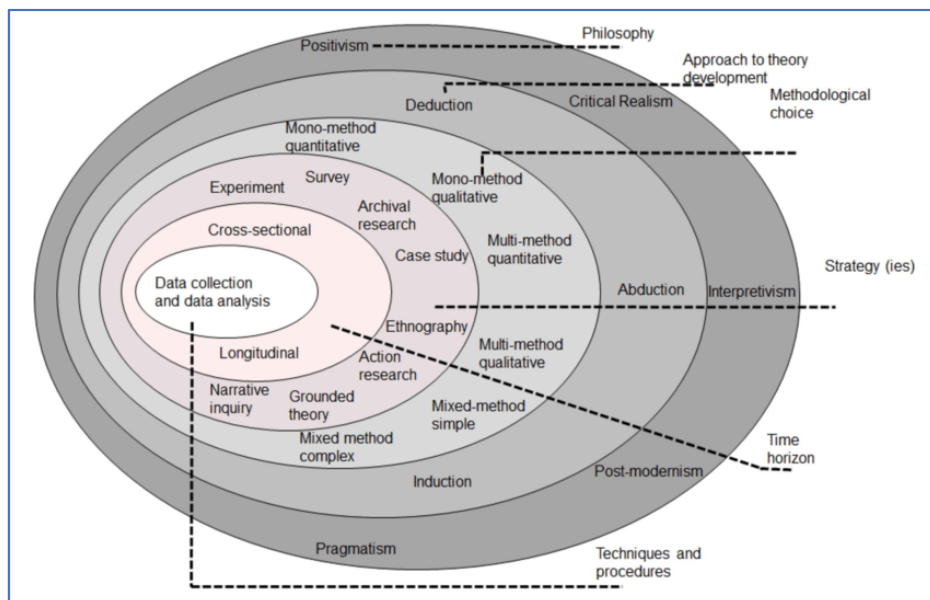


Figure 3: Research onion layers Source (Saunders et al., 2019)

4.2 Research philosophy

The research philosophy can be described as the assumptions under which knowledge is developed and interpreted in the research (Kironko et al., 2020). It affected the framing of the research questions or hypotheses, the way data were collected and the interpretation of results. Positivism, interpretivism, and pragmatism are commonly used philosophies in business and management research (Goldkuhl, 2012).

Interpretivism assumes that reality is created socially and can only be analysed using subjective experiences. It was frequently associated with qualitative research and other

approaches, including interviews or case studies. Although it would have been useful to examine deep meanings, interpretivism was not the most suitable methodology for this study because the study tested quantifiable relationships, not examining lived experiences (Goldkuhl, 2012). Pragmatism, however, emphasised the use of any method that best provided the answer to the hypotheses presented. Pragmatism frequently involved a combination of both qualitative and quantitative tools, but it was resource and time-consuming for this research (Park et al., 2020).

Positivism, is founded on the assumption that reality is independent of human interpretation and can be observed, measured, and tested. It is in line with quantitative data and statistical analysis. It was therefore an appropriate philosophy for this study, as the aim of the study was to test the relationship between sustainability tension, paradoxical framing, and environmental outcomes through hypothesis testing (Xiao et al., 2023). Objectivity was achieved by positivism, since data was gathered using structured questionnaires and analysed by standardised statistical methods.

In this study, the positivist research philosophy was adopted. This approach allowed the investigation to focus on observable phenomena and quantifiable data while reducing the influence of researcher bias (Park et al., 2020). By emphasising objective measurement and empirical evidence, positivism ensured that the results were credible, replicable, and generalisable (Saunders & Lewis, 2018). This philosophical stance aligned with the study's goal of contributing both theoretically and practically to the understanding of sustainability practices and paradox management within the mining industry.

4.3 Research approach

The methodology explained the rational direction that connected theory with data. Inductive and deductive were the two primary approaches that were at the disposal of the study (Berryman, 2019). The inductive method is founded on the construction of a theory based on observation. It was frequently applied to qualitative research methodologies where the researcher would first gather data and then analyse the patterns, as a way of forming new theories. Induction was appropriate in case there was a paucity of research before, or the researcher wanted to come up with new constructs (Kumar 2024). Nevertheless, it was not appropriate for this research because the objective was not to develop another theory, but to test the one.

The deductive approach, operates contrary to the inductive approach. It starts with the available literature and theories and formulated hypotheses, which are subsequently validated using data gathered and analysed (Berryman, 2019). Deduction was frequently associated with quantitative research since it entailed the use of structured tools and statistical testing. This rendered it appropriate in studies where an association between variables was previously indicated in the literature.

This research was deductive. The theory of paradox and its contribution to CS had already been discussed in the prior literature, especially by Carmine & De Marchi (2022, 2023). These studies led to the formulation of hypotheses regarding the connection between the sustainability tensions, paradoxical cognitive framing, and environmental outcomes. A deductive approach was selected because it enabled these assumptions to be tested in a new environment, the South African mining industry on the ground of paradox theory. Through deduction, the research has made the methodology systematic, theory-directed and consistent to validate existing concepts in a new cultural and institutional context. This gave it a theoretical contribution and practical relevance.

4.4 Research design and purpose

The research design is the blueprint that led this study (Mwange et al., 2023). It offers a structured framework for connecting the research goals to the data collection and analysis procedures (Saunders & Lewis, 2018). The design aim was to make sure that the research problem was tackled in a systematic and coherent manner, minimising the chances of bias and enhancing the credibility of the results. The proper design was also significant since it enabled the researcher to concentrate on the main relationships between the perceived experience of tensions of sustainability, the paradoxical cognitive framing, and the environmental outcomes.

There were various designs including exploratory, descriptive and explanatory (Saunders & Lewis 2018). The exploratory design is usually applied when the research problem is not clearly defined and needs further knowledge (Thomas & Lawal, 2020). A descriptive design is interested in the description of variables but not in testing the relationships (Imbeau et al., 2021). An explanatory design, in contrast, is meant to test cause-and-effect, or relational, relationships between variables (Imbeau et al., 2021). In this research, an explanatory design was followed because the focus was on testing the hypothesis and testing how paradoxical cognitive framing moderated the relationship between perceived

experience of sustainability tensions and results. The study was designed based on a quantitative design that facilitated measurement, statistical testing, and validation of the hypothesis. Through this design, the study resulted in objective and reproducible evidence. This was crucial as it was necessary to contribute in both theoretical discussions on the paradox theory and in the application to the mining industry.

4.5 Methodological choice

The methodological decision was what dictated the study to use qualitative, quantitative, or mixed methods (Emon, 2024). Both of these options had their own strengths and weaknesses. The qualitative methodology was premised on the exploration of meanings, experiences, and interpretations using non-numerical data, like an interview or focus group (Bao et al., 2020). It helped in formulating new theories or gaining profound knowledge on human behaviour. Nonetheless, it did was not appropriate for this study, because the emphasis was on whether it was possible to measure the relationships between variables and not on the experiences of individuals.

The mixed methods approach entails a combination of qualitative and quantitative methods. It gave a more comprehensive insight into complicated issues, as it enabled the researcher to employ various viewpoints (Saunders & Lewis, 2018). Although this method was useful, it required large resources, time, and knowledge. This research could not use a mixed design as time was a constraint, and the study's aim was to test a hypothesis.

A quantitative research design concentrates on numerical information and statistical research (Berryman, 2019). It was best suited to analyse the correlation among variables, and to test theories systematically. This methodology is appropriate for the aim of this research, which is to test the moderating effect of the paradoxical cognitive framing in the connection between sustainability tensions and environmental results.

A quantitative methodological approach was followed for this study. This approach permitted the study to utilise structured questionnaires, create reliable measurements and test hypotheses using statistical tools (Emon, 2024). The methodology made the results objective, replicable, and able to meet both theoretical and practical requirements of the research.

4.6 Time horizon

The time horizon explained the time frame in which the data were taken. There were two options available: cross-sectional and longitudinal (Tucker et al., 2017). A longitudinal time horizon represents a collection of data on the same participants over a long period. This method proved helpful in examining changes and trends, in particular, when the researcher wanted to see how variables changed over time (Dawadi et al., 2021). Nonetheless, it needed a substantial amount of resources, long-term investment, and more access to participants, which made it inappropriate for this research. However, a cross-sectional time horizon entails the gathering of data at one time (Tucker et al., 2017). It gave a picture of the relationship between variables and was feasible in research that was constrained in time and resources (Sileyew, 2019). Cross-sectional studies were not effective in identifying long-term developments and establishing causality, but they were useful in identifying correlations and testing hypotheses within a particular context.

In this study, a cross-sectional time horizon was employed, and data was collected from July 2025 to September 2025 within South Africa. The research objective was to investigate the connections between sustainability tensions, paradoxical cognitive framing, and environmental outcome at a particular time in the South African mining industry. The restricted nature of the time to conduct the research implied that the research would not be conducted using longitudinal data. Thus, cross-sectional was the most convenient and appropriate for the research objectives.

4.7 Population and unit of analysis

The study was conducted within the South African mining industry setting. At the time of data collection, all participants in the sample were employed in the industry and actively interacting with the organisation's CS framework through formulation or implementation.

The population sample selected for this study was informed by the hypothesis formulated, the actors' roles in sustainability practices and organisational strategy. Bao et al. (2020) postulate that the CEO's ability to identify and interpret the opposing effect of strategy (ambivalence) in relation to environmental changes is fundamental in shaping the organisational cognitive frame. The study's findings postulate that the stronger the CEO's ability to manage strategy tensions, the stronger the organisational paradoxical cognitive framing, in the form of ambidexterity.

Implementing sustainability practices occurs at the multi-organisational level (Faraz et al., 2023). Faraz et al. (2023) provides statistical evidence that middle management' environmentally responsible leadership mediates the relationship between corporate environmental strategy and employee green behaviour, while the CEOs' environmentally responsible leadership moderates the connection between corporate environmental sustainability and middle management' leadership. Although some studies argue that the sustainability committee moderates the chief sustainability officer's impact on implementing sustainability systems and practices (Fu et al., 2020). Bianchi & Testa (2022) consider top management critical to implementing sustainability practices as their values and frames shape the organisation's cognitive frame, which is critical for dealing with tensions. This underscored the role and the contribution of these three categories of actors (middle management, senior management and executive committee members in sustainability practices, and qualified their potential ability to answer a structured questionnaire credibly. Given this view, the hypotheses were tested on the mining organisations' CEO's, senior management and middle management (units of analysis).

The researcher is a mining engineer and worked in the South African mining sector at the time of the research, and leveraged industry affiliations to access the targeted population.

4.8 Sampling method, criteria, and size

Sampling was an important part of this study because it was not possible to collect data from the entire population of the South African mining sector. A sample had to be selected to represent the larger group while remaining practical and manageable. In research, sampling methods were generally divided into probability and non-probability approaches (Turner, 2020).

Probability sampling gives every individual in the population an equal chance of being selected. This method was often used in large-scale studies because it increased generalisability (Busetto et al., 2020). However, access to a complete list of the population was required, which was not available in this study.

Non-probability sampling, in contrast, relies on the researcher's judgment to select participants based on specific criteria (Turner, 2020). It did not guarantee representativeness but was practical when the population was difficult to access. Within

this category, purposive sampling was widely used when participants needed to meet certain qualifications or hold relevant experience (Saunders & Lewis, 2018).

This study applied purposive non-probability sampling. Participants were selected because they met the criteria of being actively involved in sustainability practices within the mining industry. The criteria included employment in a mining organisation, direct engagement in sustainability-related planning or implementation, and membership in one of the three strategic roles: executive committee members, senior management, or middle management. The researcher used the purpose section of the survey instrument and the demographic section in the survey to select a suitable group qualified to complete the survey. The sample size was determined through a power analysis (Baguley, 2004). For regression and ANOVA tests, an ideal sample of approximately 252 participants was identified. However, due to time and resource limitations, the sample of study consisted of 123 participants; as such, the limitation of generalisability was identified.

4.9 Measurement instrument

A structured questionnaire is the measurement instrument used in the study (Saunders & Lewis, 2018). This is a good tool since it is consistent, where every participant would answer a set of similar questions (Beyera et al., 2020). The questionnaire was subdivided into parts that assessed perceived sustainability tensions, paradoxical cognitive framing, environmental outcomes and demographic details. Likert-scale items were used to measure perceptions in a numeric format, which is appropriate for testing them statistically. The measurement instrument was developed using a literature review process (Beyera et al., 2020).

Previous studies, like Carmine & De Marchi (2022), used validated scales, which were translated into the context of the mining industry, guaranteeing reliability and connection to previous studies. Section A of the questionnaire was aimed at ensuring that suitable candidates were selected with the correct demographics. The training section of the questionnaire, Section A of the survey instrument, was underpinned by the scholarly articles of Banasiewicz et al. (2020) and Bianchi & Testa (2022), which focused on organisational learning and individual learning as conduits through which the cognitive frame can be altered.

Section B of the questionnaire was derived from Carmane & De Marchi (2022), Saviom (2024) and Zai & Lee (2024), which provided a foundation on the nature of sustainability tension, the existing tension between efficiency, profitability and long-term environmental resilience and adaptability. Sections C and D, related paradoxical framing as a conduit through which sustainability tensions can be navigated by assessing organisational cognitive frames and individual cognitive frames. The review on literature produced by Edward (2021), Rietdijk et al. (2024), Wand & Zeng (2024), Annesi et al. 2024 and De Klerk & Swart (2024) was applied to derive questions in Sections C and D of the instrument. Lastly, Section E focused on environmental sustainability outcomes and was supported by Frazer (2024) and Okeke (2024). The questionnaire was developed in English, and simpler words were used to enhance clarity. The answers were received in an electronic form using Google Forms to be stored safely. Appendix four, which represents the consistency matrix demonstrate in brief how hypotheses were set out and which articles were utilised to support the hypotheses.

4.10 Data collection process

Data was collected using a structured online survey (Sileyew, 2019). The questionnaire was designed with Google Forms, which offered an effective and safe means of obtaining the responses. The survey was shared using professional contacts, LinkedIn, WhatsApp, email, and industry contacts to target the survey to people who are in the mining industry in South Africa. This approach was to ensure that the targeted roles of CEOs, senior management and middle management were invited to participate. Participants were given an informed consent statement before they saw the questions. This justified the aim of the study, privacy, and explained that participation in the study was voluntary. Only consenting participants continued and filled out the survey.

The questionnaire was designed into blocks of the sustainability tensions, paradoxical cognitive framing, environmental outcomes, and demographics. Perceptions were measured using Likert-scale items, which rendered the answers suitable for statistical analysis (Mwange et al., 2023). To enhance understanding and reduce misinterpretation, the questionnaire was drafted in English using simplified terms and a pilot test was run. The responses were automatically added to a secure Google Sheet, minimising the possibility of losing the data and ensuring accuracy. This was a viable and systematic way of gathering quality information, given the time and resource limitations of the research.

4.11 Data analysis and quality assurance

The data analysis plan was designed to convert the gathered survey responses into meaningful findings that answered the research objectives (Yuan et al., 2019). Descriptive statistics were run to determine the mean, standard deviation and frequencies (Saunders & Lewis, 2018). However, beforehand, data was screened and cleaned to ensure that the quality of the study and the results of the research is maintained. Missing value analysis was conducted, and the guideline threshold as outlined by Dong & Peng (2013) was used as a benchmark (acceptable level below 10%). Data were sorted and coded (code book shown in Table 3), and Kurtosis and Skewness were measured to determine the distribution and shape of the data set, which may affect the direction of the study's statistical analyses (George & Mallery, 2010).

A reliability test was performed to ensure the quality of the research was maintained, establish credibility, and provide a foundation for factor analyses (Kimberlin & Winterstein, 2008b). Internal consistency of the constructs was measured using Cronbach's alpha (α), which was found to be above 0.7, and deemed to be sufficient (Hair et al., 2019). The Bartlett test of sphericity and the Kaiser-Meyer-Olkin (KMO) test were run to assess sampling adequacy and the intercorrelation of variables, as these are requirements for evaluating data suitability for factor analysis (Othman et al., 2019). Furthermore, the Corrected Item-Total Correlation (CITC) was assessed to identify weak items and to assess the association of each item with the others. A CITC above 0.3 is generally acceptable (Santos, 2018). Validity tests.

Exploratory factor analyses (EFA) were conducted to determine the hidden structure of the constructs. The outcome of Bartlett's test and KMO was utilised to support the analyses. Subsequently, the measurement and structural models were assessed using Partial Least Squares Structural Equation Modelling (PLS-SEM) to identify and eliminate items with low loadings, which are critical for improving construct validity and ensuring that model redundancy is eliminated. Based on the outcome, the model was refined, and 17 items loaded on six constructs. Model fit was then assessed using Standardised Mean Square Residual (SRMR), and the adequacy of the model specification was validated.

Internal consistency reliability was assessed using Cronbach's alpha, and the outcome was compared to the Hair et al. (2019) recommended threshold. The study used average variance extracted (AVE) to confirm convergent validity, which is essential for determining

if the items in the survey truly explain the construct. Lastly, to affirm the model's validity, discriminant validity was analysed using Heterotrait-Monotrait ratio of correlations (MTMT). The model was then tested for predictive relevance and explanatory power, and the model was found to be aligned with the benchmark as determined by (Hair et al., 2019) and Cohen (2013), respectively. Collinearity was then confirmed to ensure to multicollinearity is not a concern.

Hypothesis 1 was tested using PLS-SEM and path analyses with bootstrapping was conducted as it was suitable to determine the relationship between perceived experience of sustainability tensions (PEST) and environmental sustainability outcomes (ESO). Hypothesis 2 was tested using PLS-SEM moderation analysis, and the test was suitable because it examined the moderating effect of paradoxical cognitive framing on the relationship between PEST and ESO. To test hypotheses 3a and 3b, a one-way ANOVA was used, as hypothesis 3a aimed to examine if paradoxical cognitive framing differs across the type of training in sustainability, while hypothesis 3b tested whether cognitive framing was influenced by roles (executive committee members, middle management and senior management). One-way ANOVA is appropriate because it compares the means of a single dependent variable across multiple independent variables to determine whether differences are statistically significant. Hypothesis 3c was tested using two-way ANOVA, as the hypothesis aimed to examine interactions between the type of training and type of role and how it influences paradoxical cognitive framing.

4.12 Ethical considerations

Ethical standards were adhered to safeguard the participants and make the study a responsible one. Ethical clearance was obtained from the university before data collection. The informed consent statement was provided to participants at the beginning of the survey (see Appendix 4a) and included the study's purpose (Wardhono & Lestari, 2023), the need to maintain confidentiality, and a statement confirming that participation was voluntary. No personal data was gathered, and the responses were anonymous. All the data were saved in safe files that were only deciphered by the researcher using passwords. The questions were not to be created in a sensitive and offensive language and were limited to professional practices and their sustainability problems (Kumar & Praveenakumar, 2025; Sileyew, 2019). Findings were reported in a generalised form such that no personality or institution could be identified. The measures ensured the fairness, transparency, and credibility of the study.

4.13. Limitations

This research was limited in several ways. First, the cross-sectional design limited the amount of causality that could be determined because the data were gathered at one time (Alosi et al., 2023). The research required 252 sample size to achieve 80% statistical power, a 5% significance level of the study (Xiao et al., 2023), which is too high given the time period and the scope of the study. However, a sample size of 123 was achieved, and as a result, the generalisability of the study is represented as a limitation, given that the required sample size to meet the statistical power requirement was not met.

Second, the study assumed interaction and relationship are limited to the constructs studied and ignores any other conditions that influence the relationship between the variables studied, such as organisational culture and time horizon (Carmine & De Marchi, 2022). For instance, the adoption of paradoxical cognitive frames at an organisational level may be influenced by the strategic agility of the organisation, which encompasses access to resources, resource flexibility, resource coordination, and institutional norms and pressures, such as regulatory governance pressure (Qin et al., 2022). An additional example is the Coronavirus disease of 2019 (COVID-19) crisis, where companies with flexibility and access to resources were able to adjust and continue working while observing COVID-19 safety protocols by introducing measures such as remote work (Pradies et al., 2021). This study, however, did not consider the degree to which external and internal factors presented by the environment may shape organisational cognitive framing and how that, in turn, may impact the way in which perceived tensions of sustainability are navigated.

At the time of the survey, 82% of the respondents were employed in larger companies with employee numbers exceeding 500. However, scholars argue that environmental strategies of larger companies are more proactive than those of small companies (Seroka-Stolka & Fijorek, 2020), and this may be the root of a dichotomy between how large companies and smaller-sized companies manage sustainability tensions. Therefore, the study results and findings may be limited to large mining companies in South Africa.

Reliance on self-reported data introduces bias limitations, such as confirmation bias and non-response bias. Confirmation bias occurs when the researcher favours data that confirms their existing belief or hypothesis (Ortego et al., 2025). Non-response bias occurs when a certain population is selected for the study with a different view from the population

that respondents do not respond to, skewing the result of the study (Ortego et al., 2025). The use of self-report responses in this study created some risks, like recall bias and social desirability bias, which may influence accuracy. Moreover, there was low availability of CEOs as respondents, which represented only 10% of the sample, which could have minimised the balance between roles and reflected results that are more towards perceived experiences of middle and senior management.

4.14 Conclusion

The chapter discussed the research methodology that was used to direct the study. The design, philosophy and deductive approach were detailed and rationalised, demonstrating how it matched with the purpose of the research, which was to test relationships between sustainability tensions, paradoxical framing and environmental outcomes. The methodological approach was a quantitative approach that used a cross-sectional time period and a survey strategy. The population was considered as the mining industry employees in South Africa, and the unit of analysis was the executive committee members, senior management and middle management. The information about sampling, measurement tools, data gathering and data analysis was presented. Ethical protection, quality control, and study restrictions and confines were identified. The methodology followed ensured the research was carried out in a valid, reliable, and structured manner.

5. RESULTS OF THE STUDY

5.1 Introduction

This study examined how the top management team (TMT) perceive sustainability tensions between efficiency and environmental sustainability, and also determined whether paradoxical cognitive framing moderated this relationship. This quantitative study had 123 responses from executive committee member, senior, and middle management within the mining sector. This chapter presents the results of the empirical data.

Before the analysis, the data was cleaned and screened to ensure good quality. Initially, the data were analysed for missing values, and they were within the acceptable levels since they were below the 10% threshold (Appendix one) as proposed by Dong & Peng (2013). Data were also analysed for common method variance (CMV) using the Harman single-factor test. The Harman single factor test was conducted using exploratory factor analysis (Appendix Two). The unrotated solution revealed that the first factor accounted for 18.55% of the total variance, which is well below the critical threshold of 50%. This indicates that no single factor dominated the variance. Therefore, common-method bias is unlikely to be a major concern in this study (Podsakoff et al., 2003).

This chapter starts with demographic information, followed by descriptive statistics which assessed the central tendency and spread. Flowing from this is the testing of the hypotheses that were presented in Chapter three.

5.2 Demographic information

Participants held various roles in sustainability within their companies. Most were in senior management positions (56.1%), followed by middle management (35.0%), and a smaller proportion were from executive management (8.9%) as presented in Table 1. In terms of sustainability training, more than half (56.1%) reported having informal training which consisted mainly of on-the-job or ad hoc sessions, while 33.3% had formal training, which were certified courses or university training, and 10.6% had no training.

Regarding mining experience, 47.1% had 16–25 years of experience, 42.1% had 6–7 years of experience, 7.4% had more than 25 years of experience, and only 3.3% had 5 years or less. Most of the respondents (82.9%) were employed in large mining companies

with 500 or more employees, while 13.0% worked in medium-sized companies and 4.1% in small companies.

Table 1: Demographic information of the respondents

		Frequency	% Frequency
Role in sustainability:	Executive management	11	8.9
	Senior management	69	56.1
	Middle management	43	35.0
	Total	123	100.0
Type of sustainability training	None	13	10.6
	Informal	69	56.1
	Formal	41	33.3
	Total	123	100.0
Experience in mining	5 years or less	4	3,3
	6 - 15 years	51	42,1
	16 - 25 years	57	47,1
	More than 25 years	9	7,4
	Total	121	100,0
Company size (number of employees)	Less than 100	5	4.1
	100 - 499	16	13.0
	500 or more	102	82.9
	Total	123	100.0

5.3 Descriptive statistics and reliability

5.3.1 Descriptive statistics

Descriptive statistics were computed for all items measured on a five-point Likert scale (1 = Strongly disagree, 5 = Strongly agree). Table 2 presents the mean (M), standard deviation (SD) and median (Md) for each of the 27 items (VAR5–VAR31). Table 3 presents the codebook with details of the items. The mean values ranged from 2.89 to 4.26, suggesting that the respondents generally agreed with most statements related to sustainability adaptability and integration. The median response across all items was 4.00, which shows that most of the participants leaned toward agreement.

The items with which the respondents were most satisfied were VAR26: 'I feel proud when I can address contradictory sustainability issues regarding efficiency and environmental adaptability' (M = 4.26, SD = 0.50, Md = 4.00). Followed by VAR30: 'Our organisation has

improved compliance with environmental regulations' ($M = 4.22$, $SD = 0.76$, $Md = 4.00$), then VAR18: 'Our company is proud when it manages to address contradictory sustainability issues concerning efficiency and environmental adaptability' ($M = 4.24$, $SD = 0.47$, $Md = 4.00$).

The other items in the top five were VAR19: 'Our company integrates competing short-term efficiency and long-term environmental adaptability goals into its sustainability strategy' ($M = 4.14$, $SD = 0.64$, $Md = 4.00$) and VAR15: 'Our company is proud when it manages to pursue competing short-term efficiency and long-term environmental adaptability goals' ($M = 4.14$, $SD = 0.82$, $Md = 4.00$).

The items with which the respondents least agreed were VAR9: 'We struggle to achieve short-term efficiency and long-term adaptability to adverse environmental change' ($M = 2.89$, $SD = 1.09$, $Md = 3.00$). This was followed by VAR7: 'Our company sometimes takes actions regarding environmental sustainability goals that contradict each other' ($M = 3.02$, $SD = 1.22$, $Md = 3.00$) and VAR11: 'Usually, when our company addresses short-term efficiency and long-term environmental problems, they seem contradictory' ($M = 3.02$, $SD = 1.14$, $Md = 3.00$).

Table 2: Descriptive statistics

	Mean	Median	Std. deviation	Skewness	Kurtosis
VAR5	3.90	4.00	1.051	-1.351	1.540
VAR6	3.50	4.00	1.155	-0.659	-0.503
VAR7	3.02	3.00	1.215	-0.115	-1.076
VAR8	3.47	4.00	1.074	-0.753	-0.243
VAR9	2.89	3.00	1.085	0.057	-1.168
VAR10	3.40	4.00	1.069	-0.569	-0.703
VAR11	3.02	3.00	1.141	0.019	-1.299
VAR12	3.67	4.00	1.014	-1.017	0.485
VAR13	3.66	4.00	1.015	-0.896	0.179
VAR14	3.44	4.00	1.049	-0.788	-0.190
VAR15	4.14	4.00	0.816	-1.097	1.719
VAR16	3.70	4.00	0.966	-0.858	0.348
VAR17	3.30	4.00	1.108	-0.401	-0.807
VAR18	4.24	4.00	0.471	0.670	-0.248
VAR19	4.14	4.00	0.639	-0.723	1.900
VAR20	3.99	4.00	0.732	-1.117	2.033
VAR21	3.98	4.00	0.923	-1.238	1.480
VAR22	3.86	4.00	0.986	-1.021	0.697
VAR23	3.89	4.00	0.904	-1.143	1.618
VAR24	3.89	4.00	0.857	-1.144	1.718
VAR25	3.55	4.00	1.010	-0.705	-0.136
VAR26	4.26	4.00	0.497	0.434	-0.407
VAR27	4.18	4.00	0.545	0.096	0.045
VAR28	3.91	4.00	1.008	-1.086	0.718
VAR29	3.76	4.00	1.064	-0.634	-0.497
VAR30	4.22	4.00	0.763	-1.070	1.448
VAR31	3.70	4.00	1.086	-0.858	0.127

Table 3: Code book

5. In environmental sustainability activities, our company often has competing demands that need to be addressed simultaneously.	VAR5
6. Our company often has short-term efficiency and long-term environmental adaptability goals in conflict.	VAR6
7. Our company sometimes takes actions regarding environmental sustainability goals that contradict each other.	VAR7
8. There is a tension between short-term efficiency and long-term adaptability to adverse environmental change.	VAR8
9. We struggle to pursue short-term efficiency and long-term adaptability to adverse environmental change.	VAR9
10. Our company often must decide between short-term efficiency and long-term environmental adaptability to adverse changes.	VAR10
11. Usually, when our company addresses short-term efficiency and long-term environmental problems, they seem contradictory.	VAR11
12. Our company is comfortable dealing with conflicting short-term efficiency and long-term environmental adaptability demands.	VAR12
13. Accepting short-term efficiency and long-term environmental adaptability contradictions is essential for our company's success.	VAR13
14. Tensions between short-term efficiency and long-term environmental adaptability issues enhance our company's sustainability efforts.	VAR14
15. Our company is proud when it manages to pursue competing short-term efficiency and long-term environmental adaptability goals.	VAR15
16. Our company often finds itself simultaneously embracing conflicting sustainability demands concerning efficiency and environmental adaptability goals.	VAR16
17. Our company is comfortable working on sustainability tasks that contradict each other, such as short-term efficiency and long-term environmental adaptability tasks.	VAR17
18. Our company is proud when it manages to address contradictory sustainability issues concerning efficiency and environmental adaptability.	VAR18
19. Our company integrates competing short-term efficiency and long-term environmental adaptability goals in its sustainability strategy.	VAR19
20. I feel comfortable dealing with conflicting short-term efficiency and long-term environmental adaptability demands.	VAR20
21. I believe accepting the contradictions between short-term efficiency and long-term environmental adaptability is essential for our company's success.	VAR21
22. I believe that tensions between short-term efficiency and long-term environmental adaptability issues enhance our company's sustainability efforts.	VAR22
23. I feel proud when I can pursue contradictory short-term efficiency and long-term environmental adaptability goals.	VAR23

24. I simultaneously embrace conflicting sustainability demands concerning efficiency and environmental adaptability goals.	VAR24
25. I feel comfortable working on sustainability tasks that contradict each other, such as short-term efficiency and long-term environmental adaptability tasks.	VAR25
26. I feel proud when I can address contradictory sustainability issues concerning efficiency and environmental adaptability.	VAR26
27. I do attempt to integrate competing short-term efficiency and long-term environmental adaptability goals in its sustainability.	VAR27
28. Our Organisation has reduced environmental waste through operational improvement	VAR28
29. Our organisation has lowered energy or resource consumption while maintaining productivity.	VAR29
30. Our organisation has improved compliance with environmental regulations.	VAR30
31. Our organisation has developed new sustainable technologies or practices.	VAR31

Skewness and kurtosis are important indicators of the shape and normality of a data distribution. Most items exhibited negative skewness, ranging approximately from -1.35 (VAR5) to -0.40 (VAR17). This indicates that participants generally selected higher response options (agree to strongly agree) on the five-point Likert scale. Kurtosis values ranged from approximately -1.30 to $+2.03$, which are within the normal range for Likert-type data. As such, the skewness and kurtosis values were within the acceptable range of -2 to $+2$ (George & Mallery, 2010), suggesting the data approximate normal distribution.

5.3.2 Reliability

A reliability analysis was conducted to assess the internal consistency of the scale comprising 27 items (VAR5–VAR31). The analysis yielded a Cronbach's alpha of .708, indicating acceptable internal consistency. The 'Cronbach's Alpha if Item Deleted' values ranged from .685 to .716, suggesting that removing any individual item would not substantially improve the overall reliability of the scale. Several items (such as: VAR7, VAR9, VAR11, VAR20, VAR29, VAR30, and VAR31) showed relatively low corrected item-total correlations ($r < .20$), indicating weaker relationships with the overall scale score and suggesting these items may not be strongly aligned with the underlying construct. In contrast, items such as VAR16 ($r = .443$) and VAR17 ($r = .399$) demonstrated stronger associations with the total score.

Overall, the scale demonstrated adequate reliability for research purposes, although potential refinement could include reviewing or revising items with low item-total correlations to enhance internal consistency.

5.4 Exploratory factor analysis for paradox framing

An exploratory factor analysis (EFA) using Principal Component Analysis (PCA) with Varimax rotation was conducted to examine the underlying factor structure of the 16-item scale (VAR12–VAR27) of paradox framing. Prior to performing the analysis, the data's suitability for factor analysis was assessed. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was .707, indicating a mediocre but acceptable level of sampling adequacy. Bartlett's Test of Sphericity was significant, $\chi^2(120) = 435.70$, $p < .001$, suggesting that the correlation matrix was not an identity matrix and that the data were appropriate for factor analysis (Table 5).

Table 4: KMO and Bartlett's test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,707
Bartlett's Test of Sphericity	Approx. Chi-Square	435,703
	df	120
	Sig.	<.001

The initial extraction revealed four components with eigenvalues greater than 1.0, explaining a total of 56.86% of the variance. Specifically, the first factor accounted for 25.48% of the variance, the second for 11.92%, the third for 10.64%, and the fourth for 8.83%. After varimax rotation, the four-factor solution provided a more interpretable structure, with each item loading strongly on one factor as presented in Table 6.

Table 5: Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4,076	25,476	25,476	4,076	25,476	25,476	2,403	15,022	15,022
2	1,907	11,916	37,392	1,907	11,916	37,392	2,396	14,975	29,997
3	1,702	10,638	48,029	1,702	10,638	48,029	2,285	14,281	44,277
4	1,412	8,828	56,857	1,412	8,828	56,857	2,013	12,580	56,857
5	,989	6,183	63,040						
6	,900	5,626	68,666						
7	,839	5,241	73,907						
8	,734	4,590	78,497						
9	,615	3,842	82,339						
10	,554	3,465	85,804						
11	,504	3,151	88,954						
12	,457	2,855	91,809						
13	,443	2,766	94,575						
14	,336	2,103	96,678						
15	,306	1,916	98,593						
16	,225	1,407	100,000						

Extraction Method: Principal Component Analysis.

Inspection of the rotated component matrix indicated the following pattern of loadings: Factor 1: Items VAR21, VAR22, VAR14, VAR23, and VAR16 loaded strongly (0.42 - 0.81), representing a dimension (Paradox 4 – 'Para 4'). Factor 2: Items VAR18, VAR27, VAR19,

and VAR15 loaded prominently (0.51 - 0.81), reflecting (Paradox 3 – ‘Para 3’). Factor 3: Items VAR20, VAR25, VAR26, and VAR24 loaded highly (0.55 - 0.82), suggesting Paradox 2 – ‘Para 2’. Factor 4: Items VAR12, VAR17, and VAR13 loaded strongly (0.69 – 0.74), reflecting Paradox 1 – ‘Para 1’ as presented in Table 7.

Table 6: Rotated component matrix

	Component			
	1	2	3	4
VAR21	,809	,100	,129	-,021
VAR22	,731	-,006	,222	,071
VAR14	,576	-,085	-,073	,385
VAR23	,567	,238	,394	-,138
VAR16	,421	,360	-,240	,281
VAR18	,071	,808	-,051	,178
VAR27	-,137	,671	,199	,029
VAR19	,097	,629	,231	,012
VAR15	,320	,509	,023	,039
VAR20	,036	,045	,823	,030
VAR25	,291	,002	,668	,320
VAR26	-,014	,449	,586	-,228
VAR24	,344	,224	,551	,184
VAR12	-,120	,239	,341	,738
VAR17	,112	,322	,114	,722
VAR13	,128	-,146	-,076	,686

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalisation.^a

a. Rotation converged in 7 iterations.

5.5 Structural equation modelling

5.5.1 Measurement model

A Partial Least Squares Structural Equation Modeling (PLS-SEM) approach was used to assess both the measurement and structural models. The measurement model was evaluated first to determine the reliability and validity of the latent constructs. Indicators (items VAR5–VAR31) were initially included with the four sub-constructs of paradox framing based on the exploratory factor analysis (EFA) results. Indicators with factor loadings below .60 were removed from the model to improve construct reliability and discriminant validity, consistent with Hair et al. (2019) guidelines. Specifically, VAR5,

VAR6, VAR9, VAR10, VAR11, VAR13, VAR14, VAR26, VAR28, VAR29, VAR30, and VAR31 showed low loadings ($< .60$) in the initial model and were excluded from the final PLS-SEM model. 'Para 1' measured the paradoxical cognitive frame regarding companies' comfort in navigating sustainability tensions (Edwards, 2024); 'Para 2' measured individual cognitive framing related to embracing PEST (Carmin & Marchi, 2022). 'Para 3' measured organisational cognitive framing at the strategic level (Annesi et al., 2024), and 'Para 4' was concerned with individual paradox framing shaped by management's beliefs and practical wisdom (Sasse-Werhann et al., 2018).

The refined model (Figure 3) retained 17 items loading on six constructs: Perceived experience of sustainable tensions (ESO) (4 items: VAR7–VAR11), Para 1 (3 items: VAR12, VAR17; loadings = .858–.860), Para 2 (3 items: VAR24, VAR25, VAR20; loadings = .710–.828), Para 3 (3 items: VAR15, VAR19, VAR27; loadings = .609–.846), Para 4 (3 items: VAR21, VAR22, VAR23; loadings = .629–.878) and environmental sustainability outcomes (PEST) (4 items: VAR28–VAR31; loadings = .719–.820).

Model fit was evaluated using the Standardised Root Mean Square Residual (SRMR), a commonly used measure of approximate model fit in PLS-SEM. The SRMR value for both the saturated model and the estimated model was .083, which is below the recommended maximum threshold of .10 (Hair et al., 2019).

This indicates that the model demonstrates an acceptable level of fit, suggesting that the discrepancy between the observed and predicted correlations is relatively low. Therefore, the measurement and structural models exhibit a satisfactory overall model fit, supporting the adequacy of the proposed model specification.

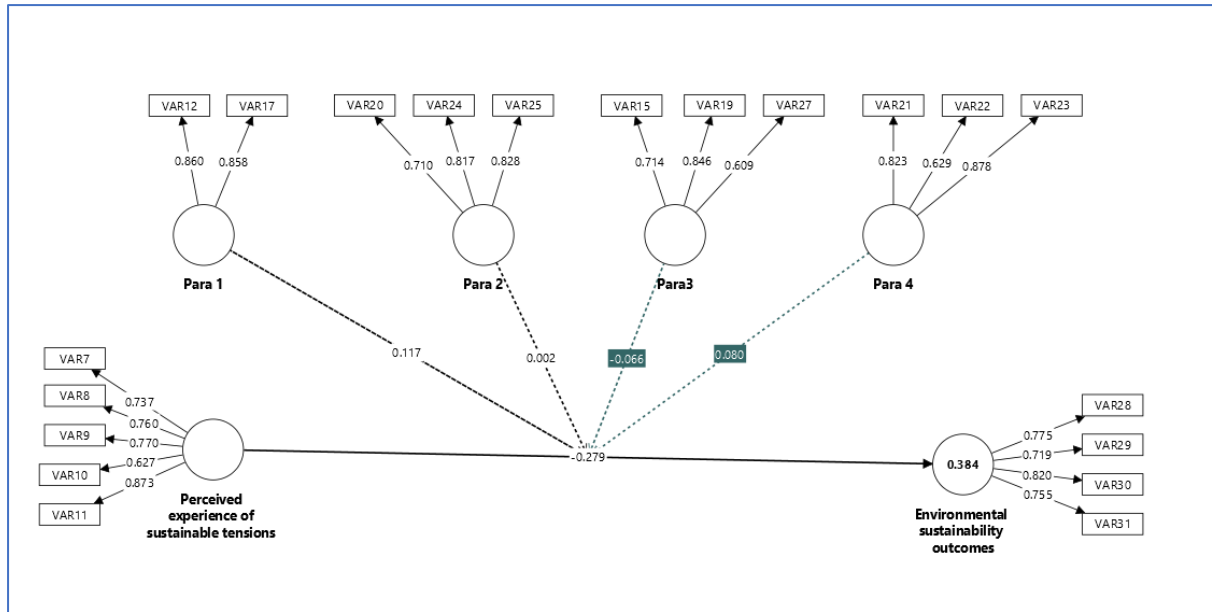


Figure 4: The refined model (Structural Model, PLS-SEM)

Table 7: Rotated component matrix

	Saturated model	Estimated model
SRMR	0.083	0.083

The internal consistency reliability, and convergent validity of the constructs were evaluated using Cronbach's alpha (α), composite reliability (ρ_a and ρ_c), and the average variance extracted (AVE). As shown in Table 8, most constructs demonstrated acceptable reliability and validity levels according to the recommended thresholds (Hair et al., 2019).

Cronbach's alpha values ranged from .567 to .820, indicating moderate to good internal consistency. Composite reliability values (ρ_a and ρ_c) were above the minimum acceptable value of .70 for most constructs, confirming satisfactory internal consistency reliability. The average variance extracted (AVE) values ranged from .532 to .738, exceeding the recommended minimum threshold of .50, which suggests that each construct explains more than 50% of the variance in its indicators, thus establishing convergent validity. Although 'Para 3' had slightly lower Cronbach's alpha ($\alpha = .567$), its composite reliability (.770) and AVE (.532) remained above the acceptable cutoff levels, indicating adequate reliability for exploratory research. Overall, the constructs met the criteria for internal consistency and convergent validity, supporting the soundness of the measurement model.

Table 8: Reliability and convergence validity analysis

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
ESO	0.770	0.782	0.852	0.590
Para 1	0.646	0.646	0.849	0.738
Para 2	0.689	0.693	0.829	0.619
Para 4	0.709	0.831	0.825	0.615
Para3	0.567	0.623	0.770	0.532
PEST	0.820	0.887	0.869	0.574

Discriminant validity was assessed using the Heterotrait–Monotrait (HTMT) ratio of correlations as recommended by Henseler et al. (2015). The HTMT criterion evaluates the degree of similarity between constructs by comparing correlations across different traits (heterotrait) relative to correlations within the same construct (monotrait).

For adequate discriminant validity, HTMT values should be below .85 for conceptually distinct constructs or below .90 for more closely related constructs (Henseler et al., 2015; Hair et al., 2019). In the current model, the HTMT ratios among constructs ranged from .064 to .691, all of which are below the conservative threshold of .85, indicating that discriminant validity was established. The results suggest that each construct is empirically distinct and measures a unique conceptual dimension. Additionally, interaction terms (Para 1 × PEST, Para 2 × PEST, Para 3 × PEST, and Para 4 × PEST) also displayed HTMT values below .85 relative to their main constructs.

Table 7: Discriminant validity

	ESO	Para 1	Para 2	Para 4	Para3	PEST	Para3 x PEST	Para 2 x PEST	Para 1 x PEST	Para 4 x PEST
ESO										
Para 1	0.528									
Para 2	0.375	0.632								
Para 4	0.214	0.322	0.691							
Para3	0.646	0.347	0.403	0.438						
PEST	0.425	0.293	0.432	0.114	0.223					
Para3 x PEST	0.085	0.156	0.128	0.271	0.096	0.249				
Para 2 x PEST	0.114	0.119	0.113	0.095	0.174	0.302	0.468			
Para 1 x PEST	0.079	0.064	0.114	0.251	0.247	0.114	0.404	0.526		
Para 4 x PEST	0.165	0.305	0.064	0.113	0.307	0.256	0.495	0.489	0.170	

Overall, the HTMT analysis supports the conclusion that the measurement model demonstrates strong discriminant validity, complementing the evidence of reliability and convergent validity from earlier analyses.

5.5.2 Predictive relevance, explanatory power and multicollinearity

The Stone–Geisser’s Q^2 value for Environmental Sustainability Outcomes (ESO) was 0.220, which is greater than zero as presented in Table 9, indicating that the model possesses predictive relevance for this endogenous construct (Hair et al., 2019). The Root Mean Square Error (RMSE) (0.904) and Mean Absolute Error (MAE) (0.694) values further support acceptable model prediction accuracy, showing that the predictive errors between the observed and predicted values are relatively low.

In terms of explanatory power, the R^2 value for ESO was 0.384, with an adjusted R^2 of 0.335, suggesting that approximately 38.4% of the variance in ESO is explained by its predictor constructs (such as Perceived Experience of Sustainable Tensions and the moderating variables). According to Cohen (2013), this represents a moderate level of explanatory power. Overall, the results indicate that the PLS-SEM model demonstrates acceptable predictive relevance and moderate explanatory capability for explaining environmental sustainability outcomes.

Table 8: Predictive relevance and explanatory power

	Q^2_{predict}	RMSE	MAE
ESO	0.220	0.904	0.694
	R-square	R-square adjusted	
ESO	0.384	0.335	

Before evaluating the structural relationships, collinearity diagnostics were performed to ensure that multicollinearity was not a concern among the predictor indicators. Variance Inflation Factor (VIF) values were examined for all measurement items and interaction terms. As shown in Table 10, all VIF values ranged from 1.000 to 1.968, which are well below the recommended threshold of 5.0 (Hair et al., 2019). This indicates that collinearity among indicators was not a problem and that the predictors are statistically independent.

Specifically, the highest VIF value was observed for VAR11 (1.968), while the lowest was for the interaction terms (Para 1 $\times$ PEST, Para 2 $\times$ PEST, Para 3 $\times$ PEST, and Para 4 $\times$ PEST), all equal to 1.000, suggesting no redundancy among the moderating variables.

Thus, the results confirm that the model is free from multicollinearity issues, ensuring stable and interpretable path estimates in the PLS-SEM analysis.

Table 9: Multicollinearity analysis

VARIABLES	VIF
VAR10	1.506
VAR11	1.968
VAR12	1.294
VAR15	1.169
VAR17	1.294
VAR19	1.227
VAR20	1.187
VAR21	1.704
VAR22	1.373
VAR23	1.371
VAR24	1.548
VAR25	1.534
VAR27	1.135
VAR28	1.415
VAR29	1.469
VAR30	1.675
VAR31	1.546
VAR7	1.552
VAR8	1.669
VAR9	1.656
Para 1 x PEST	1.000
Para 2 x PEST	1.000
Para 4 x PEST	1.000
Para3 x PEST	1.000

5.5.3 Structural model and hypotheses

Table 11 presents the path coefficient of the structural model which was used to test hypothesis 1 and hypothesis 2.

Table 10: Path coefficients

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values
Para 1 -> ESO	0.241	0.242	0.083	2.901	0.004
Para 1 x PEST-> ESO	0.117	0.115	0.094	1.248	0.212
Para 2 -> ESO	0.023	0.011	0.100	0.235	0.815
Para 2 x PEST-> ESO	0.002	0.007	0.119	0.013	0.990
Para 4 -> ESO	-0.052	-0.017	0.112	0.467	0.641
Para 4 x PEST-> ESO	0.080	0.057	0.132	0.605	0.545
Para3 -> ESO	0.403	0.384	0.094	4.294	0.000
Para3 x PEST-> ESO	-0.066	-0.058	0.113	0.582	0.561
PEST-> ESO	-0.279	-0.286	0.078	3.576	0.000

After confirming the reliability, validity, and absence of multicollinearity, the structural model was assessed to test the hypothesised relationships among constructs. The model evaluated both direct and moderating effects using bootstrapping with 5,000 subsamples (Hair et al., 2019).

Direct Effect (H1)

Hypothesis 1 (H1) proposed that perceived experience of sustainable tensions (PEST) would have a significant effect on environmental sustainability outcomes (ESO). The results revealed a significant negative relationship between PEST and ESO ($\beta = -0.279$, $t = 3.576$, $p < .001$), indicating that higher levels of perceived sustainable tensions are associated with lower environmental sustainability outcomes. Thus, H1 is supported.

Moderation Effects (H2a -H2d)

Hypothesis 2 (H2) examined whether Para 1, Para 2, Para 3, and Para 4 moderate the relationship between PEST and ESO. Para 1 $\times$ PEST $\rightarrow$ ESO: The interaction term was not significant ($\beta = 0.117$, $t = 1.248$, $p = .212$), indicating that Para 1 does not moderate the effect of PEST on ESO. Para 2 $\times$ PEST $\rightarrow$ ESO: The interaction was non-significant ($\beta = 0.002$, $t = 0.013$, $p = .990$), suggesting no moderating effect. Para 3 $\times$ PEST $\rightarrow$ ESO: The moderation effect was also non-significant ($\beta = -0.066$, $t = 0.582$, $p = .561$), indicating that Para 3 does not alter the PEST–ESO relationship. Para 4 $\times$ PEST $\rightarrow$ ESO: Similarly, the interaction was non-significant ($\beta = 0.080$, $t = 0.605$, $p = .545$), showing no moderation effect. Hence, none of the moderation effects on hypothesis H2 was supported.

However, the direct paths from Para 1 ($\beta = 0.241$, $t = 2.901$, $p = .004$) and Para 3 ($\beta = 0.403$, $t = 4.294$, $p < .001$) to ESO were significant, indicating that these parameters exert a positive and direct influence on environmental sustainability outcomes independent of the moderating effects. The remaining direct effects, Para 2 $\rightarrow$ ESO ($\beta = 0.023$, $p = .815$) and Para 4 $\rightarrow$ ESO ($\beta = -0.052$, $p = .641$) were not significant.

5.5.4 One-way and two-way and hypothesis testing

Hypothesis 3a (H3a) proposed that there would be statistically significant differences in Para 1, Para 2, Para 3, and Para 4 among respondents at different management levels: executive management, senior management, and middle management. The descriptive statistics is presented in Table 14.

Table 11: Descriptive statistics

Descriptives									
		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Para1	None	13	3,7385	,83420	,23137	3,2344	4,2426	2,20	4,60
	Informal	69	3,8580	,57199	,06886	3,7206	3,9954	1,80	5,00
	Formal	41	3,6488	,68525	,10702	3,4325	3,8651	2,20	5,00
	Total	123	3,7756	,64355	,05803	3,6607	3,8905	1,80	5,00
Para2	None	10	4,0000	,28868	,09129	3,7935	4,2065	3,50	4,50
	Informal	65	4,1731	,38508	,04776	4,0777	4,2685	3,25	5,00
	Formal	33	4,3258	,47797	,08320	4,1563	4,4952	3,00	5,00
	Total	108	4,2037	,41602	,04003	4,1243	4,2831	3,00	5,00
Para3	None	10	3,8000	,71492	,22608	3,2886	4,3114	2,50	4,75
	Informal	64	4,0273	,50615	,06327	3,9009	4,1538	2,50	5,00
	Formal	35	3,9500	,52790	,08923	3,7687	4,1313	2,50	5,00
	Total	109	3,9817	,53328	,05108	3,8804	4,0829	2,50	5,00
Para4	None	13	3,0769	,90935	,25221	2,5274	3,6264	1,50	4,00
	Informal	69	3,5145	,93922	,11307	3,2889	3,7401	1,00	5,00
	Formal	41	3,5610	,85290	,13320	3,2918	3,8302	1,00	5,00
	Total	123	3,4837	,91198	,08223	3,3210	3,6465	1,00	5,00

Table 12: ANOVA analysis

		Sum of Squares	df	Mean Square	F	Sig.
Para1	Between Groups	1,146	2	,573	1,392	,253
	Within Groups	49,381	120	,412		
	Total	50,527	122			
Para2	Between Groups	,968	2	,484	2,894	,060
	Within Groups	17,551	105	,167		
	Total	18,519	107			
Para3	Between Groups	,499	2	,249	,875	,420
	Within Groups	30,215	106	,285		
	Total	30,713	108			
Para4	Between Groups	2,461	2	1,231	1,492	,229
	Within Groups	99,006	120	,825		
	Total	101,467	122			

The results of the one-way ANOVA indicated that there were no statistically significant differences among management levels for Para 1, Para 2, or Para 3. However, there was a significant difference for Para 4, suggesting that perceptions related to this parameter vary by management level. Para 1: $F(2, 120) = 1.165$, $p = .315$, Para 2: $F(2, 105) = 0.201$, $p = .819$, Para 3: $F(2, 106) = 0.663$, $p = .517$, Para 4: $F(2, 120) = 3.379$, $p = .037$ (Table 15).

Since the one-way ANOVA for Para 4 revealed a statistically significant difference among management levels, $F(2, 120) = 3.379$, $p = .037$, a post hoc analysis using the Least Significant Difference (LSD) test was conducted to determine which specific groups differed significantly from each other. The results indicated that the Senior Management group ($M = 3.64$, $SD = 0.77$) scored significantly higher on Para 4 than the Middle Management group ($M = 3.20$, $SD = 1.01$), with a mean difference of 0.44, $p = .013$, 95% confidence interval (CI) [0.096, 0.784]. However, the differences between Executive Management ($M = 3.64$, $SD = 1.14$) and Senior Management ($p = .996$) or Middle Management ($p = .149$) were not statistically significant.

Table 13: Descriptive statistics

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Para1	Executive management	11	3,8727	,38234	,11528	3,6159	4,1296	3,20	4,40
	Senior management	69	3,8348	,63334	,07625	3,6826	3,9869	1,80	5,00
	Middle management	43	3,6558	,70417	,10739	3,4391	3,8725	2,20	5,00
	Total	123	3,7756	,64355	,05803	3,6607	3,8905	1,80	5,00
Para2	Executive management	10	4,1500	,42817	,13540	3,8437	4,4563	3,50	5,00
	Senior management	60	4,2250	,40048	,05170	4,1215	4,3285	3,25	5,00
	Middle management	38	4,1842	,44526	,07223	4,0379	4,3306	3,00	5,00
	Total	108	4,2037	,41602	,04003	4,1243	4,2831	3,00	5,00
Para3	Executive management	10	4,1500	,59161	,18708	3,7268	4,5732	3,00	5,00
	Senior management	64	3,9453	,53354	,06669	3,8120	4,0786	2,50	5,00
	Middle management	35	4,0000	,52159	,08817	3,8208	4,1792	2,50	5,00
	Total	109	3,9817	,53328	,05108	3,8804	4,0829	2,50	5,00
Para4	Executive management	11	3,6364	1,14217	,34438	2,8690	4,4037	1,00	5,00
	Senior management	69	3,6377	,77119	,09284	3,4524	3,8229	1,00	5,00
	Middle management	43	3,1977	1,00676	,15353	2,8878	3,5075	1,00	5,00
	Total	123	3,4837	,91198	,08223	3,3210	3,6465	1,00	5,00

Table 14: ANOVA analysis

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Para1	Between Groups	,962	2	,481	1,165	,315
	Within Groups	49,564	120	,413		
	Total	50,527	122			
Para2	Between Groups	,070	2	,035	,201	,819
	Within Groups	18,448	105	,176		
	Total	18,519	107			
Para3	Between Groups	,380	2	,190	,663	,517
	Within Groups	30,334	106	,286		
	Total	30,713	108			
Para4	Between Groups	5,410	2	2,705	3,379	,037
	Within Groups	96,057	120	,800		
	Total	101,467	122			

This suggests that Senior Management perceives or engages more strongly with the construct represented by Para 4 compared to middle management, while executive management's perceptions do not significantly differ from either group. As such, hypothesis 3a is partially supported.

Hypothesis 3b (H3b) proposed that there are significant differences in the levels of Para 1, Para 2, Para 3, and Para 4 among the three groups — None, Informal, and Formal. To examine this, a one-way ANOVA was conducted for each parameter. The descriptive statistics are provided in Table 12. Mean comparisons indicated that participants in the Informal group tended to report slightly higher mean scores across most parameters compared to the None and Formal groups. For instance, Para 2 means were highest among the Formal group ($M = 4.33$, $SD = 0.48$), followed by the Informal ($M = 4.17$, $SD = 0.39$), and None ($M = 4.00$, $SD = 0.29$) groups. The ANOVA results (Table 13) showed no statistically significant differences in the mean scores of Para 1, Para 2, Para 3, or Para 4 across the three groups.

Table 15: Post hoc test (Multiple comparison)

LSD							
Dependent Variable	(I) Role in sustainability:	(J) Role in sustainability:	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Para4	Executive management	Senior management	-,00132	,29047	,996	-,5764	,5738
		Middle management	,43869	,30230	,149	-,1598	1,0372
	Senior management	Executive management	,00132	,29047	,996	-,5738	,5764
		Middle management	,44001*	,17383	,013	,0958	,7842
	Middle management	Executive management	-,43869	,30230	,149	-1,0372	,1598
		Senior management	-,44001*	,17383	,013	-,7842	-,0958

*. The mean difference is significant at the 0.05 level.

In summary, Hypothesis 3b was not supported. The results indicate that the type of engagement group based on training variability (None, Informal, or Formal) does not significantly influence participants' scores on Para 1, Para 2, Para 3, or Para 4.

A two-way ANOVA was conducted to examine the main and interaction effects of Role in organisation (Executive, Senior, and Middle management) and Type of Sustainability Training (None, Informal, Formal) on the four dependent variables (Para 1–Para 4). For Para 1, results indicated no significant main effects or interaction effects. The main effect of Role in Sustainability was not significant, $F(2, 114) = 2.03$, $p = .136$, $\eta^2 = .034$, and the main effect of Type of Sustainability Training was also non-significant, $F(2, 114) = 0.72$, $p = .490$, $\eta^2 = .012$. Furthermore, the interaction between Role in Sustainability and Type of Sustainability Training was not significant, $F(4, 114) = 0.65$, $p = .630$, $\eta^2 = .022$. The overall model explained only 6.6% of the variance in Para 1 (adjusted $R^2 = .000$) (Table 16).

Table 16: Para 1 for test of between-subjects effects

Dependent Variable: Para1						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3,333 ^a	8	,417	1,006	,435	,066
Intercept	582,545	1	582,545	1407,163	<.001	,925
Role in sustainability	1,678	2	,839	2,027	,136	,034
Type of sustainability training	,594	2	,297	,717	,490	,012
Role in sustainability * Types of sustainability training	1,071	4	,268	,647	,630	,022
Error	47,194	114	,414			
Total	1803,920	123				
Corrected Total	50,527	122				

a. R Squared = ,066 (Adjusted R Squared = ,000)

For Para 2, neither main effects nor interaction effects were statistically significant. The effect of Role in an organisation was non-significant, $F(2, 99) = 0.07$, $p = .932$, as was the effect of Type of Sustainability Training, $F(2, 99) = 0.92$, $p = .402$. The interaction effect between Role and Training was also non-significant, $F(4, 99) = 0.38$, $p = .824$. The model accounted for 6.9% of the variance (adjusted $R^2 = -.006$) as presented in Table 17.

Table 17: Para 2 for test of between-subjects effects

Dependent Variable: Para2						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1,281 ^a	8	,160	,920	,504	,069
Intercept	601,658	1	601,658	3455,494	<.001	,972
Role in sustainability	,025	2	,012	,071	,932	,001
Type of sustainability training	,320	2	,160	,919	,402	,018
Role in sustainability * Types of sustainability training	,263	4	,066	,378	,824	,015
Error	17,238	99	,174			
Total	1927,000	108				
Corrected Total	18,519	107				
a. R Squared = ,069 (Adjusted R Squared = -,006)						

For Para 3, the analysis revealed no significant main or interaction effects. The main effect of Role in an organisation approached but did not reach statistical significance, $F(2, 100) = 2.36$, $p = .100$. The effects of type of sustainability training, $F(2, 100) = 0.07$, $p = .930$, and the interaction effect, $F(4, 100) = 1.22$, $p = .306$, were not significant. The model explained 7.6% of the variance (adjusted $R^2 = .002$).

Table 18: Para 2 for test of between-subjects effects

Dependent Variable: Para3						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2,342 ^a	8	,293	1,032	,417	,076
Intercept	595,259	1	595,259	2098,128	<.001	,955
Role in sustainability	1,339	2	,670	2,360	,100	,045
Type of sustainability training	,041	2	,020	,072	,930	,001

Role in sustainability * Type of sustainability training	1,387	4	,347	1,222	,306	,047
Error	28,371	100	,284			
Total	1758,750	109				
Corrected Total	30,713	108				
a. R Squared = ,076 (Adjusted R Squared = ,002)						

For Para 4, the two-way ANOVA also found no significant main or interaction effects. The effect of Role in organisation was not significant, $F(2, 114) = 2.27$, $p = .108$, $\eta^2 = .038$, and Type of Sustainability Training was also non-significant, $F(2, 114) = 0.03$, $p = .975$, $\eta^2 = .000$. Similarly, the interaction effect between Role and Training was non-significant, $F(4, 114) = 0.27$, $p = .900$, $\eta^2 = .009$. The model accounted for 7.2% of the variance (adjusted $R^2 = .007$).

Table 19: Para 4 for test of between-subjects effects

Tests of Between-Subjects Effects						
Dependent Variable: Para4						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	7,315 ^a	8	,914	1,107	,364	,072
Intercept	484,151	1	484,151	586,211	<.001	,837
Role in sustainability	3,755	2	1,877	2,273	,108	,038
Type of sustainability training	,042	2	,021	,025	,975	,000
Role in sustainability * Type of sustainability training	,877	4	,219	,265	,900	,009
Error	94,152	114	,826			
Total	1594,250	123				
Corrected Total	101,467	122				

a. R Squared = ,072 (Adjusted R Squared = ,007)

Overall, the two-way ANOVA results indicated no significant main or interaction effects of Role in Sustainability or Type of Sustainability Training on Para 1–Para 4. These findings suggest that neither managerial role nor training type significantly influenced the Para variables, and that their combined effects do not produce meaningful differences. As such, hypothesis 3c is not supported.

5.6 Conclusion

The present study aimed to explore the relationship between Perceived Experience of Sustainable Tensions (PEST) and Environmental Sustainability Outcomes (ESO), as well as the moderating effects of Para 1, Para 2, Para 3, and Para 4 (H2) on this relationship. Hypothesis 1 proposed that PEST would negatively affect ESO. The results strongly support this hypothesis, as a significant negative relationship was found between PEST and ESO ($\beta = -0.279$, $t = 3.576$, $p < .001$). This suggests that higher levels of sustainable tensions are associated with lower environmental sustainability outcomes, indicating that perceived tensions may act as a barrier to achieving effective sustainability results. Hypothesis 2, which examined the moderating effects of Para 1, Para 2, Para 3, and Para 4 on the PEST–ESO relationship, was not supported. None of the interaction terms between PEST and the para variables showed a significant effect on ESO. Specifically, the interactions between Para 1 $\times$ PEST, Para 2 $\times$ PEST, Para 3 $\times$ PEST, and Para 4 $\times$ PEST were all non-significant, indicating that these para variables do not moderate the relationship between sustainable tensions and sustainability outcomes in this context. In summary, the study reveals that while PEST directly impacts ESO, the hypothesised moderating effects of the para variables were not substantiated. Hypothesis 3 is partially supported, specifically regarding the influence of role on Para 4, suggesting that the senior management role (3a) affects the paradoxical cognitive framing of sustainability-prone challenges. These findings suggest that addressing the negative impact of sustainable tensions on environmental outcomes may be more crucial than focusing on potential moderating factors.

6. DISCUSSIONS OF RESULTS

6.1 Introduction

This chapter interprets the results and links them to the aims of the study. It explains what the results mean for management and firms in the South African mining industry. It connects the findings to paradox theory and to the literature on corporate sustainability (CS). It shows where the study's results confirm past work, identifies the nuances and contribute something new. It also notes any results that differ from expectations. Each section follows the research objectives and hypotheses. The discussion keeps the context in view. It considers roles, training, and outcomes and highlights practical lessons.

CS is an essential aspect of the modern business model, and companies seeking to advance legitimate business practices in their businesses pursue CS through frameworks such as the triple bottom line, which advocate for the balance of economic, social and environmental performance (Wannang & Gold, 2020). However, this embodies challenges that manifest in the form of tensions (Bianchi & Testa, 2022). This underscored the purpose and the aim of the study, which is to investigate how executive leaders and management (TMT) in the South African mining industry perceive and act on sustainability tensions, specifically between production efficiency and long-term environmental resilience.

In this instance, the environmental resilience represented the environmental outcome. Additionally, the study evaluated the paradoxical framing of the perceived experience of sustainability tensions amongst TMT and how it modulates the interaction between the perceived sustainability tensions and the environmental outcomes. Lastly, the study also tested whether organisational functional roles, variations in sustainability training, shaped management' paradoxical cognitive framing of sustainability tensions, which in turn influenced positive environmental outcomes within the South African mining industry. The research is grounded in sustainability literature and the paradox theory.

6.2 Relationship between perceived sustainability tensions (efficiency versus resilience) and environmental sustainability outcomes

Prior research by Frazer (2021) suggested that the manager's perception of sustainability tension, not founded on the principle of the paradox theory, but based on the perception of a trade-off where production efficiency is prioritised over long-term environmental resilience, contributes to adverse environmental outcomes. Therefore, Hypothesis 1 (H1) sought to test the existence of a relationship between perceived sustainability tensions by TMT and the environmental sustainability outcome. In contrast, the Null hypothesis (H0) posits that there is no correlation between perceived sustainability tensions by TMT and the environmental sustainability outcomes.

The Likert-scale outcome showed some nuances in the distribution of respondents' feedback, with the mean and median for the item measured at 3.02 to 3.90 and 3.00 to 4.00, respectively. According to the mean score, there is a split perception amongst the participants, in that a minority who did not agree with the sentiment were unsure how to express their views, while others seemed to believe that sustainability-born tensions did not exist in their organisation. These results showed a skewed distribution that leans towards the left, indicating a central tendency which is indicative of participants' agreement with the sentiments of the items presented in the questions. This positioning of the results seems to support the view that the mining industry constantly has to navigate tensions of sustainability, particularly between efficiency and environmental sustainability, as argued by Mnwana & Bowman (2022).

Notably, although the slight majority of participants leaned towards disagreeing with the sentiment that their organisation struggled to pursue short-term efficiency and long-term adaptability to adverse changes, as represented by item VAR9, some respondents were neutral, while others disagreed with the sentiment. The combination of neutral participants and those who agreed with the sentiment, however, was considerable (mean = 2.89, median = 3.00). These notable differences in the distribution of the results, particularly in perception as measured by item VAR9, align with the view that some mining companies still prioritise efficiency or cost reduction over environmental stewardship and consistent with Bora (2024).

The company's environmental sustainability outcomes, as measured by items VAR28 to VAR31, the overwhelming majority seem to agree that their companies have been successful in achieving desirable environmental outcomes, as expressed by the mean range of 3.70 to 4.22 and the median of 4.00. However, there are differences in the distribution of results regarding participants' perceptions, with some respondents expressing sentiments suggesting a lack of success in achieving positive environmental sustainability outcomes. The data distribution is also skewed to the left, which seems to support Okeke's (2024) argument that some organisations still struggle to manage the tensions of sustainability, as results that favour company profitability always disadvantage environmental sustainability outcomes. This may be attributed to the business case approaches to sustainability adopted by some organisations, where economic strategic demands outweigh social and environmental investments, thereby simplifying organisational tensions (Unison, 2025; Rezaess, 2020).

The inferential analyses results that examine the relationship between perceived experience of sustainable tensions (PEST) and environmental sustainability outcome (ESO) revealed a negative relationship between PEST and ESO ($\beta = -0.279$, $t = 3.576$, $p < .001$), suggesting an association of a higher level of perceived sustainability tension by TMT with a lower sustainability outcome. Thus, supporting hypothesis 1 (H1), which postulated a negative relationship between ESO and PEST. The results are misaligned with Frazers' (2021) argument that increased managerial awareness of sustainability tensions leads to desirable environmental outcomes. The results are consistent with Carmine & Marchi's (2022) view that the relationship between the two constructs, if not moderated, was negative.

Wu et al. (2024) argued that institutional logics that favour business performance at the expense of sustainability commitment are the real hindrance to sustainability performance. Depending on the leadership orientation to sustainability, which is critical to shaping the company's strategy and culture, the organisation may respond to the tensions with actions that yield symbolic or substantial sustainability change (Wu et al., 2024).

Although TMT may have heightened knowledge and awareness of sustainability tensions, decision-making by high-level leadership may not necessarily be focused

on identifying innovative solutions that ensure the mutual pursuit of goals that include environmental stewardship and social welfare, as it may compromise short-term profitability. For instance, if the top leadership of the organisation subscribes to Friedman (1970), who argues that the existence of the business in society is to make a profit, the strategic decisions taken in boardrooms will pursue economic goals over environmental and social goals. However, if top leadership aligns with logics such as the business case for sustainability, which advocates shared value creation, the strategic decisions and direction will reflect a legitimate intention to drive all elements of sustainability (Freudenreich et al., 2020).

The scholarly literature on practical guidelines on how to implement CS strategies is scant, and there is also a gap in the integration of decision-making, strategic management and corporate sustainability (Kitsios et al., 2020). Although this presents an opportunity for theoretical development, it also explains the results of this study. Given the complexity of CS, there is a considerable distance between strategic implementation, decision-making, and strategic management. Although tensions may be easily identified, the lack of a clear practical guide on how to integrate decision-making practices that consider the principle of corporate sustainability might hinder business response (Kitsios et al., 2019). This, therefore, translates into a negative sustainability outcome for the organisation.

Furthermore, if there is a strategic gap, the senior management and middle management may find it challenging to implement and communicate with lower levels of work, thus impacting the company's sustainability performance. Interestingly, the majority of participants in the study were in middle and senior management (executive management = 8.9%, senior management = 56%, middle management = 35%).

According to Sajj et al. (2023), leaders of the executive level, particularly the CEO, influence the sustainability strategic vision and are responsible for defining the sustainability strategic objective. In comparison, senior management translates the vision and objectives into policies, processes, and goals (Famiyer et al., 2021). Therefore, a lack of clarity in the vision and strategic sustainability objective will negatively affect the successful implementation of the company's corporate sustainability strategy, further creating a gap between the perceived experience of tensions and the actual environmental sustainability outcome.

6.3 The moderating effects of paradoxical framing

Sustainability literature founded on the paradox theory acknowledges the role of cognitive frames in shaping managerial responses and decision-making in CS (Lewis & Smith, 2022). Furthermore, empirical studies postulated that management with strong qualities of paradoxical cognitive framing can transform latent tensions into salient tensions and demonstrate a positive outlook on their persistence and contradictory nature, thereby employing an innovative approach that fosters positive environmental sustainability outcomes (De Klerk & Swart, 2023; Carmine & De Marchi, 2022).

Hypothesis 2 (H2) examines whether the presence of paradoxical cognitive framing (Para 1 to Para 4) mediates the relationship between sustainability tensions and environmental outcome. The null hypothesis (H0), argues that there is no modulation effect of paradoxical cognitive framing on the correlation between perceived experience of sustainability tensions and environmental outcomes. The hypotheses presented are underpinned by De Klerk & Swart (2023), Lewis & Smith (2022) and Carmine & De Marchi (2022) assertions, which argue that organisational and individual paradoxical frames shape managerial decision making concerned with sustainability tensions and drive balanced performance amongst all domains of sustainability.

The results suggest that participants agreed with the sentiments expressed by the items proposed to explain the organisational construct and moderately agreed with those proposed to explain individual cognitive framing. The means for items measuring organisational paradoxical cognitive framing (VAR12 to VAR19) were between 3.30 and 4.24, and the median was 4.00. The distribution of feedback on organisational paradoxical framing showed a slightly skewed distribution, with the central tendency leaning to the left for VAR12, VAR13, VAR14, VAR16, and VAR17. This suggests that some companies are still maintaining symbolism in their sustainability approach, preferring a trade-off approach over a paradoxical one, which agrees with Seidemann (2024), given its lack of pragmatism. Interestingly, VAR15, VAR18, and VAR19 showed a positively skewed distribution, suggesting that only few participants did not agree with the proposed sentiments. Thereby supporting the view that companies are increasingly moving away from a trade-off approach when managing sustainability practices and are beginning to adopt a paradoxical

cognitive lens to shape how they respond to sustainability tensions (Wannang & Gold, 2020). However, the results also suggest that companies still face perception challenges in how they interpret and respond to the paradoxes of CS, although insignificant.

Whereas, the mean range for items measuring individual paradoxical cognitive framing ranged from 3.86 to 3.99, and the median was 4.00. Data distributions for these variables showed slightly left-skewed curves. Although the majority of the respondents agreed with the paradoxical framing of tensions of sustainability on an individual level, there were a few who were either indecisive or did not agree, which did not fully support Okeke's (2024) view on challenges faced by the mining industry regarding balancing the competing goals of sustainability, as the results seek to suggest that on an individual level the perception is swayed towards paradoxical framing of C tensions

Hypothesis (H2) examined whether Para 1-4 moderated the relationship between perceived experience of sustainability tensions and environmental sustainability outcomes. The results indicated that Para 1, Para 2, Para 3 and Para 4 did not moderate the relationship between PEST and ESO. As a result, hypothesis two, which postulated a moderation effect of paradoxical cognitive effect on the relationship between the PEST and the ESO, was rejected. The result seeks to oppose the quantitative results of Carmine & De Marchi (2022), which found a positive moderation effect between perceived experience of sustainability tension and environmental outcomes. Notably, a direct path from Para 1 to Para 3 was significant, suggesting a positive influence on ESO. Organisational paradox framing, represented by Para 1 and Para 3, therefore has a direct and positive effect on ESO. This aligns with Bloemelburg et al. (2023), who argue that the conceptual link between organisational learning and paradoxical cognitive framing shapes organisational attitudes towards excellent sustainability performance.

The literature anticipates a moderating role for paradoxical framing. Paradox theory holds that contradictions such as efficiency and resilience are persistent and interdependent; thus, organisations require integrative frames that enable actors to accept both poles and to design routines, metrics, and governance that coordinate them over time (Waldman et al., 2019; Carmine & Smith, 2024). Research on

corporate sustainability cautions that narrow trade-off logics create long-term risk (Susanna, 2025), while simple win-win claims can neglect constraints (Riedjiek et al., 2024) and a both-and approach, supported by formal processes and learning systems, is recommended. Furthermore, Seiden (2024) cautions that the principles of paradox theory in sustainability may be idealistic and largely conceptual, given real-world contextual considerations such as resource scarcity, power imbalances, and policy constraints, which may push the company to not fully commit to paradox theory. Ingram (2025) further identifies the delayed and absent responses of organisations to sustainability tensions as one of the unintended consequences of excessive paradox theory. The influence of paradox theory on the interaction between sustainability tension and environmental sustainability outcome, when controlled by other organisational factors, may be possible. However, the theoretical extension of the paradox theory in corporate sustainability may be hindered by the dynamism of the environment and other organisational factors, as stated by scholars such as Seidemann (2022) and Igram (2024), and supported by the research results of the current study presented.

The dominant theoretical expectation also anticipated that individual paradoxical cognitive effects would moderate perceived sustainability tensions and environmental sustainability outcomes, as posited by Carmin & De Michi (2022), Carmin & Smith (2024), Lewis & Smith (2024) and Waldman et al. (2019), but the study's results did not support this. Leung et al. (2018) explain one reason why the study's results did not support H2. Framing of paradoxes often results in defensive responses such as denial of tensions, suppression, or compartmentalisation, thereby preventing orientation of the company's response mechanisms towards strategies that are proactive and transform tensions into innovative sustainability outcomes into favourable ones (Leung et al., 2018). For instance, leaders who subscribe to stability and exploitation principles pursue the innovative values of the company that seeks to navigate paradoxes of sustainability (Bojica & Martínez-Del-Río, 2023). From a theoretical perspective, institutional norms that define organisational and societal culture may intersect with individual processing of paradoxes of sustainability. Thereby imposing a trade-off effect on their response to sustainability tensions and inhibiting the application of paradoxical cognitive framing (Sasse-Werhahn et al., 2018). The distribution of results underscores the complexity of sustainability strategies and the subjectivity of paradox theory for both theoretical and operational

perspectives. The results suggest that although participants perceive the principles of paradox theory in the identification and interpretation of sustainability tensions, their responses to these tensions are often disconnected from these principles, which anticipate positive outcomes.

Sample characteristics provide further context. Most respondents operate in large enterprises and in senior or middle management positions, which are settings with stronger external scrutiny and more extensive environmental systems, yet the training profile remains predominantly informal. Informal training may strengthen practice (Hahn et al., 2014) but may not disseminate a deep paradox mindset consistently across divisions. This configuration can support improved outcomes and some alignment between organisational and individual frames, while falling short of the institutional depth typically associated with robust moderation effects (Schröder et al., 2023; Draghici et al., 2021). The observed pattern is therefore consistent with an early or intermediate stage of institutionalisation in which outcome gains are visible, individual framing alleviates perceived tensions, and organisational framing has not yet produced a statistically apparent attenuation of the tensions–outcomes link.

6.4 Strategic roles and sustainability training: interaction effects on paradoxical cognitive framing

This research evaluates whether strategic role and sustainability training are linked to differences in paradoxical cognitive framing and whether their joint influence is present. Paradoxical cognitive framing was assessed at the individual level and at the organisational level, and the sample included executives, senior management, and middle management with varying exposure to none, formal and informal sustainability training.

The results suggest that the difference between management roles in terms of paradoxical cognitive framing, as expressed in Para 1 to 3, was not significant. All participants shared similar sentiments. The analyses, however, further indicate that the significant difference in role-specific effect on individual paradox framing, as expressed by Para 4, was evident in senior management and middle management. However, it was more prevalent in senior management.

The dominant anticipation in the literature supported the proposed hypothesis. Leadership scholars argue that executives assemble the company vision and advance sustainability to develop legitimacy. Senior management, however, translate strategy into processes, and middle management handle operational tensions where trade-offs are most visible. These different forms of roles shape how leadership frames paradox (Sajjad et al., 2023; Carmine & De Marchi, 2022; Leung et al., 2018). However, concerning Para 1 to Para 3, the literature's anticipation did not hold. Whereas the anticipation regarding Para 4 was supported. The majority of the participants agreed with the effect of strategic of individual paradox framing as expressed by VAR 21 to VAR23, which are all at the individual level. This outcome aligns with the literature, which anticipates role-specific shaping of individual cognitive framing. As management in different roles are confronted with paradoxes in their line of work and the constant framing of these paradoxes may alter their level of paradoxical cognitive framing (Cihan, 2025).

The results on Para 4 in relation to middle and senior management underscore the importance of the call for strategy clarity from top-tier leadership. The disconnect between the three levels of leadership has the potential to impact decision-making that aims to navigate sustainability tensions and the implementation of sustainability goals (Sajj et al.,2023).

It is also worth noting that the distribution of results might have played a role in the distribution regarding the executive committee's role in Para 1 to Para 4. The demographic information of respondents shows that only 8.9% of the participants represented the executive committee leadership group. Therefore, the statistical power required to yield reliable, predictable results may not be achieved given the size of the participants in this group. The statistical power of a sample eliminates misleading signals such as false negatives (Baguley, 2004).

Another element of speculation presented by the study is expressed by hypothesis (H3b), which aimed to suggest training variation effect on Para 1 to 4. Scholars such as Schröder et al., (2023) suggested that effective administration of formal and informal training is a conduit through which cognitive frames can be shaped. Information sharing across an organisation on sustainability bolsters sustainability knowledge and influences paradoxical cognitive framing. Formal training is critical

for embedding standardised knowledge that integrates dominant frameworks, measurable indicators and structured thinking that is rule-based (Hahn et al., 2014). Informal training such as on-the-job training, applied the theoretical aspects of sustainability training through practical application. However, it is possible to acquire informal training through a project without prior formal training, although the two forms are complementary (Schröder et al., 2023).

The average scores amongst the participants with no training, formal training and informal training were compared, and the analysis revealed that participants with formal training reported high scores across Para1 to Para 4, followed by the group with no training and those who have acquired informal training. Nonetheless, the statistical test diagnosed no significant differences amongst the group and did not align with the anticipated expectation of the literature as outlined by hypothesis 3b. However, Para 2 came close to being significant. Therefore, the claim by scholars such as Hahn et al. (2014) and Schröder et al. (2023) that suggests the type of training on sustainability had an influence on all the parameters of paradoxical cognitive framing did not hold.

The complementary effect of formal and informal training may explain the results. The role of informal training is to enforce and embed formal training, whereas formal training provides structured knowledge and a measurable value-based framework (Schröder et al., 2023). One type of training administered alone cannot realise a shift in cognitive framing towards paradoxical management. Werhahn et al. (2018) also argued that personal value systems and personal experience, which shape cognitive bias, may dilute the influence of training towards shaping paradoxical cognitive framing. Therefore, training alone may fall short if it lacks context and personalisation.

H3c explores the extent to which TMT's role in the organisation and their training exposure to sustainability interact to moderate paradoxical cognitive framing. Organisational learning theory posits that cognitive processing is shaped by organisational structures, such as assigned leadership responsibilities and training exposure (Boemelburg et al., 2023). TMT encounter tensions in organisations, particularly in companies that subscribe to the corporate sustainability model when sustainability is integrated with the mainstream business model. Scholars such as

Sasse-Werhan et al. (2018) and Boemelburg et al. (2023) aligned with the notion that the most effective way to develop and embed paradoxical cognitive framing in an organisation is through a collaborative approach combining strategic roles and practical training. Thus, the hypothesis postulates a combined intersection effect of training and strategic leadership role in shaping the paradoxical cognitive framing of sustainability tensions.

The dominant literature reviewed postulates that the combined effect of strategic roles and training shapes cognitive processing towards paradoxical cognitive framing. Statistical analyses were conducted to explore whether the leadership role and the type of sustainability training combined influenced paradoxical cognitive framing, as expressed in Para 1 to 4. The outcome demonstrated that neither training nor the TMT role had a significant effect on the framing of paradoxes. The results also showed no significant main effect of the combined training and role on paradoxical cognitive framing. Thus, the proposed effect, as postulated by hypothesis 3c and supported by Sasse-Werhan et al. (2018) and Boemelburg et al. (2023), remains unconfirmed.

Sustainability training, although predominantly identified as critical and essential for shaping the interpretation and understanding of paradoxes, requires a well-designed training mechanism that is contextually relevant and supported by organisational systems. Draghici et al. (2021) outlined that the two modes of training are fundamental: formal training contributes to structured, methodical knowledge, including a normative framework. At the same time, informal training is responsible for a learning setup that is contextually relevant and practical. In addition, the TMT role within an organisation affects how sustainability tensions are perceived and addressed. Top-tier leadership approaches sustainability as a strategic imperative connected to legitimacy and long-term growth (Sajjad et al., 2023; Carmine & De Marchi, 2022), while senior management operationalise this vision through processes, standards, and measures (Famiyeh et al., 2021). Middle management, positioned at the operational frontline, interact with sustainability tensions daily, often fostering creativity through paradoxical framing (Leung et al., 2018). Leadership alignment, particularly in decentralised organisational structures, is a key foundation that shapes how individuals frame cognition and respond to sustainability paradoxes, beyond roles and training. (Mnwana & Bowman, 2021).

The findings also reflect the importance of organisational context. Manzhynski et al. (2024) suggest that the only conduit responsible for bringing sustainability tensions to salience is information sharing and cognitive transformation. Training alone is insufficient without leadership reinforcement, cultural legitimacy, and institutional support (Carmine & De Marchi, 2022; Bianchi & Testa, 2022). Furthermore, cognitive framing and sensemaking are founded on prior experiences, individual and ethical subscription, which affect the impact of training and role (Szabo & Ruotsalainen, 2022; Benkert, 2020.). The absence of significant interaction effects in this study fundamentally highlights that paradoxical cognitive framing is complex and interconnected. This provides opportunistic grounds to explore cognitive framing beyond training and strategic role on management in organisations.

6.5 Conclusion

The findings synthesise the empirical results with the literature. Environmental sustainability outcomes are negatively associated with perceived efficiency and resilience tensions, supporting H1 and rejecting H0. Individual paradoxical cognitive framing reduces perceived tensions, while organisational framing relates positively to outcomes but shows no statistically reliable moderation; H2 is not supported.

Differences in cognitive framing are not influenced by strategic role and by training exposure, consistent with H3a; H3c. It is important to note that hypothesis 3a was partially supported on Para 4, where the participants perceived that the senior management role has a significant influence on individual cognitive framing of CS paradoxes. The role and training interaction effect on paradoxical cognitive framing remains unconfirmed. Overall, the findings extend the paradox theory in a South African mining context and suggest the following priorities: deepen individual framing capabilities, institutionalise systems and incentives, and align leadership and training to embed both for and practice.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Focus and significance of the study

The research critically analysed the perceptions and management of sustainability tensions by management in the South African mining industry between efficiency-oriented towards cost reduction and productivity, and resilience-oriented towards environmental stewardship and long-term adaptability. It was based on the paradox theory (Carmin & De Marchi, 2022) and examined how paradoxical cognitive framing moderates the connection between these competing priorities. In addition, the research studied the effects of managerial role and sustainability training exposure. This is an important area of focus given that the mining sector, despite providing about 7.5% of the GDP of South Africa, is also the source of almost 38% of greenhouse gas emissions in the country (IEA, 2024), which presents inherent contradictions between the need to have an economy and the need to take care of the environment.

According to Lou et al. (2020) and Bianchi & Testa (2022), to overcome such paradoxes, the linear thinking of trade-offs needs to be replaced by integrative reasoning. This study contributes to the body of Corporate Sustainability (CS) research, which qualitative studies have long dominated. It provides empirical data on how managerial cognition can balance profitability and planetary limits.

7.2 Contextual importance of the South African mining sector

The South African mining industry presents a good example of a paradoxical environment of co-existence of two economic prosperities and environmental destruction, hence a good study site to examine paradoxical arguments in sustainability management. The industry contributes about 7.5% of the national GDP and emits approximately 38 % of the total greenhouse gas emissions (Energy Capital and Power, 2025; IEA, 2024), which is a conflict between national and international environmental policies regarding the development of nations and priorities.

These problems of sustainability are compounded by entrenched socio-political traditions, including inequality over the ages, regulatory insecurity, and high dependence on energy produced by coal (Mnwana & Bowman, 2021). Also, institutional contradictions, including the conflict between industrialisation and protecting the environment, point to the global process of such emergent economies trying to find economic sustainability despite the push to decarbonise (Laing & Pinto,

2023). According to Herrfahrdt-Pahle et al. (2020), sustainability paradoxes are unique in South Africa due to the unstable policy and governance environment, which is highly multifaceted and context-dependent. Thus, the industry is an appropriate research setting to operationalising the paradox theory. This is because the industry demonstrates how managerial roles in bridging the gap between conflicting sustainability goals in the resource-dependent and politically constrained worlds.

7.3 Established knowledge and identified research gaps

In the existing literature on CS, the interdependence and conflict between economic, social, and environmental objectives expressed within the triple bottom line model are widely recognised (Wannags & Gold, 2020). The paradox theory also builds on this insight by proposing that these tensions ought not to be disregarded but instead encouraged since they contribute to innovation and organisational learning (Carmine & De Marchi, 2022).

Although earlier studies, including Bianchi and Testa (2022) and Hameeri et al. (2017), conceptualised paradoxical framing as a thought ability to reconcile conflicting sustainability requests, the majority of studies are theoretical or concentrate on Western corporate settings, neglecting the ones that are resource-intensive and developing. The empirical studies that measure the relationship between tensions related to perceived sustainability and environmental outcomes are limited, especially studies that test hierarchical and training-based differences in paradoxical cognition. Furthermore, the African setting, which is characterised by institutional fragility, socio-political inequalities, and reliance on extractive industries, is also severely under investigated (Mnwana & Bowman, 2021). Thus, the research bridges an important gap in providing quantitative, context-specific evidence on the impact of managerial cognition and training exposure on sustainability outcomes in the South African mining sector, on the paradox management theory and its application to emerging-market realities.

7.4 Research questions (hypotheses) and empirical answers

The research investigated three interconnected claims to provide an empirical explanation of how management and executive committee members in the South African mining industry experience and cope with sustainability tensions. The first hypothesis tested the connection between perceived experience of sustainability

tensions between efficiency and resilience, with environmental sustainability outcomes, showing a significant negative correlation: greater perceived tensions were linked to lower environmental performance, consistent with Carmine & De Marchi (2022). The second hypothesis was whether paradoxical cognitive framing moderates this association, and it was found that both the individual and organisational levels of paradoxical cognitive framing, as expressed by Para1 to 4, did not have a moderating effect between perceived experience of sustainability tension (PEST) and environmental sustainability outcome (ESO). The third group of hypotheses, supported by hypotheses 3a to 3c (H3a-c), examined the effects of middle management, senior management and executive committee members' role (TMT) and exposure to sustainability training, with results indicating no effect of training variation on management and executive leaders' paradoxical cognitive framing with weak interaction between role and training. Collectively, these results empirically measured the amounts of cognitive and institutional aspects that sustain the capacity to make sustainable decisions in the face of unrelenting paradoxes related to CS.

7.5 Methodological approach and research design

The research philosophy used in the study was positivism, which helped in objective and measurable analysis of the relationships among sustainability tensions, paradoxical cognitive framing, and environmental outcomes. To test theoretically derived hypotheses based on empirical evidence, a deductive methodology was used, relying on the paradox theory. A cross-sectional survey design was used to examine causal trends among the primary constructs in a given period, which allows generalisable and reproducible results. The questionnaire used structured questions with Likert scale items based on validated tools by Carmine & De Marchi (2022) and Bianchi & Testa (2022).

The purposive sample included 123 respondents, executive committee members, senior and middle management of South African mining companies directly involved with sustainability management. Statistical study involved testing on reliability and validity testing, and was found to be Cronbach's $\alpha > 0.7$, indicating acceptable internal consistency. The instrument overall proved to have a sufficient level of reliability for the study. Kaiser-Meyer-Olkin measure was determined to 0.71 and Bartlett's Test of Sphericity was insignificant, $\chi^2(120) = 435.70$, $p < .001$. This

qualified the data sample for factor analysis. The initial extraction yielded four factors with eigenvalues greater than 1.00, accounting for 56.86% of the variance. Varimax rotation was applied, and the four-factor solution provided a more simplified and interpretable structure as they were loading strongly on a factor. Structural equation modelling was conducted to assess the model fit of the dataset. The refined model retained 17 items loading on six constructs. Paradoxical cognitive framing is split into four factors, Par1 to Par 4. The model fit was evaluated using the standardised Root Mean Square Residual (SRMR). The SRMR was found to be below the minimum allowable threshold on both the saturated and estimated models, suggesting that the model is fit and suitable to support the adequacy of the proposed model specification.

7.6 Key findings and interpretations

The empirical evidence revealed some essential insights that enhance the comprehension of sustainability tensions and cognitive framing in the mining sector in South Africa. First, the results of structural equation model results supported the existence of a significant negative relation between perceived sustainability tensions and environmental outcomes ($\beta = -0.279$, $t = 3.576$, $p < .001$), and showed that stronger pressure of efficiency is likely to reduce environmental sustainability outcomes, which is also in line with the efficiency-resilience paradox reported by Mao et al. (2023) and Rezaee (2021). This confirms Hypothesis 1, which states that prioritisation of short-term productivity tends to undermine long-term ecological objectives.

Second, the moderating analysis revealed that the moderating effect on the correlation between the perceived experience of sustainability tensions (PEST) and the environmental sustainability outcome (ESO). In that, the interaction term measuring the moderating effect of Para 1 to Para 4 on the relationship between PEST and ESO was found to be insignificant. This implies that personal and organisational paradoxical cognitive framing cannot address paradoxes better than symbolic institutional rhetoric of tradeoff, which is inconsistent with the results of Bento et al. (2019) and Carmine & De Marchi (2022).

The third test had some nuances in that the hypothesis (H3a) was only supported on Para 4 which was concerned with the individual paradoxical framing effect on management, particularly senior management, whereas the difference of paradoxical

cognitive framing effect variation expressed by Para 1 to 3 on executive role was not significant. Management in their respective roles constantly have to navigate challenges of a paradoxical nature, particularly those shaped by sustainability, which, to an extent, shape their cognitive framing towards the paradox management principle (Cihan, 2025). The distribution of the demographic might have influenced the results for executive committee members, given the small participation rate for this group compared to senior and middle management.

Hypothesis 3b, explored the effect of training variation on the cognitive framing of the management and the executive committee. The analyses revealed no significant impact of training variation on senior management, middle management, and executive committee members, which emphasised the complementary effect of training and the possibility that other organisational factors, such as culture, values, and resource availability, may contribute to shaping one's cognitive framing (Schröder et al., 2023). For instance, the organisation that is exploitative in nature may thrive for stability at the expense of long-term environmental resilience (Ingram, 2024).

The last hypothesis that was explored was the integrated effect of variation in training modality and variation in leadership role of cognitive paradoxical framing, as expressed by Para 1 to 4. The results showed no significant impact on the integrated influence of training and role on paradoxical cognitive framing. Although the role provides an exposure to operation-specific conditions with inherent paradoxes, while training introduces knowledge and normative framework, there is still an extensive level of organisational and individual factors that explain the transformation of paradox framing. During crises, such as a global pandemic, leaders have the limitation of time; as a result, they may integrate a traditional method of decision making (Tabesh & Vera, 2020), as opposed to applying the principle of paradox theory, which is deemed conceptual and idealistic (Seiden, 2024). The operational and conceptual dynamics of paradoxical cognitive framing cannot be constrained to role or training or role and training. There is a far deeper nestedness with organisational factors and individual factors, presented as dynamics of institutional logics and norms.

7.7 Theoretical, methodological, and empirical contributions

This study makes several important contributions to the scholarly debate on CS and paradox management. Theoretically, it extends the paradox theory by empirically validating paradoxical cognitive framing as a measurable moderator between sustainability tensions and environmental outcomes, a relationship previously theorised but rarely tested quantitatively (Carmine & De Marchi, 2022). It demonstrates a multi-level influence of paradoxical cognitive framing on CS tension. Revealing a much more interconnected nature of cognitive framing that challenges the conceptual linear nature of application, thereby supporting, challenging and refining previous studies presented by scholars such as Bianchi & Testa (2022), Carmine & De Marchi (2022) and Lewis & Smith (2022). Methodologically, it pioneers the use of quantitative tools to capture paradoxical cognition through validated Likert-based constructs, enabling reliable measurement of the construct relationship studied. Empirically, it situates paradox theory within an emerging-market, extractive-industry context, bridging a significant regional gap in the literature (Mnwana & Bowman, 2021).

7.8 Managerial and practical implications

The managerial and policy implications of the current study are relevant, as they emphasise that successful sustainability management within the mining industry relies on cognitive agility and integrative decision-making instead of technical interventions only (Parfait, 2023). This suggests that mining executives should institutionalise systematic sustainability training to instill a sense of paradoxical reasoning and systems thinking, so that leaders can strike the right balance between profitability and ecological responsibility (Bao et al., 2020). Senior and middle management should operationalise these insights through the facilitation of cross-functional dialogue and paradox-awareness workshops that enhance adaptive decision-making between efficiency and resilience objectives (Bojica & Martínez-Del-Río, 2023).

At the policy level, industry associations and regulators ought to encourage leadership training programmes in the sector and integrate cognitive framing cues, given the sector's complex and interconnected nature, to assemble effective environmental, social and governance (ESG) assessment systems (Laing & Pinto,

2023). In addition, investors and other stakeholders have to evaluate organisations not just on financial and environmental performance, but also on how they reconcile conflicting sustainability priorities. Altogether, the research highlights the idea that organisational change towards sustainability in resource-intensive industries depends on institutional norms, as well as individual and organisational factors that shape cognitive framing towards paradox management, complementing training variation and organisational roles.

7.9 Directions for future research

To examine the paradoxical cognition, change over time, and its enduring influence on organisational performance as suggested by Lewis & Smith (2022), future research should adopt longitudinal designs to test the proposal to determine its dynamic nature. Such results can be tested to be applied to the emerging economies with various institutional logics and differing regulations, such as India, Indonesia, and Brazil (Laing & Pinto, 2023).

Also, the mixed-method research with the quantitative test and qualitative interview would characterise the behavioural manifestation of paradoxical framing in the managerial decision-making (Bento et al., 2019). The future models should also include the contextual variables such as the organisational culture, stakeholder pressures and governance mechanisms as the potential moderators. Furthermore, experimental or quasi-experimental studies would be adequate to measure the pre- and post-effects of paradox-based sustainability training on cognitive flexibility (Schröder et al., 2023). Additionally, the digital transformation and an Artificial Intelligence-based decision-support system should also be taken into consideration regarding their role in increasing or restricting paradoxical reasoning. Finally, the cross-disciplinary research on the use of management cognition, psychology, and environmental sciences is required in order to create adaptive and resilient sustainability systems to develop sustainable mining.

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9. APPENDICES

Appendix One: Missing value analysis

	N	Mean	Std. Deviation	Missing		No. of Extremes ^a	
				Count	Percent	Low	High
VAR5	123	3,90	1,051	0	,0	15	0
VAR6	123	3,50	1,155	0	,0	8	0
VAR7	123	3,02	1,215	0	,0	0	0
VAR8	123	3,47	1,074	0	,0	7	0
VAR9	123	2,89	1,085	0	,0	0	0
VAR10	123	3,40	1,069	0	,0	0	0
VAR11	123	3,02	1,141	0	,0	0	0
VAR12	123	3,67	1,014	0	,0	5	0
VAR13	123	3,66	1,015	0	,0	4	0
VAR14	123	3,44	1,049	0	,0	7	0
VAR15	122	4,14	,816	1	,8	6	0
VAR16	123	3,70	,966	0	,0	3	0
VAR17	123	3,30	1,108	0	,0	0	0
VAR18	111	4,24	,471	12	9,8	0	0
VAR19	118	4,14	,639	5	4,1	3	0
VAR20	111	3,99	,732	12	9,8	.	.
VAR21	123	3,98	,923	0	,0	14	0
VAR22	123	3,86	,986	0	,0	.	.
VAR23	123	3,89	,904	0	,0	.	.
VAR24	123	3,89	,857	0	,0	.	.
VAR25	123	3,55	1,010	0	,0	4	0
VAR26	118	4,26	,497	5	4,1	0	0
VAR27	120	4,18	,545	3	2,4	0	0
VAR28	123	3,91	1,008	0	,0	17	0
VAR29	123	3,76	1,064	0	,0	0	0
VAR30	123	4,22	,763	0	,0	6	0
VAR31	123	3,70	1,086	0	,0	6	0

a. Number of cases outside the range (Q1 - 1.5*IQR, Q3 + 1.5*IQR).

Appendix Two: Harman single test with exploratory factor analysis

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.008	18.547	18.547	4.236	15.688	15.688

Appendix Three: Descriptive statistics

	Mean	Median	Std. deviation	Skewness	Kurtosis
VAR5	3.90	4.00	1.051	-1.351	1.540
VAR6	3.50	4.00	1.155	-0.659	-0.503
VAR7	3.02	3.00	1.215	-0.115	-1.076
VAR8	3.47	4.00	1.074	-0.753	-0.243
VAR9	2.89	3.00	1.085	0.057	-1.168
VAR10	3.40	4.00	1.069	-0.569	-0.703
VAR11	3.02	3.00	1.141	0.019	-1.299
VAR12	3.67	4.00	1.014	-1.017	0.485
VAR13	3.66	4.00	1.015	-0.896	0.179
VAR14	3.44	4.00	1.049	-0.788	-0.190
VAR15	4.14	4.00	0.816	-1.097	1.719
VAR16	3.70	4.00	0.966	-0.858	0.348
VAR17	3.30	4.00	1.108	-0.401	-0.807
VAR18	4.24	4.00	0.471	0.670	-0.248
VAR19	4.14	4.00	0.639	-0.723	1.900
VAR20	3.99	4.00	0.732	-1.117	2.033
VAR21	3.98	4.00	0.923	-1.238	1.480
VAR22	3.86	4.00	0.986	-1.021	0.697
VAR23	3.89	4.00	0.904	-1.143	1.618
VAR24	3.89	4.00	0.857	-1.144	1.718
VAR25	3.55	4.00	1.010	-0.705	-0.136
VAR26	4.26	4.00	0.497	0.434	-0.407
VAR27	4.18	4.00	0.545	0.096	0.045
VAR28	3.91	4.00	1.008	-1.086	0.718
VAR29	3.76	4.00	1.064	-0.634	-0.497
VAR30	4.22	4.00	0.763	-1.070	1.448
VAR31	3.70	4.00	1.086	-0.858	0.127

Appendix Four : Consistency Matrix

Propositions/Questions/Hypotheses	Literature Review	Data Control Tool	Analysis
Hypothesis 1 (H1): Environmental sustainability outcomes have a negative correlation with perceived experience of sustainability tension Null Hypothesis (H0): There is no correlation between environmental sustainability outcomes and perceived experience of sustainability tensions.	Frazer, 2021 Sinaga et al., 2024 Carmine and De Marchi, 2022 Wu et al., 2025 Boemelburg et al., 2023	Question 5 to Question 11 Question 28 to Question 31	Structural Equation Model : Structural Equation: Bootstrapping with 5000 subsamples (SEM)
Hypothesis 2 (H2): The presence of paradoxical organisational cognitive framing modulates the correlation between the perceived experience of organisational sustainability tension and environmental outcomes in such a way that the impacts of perceived experience of sustainability tension on environmental outcomes increase with an increased level of paradoxical framing. Null Hypothesis (H0): Paradoxical cognitive framing has no moderating influence on the perception of the experience of the sustainability tension on the environmental outcomes relationship.	Boemelburg et al., 2023 Annesi et al., 2024 Carmine & De Marchi, 2022 Draghici et al., 2021 Jeremias De Klerk & Swart, 2023	Question 5 to Question 11 Question 12 to Question 27 Question 28 to Question 31	Structural Equation Model : Structural Equation: Bootstrapping with 5000 subsamples (SEM)
Hypothesis 3a (H3a): There is no effect of strategic position (CEO, senior management, middle managers) on paradoxical cognitive framing. Null Hypothesis (H03a): Paradoxical cognitive framing differences across strategic roles do not exist.	Boemelburg et al., 2023 Carmine and De Marchi, 2022 Sajjad et al 2022	Question 5 to Question 11 Question 12 to Question 27 Question 28 to Question 31 Question 1	One-way ANOVA
Hypothesis 3b (H3b): There are variations in paradoxical cognitive framing level of sustainability training exposure (none, informal, formal). Null Hypothesis (H03b): Paradoxical cognitive framing is not different at the levels of training exposure.	Draghici et al., 2021 Hahn et al., 2014 Schröder et al., 2023 Sasse-Werhahn et al. 2018	Question 5 to Question 11 Question 12 to Question 27 Question 28 to Question 31 Question 2	One-way ANOVA
Hypothesis 3c (H3c): Strategic role and training exposure interact to influence paradoxical cognitive framing. Null Hypothesis (H03c) Role and training exposure have no interactive effect on paradoxical cognitive framing.	Sasse-Werhahn et al. 2018 Boemelburg et al., 2023	Question 5 to Question 11 Question 12 to Question 27 Question 28 to Question 31 Question 1 and Question 2	Two-way ANOVA