The governance of the value chain of rare earth elements (REEs) for sustainable development

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ABSTRACT

This study addresses a research gap in the governance of the value chain of critical minerals governance of the chain that produces high-tech renewable energy equipment to achieve sustainable clean energy and a net-zero economy. This study aimed to explore the governance structure(s) of the value chain of rare earth elements as the key renewable energy mineral product to understand the role of different actors in exploration, mining, processing, fabrication and recycling. Using the documentary research method and key informants, we applied a political economy conceptual lens to the global value chain (GVC) framework to examine the governance of rare earth elements (REEs). This study concludes that the governance structure for South African REEs value chains is the Market type global value chain governance, which exposes the market to the dominance of lead buyers, consequently creating governance gaps in the value chain. In light of these results, we recommend that the government mediate by developing a policy to integrate renewable energy mineral exploration and extraction to provide a framework to regulate relationships of various actors in the value chain to mitigate the impact socioeconomic and environmental impact.

DECLARATION

I, Shane Seboweng Choshane, Student Number 401624, declare that this dissertation is my work and has not been submitted to other institutions apart from the Wits Graduate School of Governance as a Research Report Course (PADM7056A).

DEDICATION

In memory of the late Professor Ivor Sarakisky

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LIST OF ABBREVIATIONS AND ACRONYMS

AMP	African Mining Partnership
ANC	African National Congress
ANRC	Africa Natural Resources Management and Investment Centre
AMV	African Mining Vision
BRI	China Build Road Initiative
CDM	Clean Development Mechanism
Ce	Monazite
CE	Circular Economy
CGS	Council for Geoscience
CSIR	Council for Scientific Industrial Research
DFFE	Department of Forestry, Fisheries and the Environment
DSI	Department of Science and Innovation
DTIC	Department of Trade, Industry and Competition
EITI	Extractive Industries Transparency Initiative
EMPR	Environmental Management Programme Report
EU	European Commission
GPNs	Global Production Networks
GTP	Geoscience Technical Programme
GSZ	Green Sacrifice Zone
GVC	Global Value Chain
HREES	Heavy Rare Earth Elements
HySA	Hydrogen South Africa
IDC	Industrial Development Corporation of South Limited
IPRs	Intellectual Property Rights
IRMA	Initiative for Responsible Mining Assurance
IRMC	Integrated Research into Mine Closure
IUCN	International Union for Conservation of Nature
LCA	Life Cycle Assessment
KI	Key Informant
MEC	Mineral Energy Complex
MPRDA	Mineral and Petroleum Resource Development Act
NDCs	Nationally Determined Contributions

NdFeB	Neodymium-Iron-Boron
OAGS	Organisation of African Geological Surveys
OECD	Organization for Economic Cooperation and Development
PGM	Platinum Group Metals
RE	Renewable Energy
REEs	Rear Earth Elements
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
RDI	Research, development and innovation
REO	Rare Earth Oxides
REM	Rare Earth Magnets
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
SDGs	Sustainable Development Goals
SLO	Social License to Operate
TA	Thematic analysis
WUL	Water Usage Licence
WTO	World Trade Organisation

CHAPTER 1: INTRODUCTION

Introduction

The urgent transition to a carbon-neutral and net-zero economy depends on minerals dug from the ground to manufacture metals in green renewable technology. The net-zero economy requires the international community, under the guidance of the United Nations Framework Convention on Climate Change (UNFCCC), to fight climate change in line with the 2015 Paris Agreement commitments to reduce climate change to below 2°C above pre-industrial levels and make efforts to limit it to 1.5°C. The minerals, interchangeably called 'green minerals, transition minerals or critical minerals' underpin modern society's endeavour to produce clean energy and are also crucial in the efforts towards meeting the United Nations (UN) Sustainable Development Goals (SDG) (Jowitt et al., 2020). One such transition mineral application is rare earth elements (REEs) with high electrical conductivity for producing high-tech products for renewable energy, such as electric vehicle motors, permanent magnets for wind turbines, and space and defence sectors. More importantly, it contributes to achieving United Nations SDGs 7 and 13, respectively, aiming to realise affordable, clean energy and combat climate change.

This study explores the political economy of the governance of the value chain of rare earth minerals in the production of REEs. The transition to a low-carbon future presents opportunities for South Africa's Renewable Energy (RE) sector. In conjunction with other transition minerals in South Africa, such as manganese, copper, vanadium, and spodumene ore, the REEs present a potential lifeline to the dwindling mining sector and a strategic advantage in the clean technology space. Therefore, its governance becomes even more critical for sustainable development and dealing with the current global commodity chain framework dominated by China, considering "buyer-driven" or "producer-driven" chains (Gereffi & Fernandez-Stark, 2011).

The increasing demand for rare earth elements and other transition minerals to replace historical fossil energy sources with clean and more sustainable energy is growing. If rare earths are not mined and value-added responsibly, the demand can result in

socioeconomic, environmental and human rights abuses similar to the fossil fuel extractive sector. There are reported cases of damage to freshwater and marine ecosystems that have been documented in Canada, Russia, Australia, the Philippines, Indonesia, Papua New Guinea and New Caledonia due to nickel mining and refining practices that have posed an environmental predicament and an ironical to clean energy (Earthworks, 2021).

More than 80% of global REEs production and supply comes from China, “this puts other nations’ supply chains and national security at risk, a phenomenon known as the China risk factor” (African Natural Resources Centre ANRC, 2021). China’s rare earth mining and beneficiation dominance include control of 97% of the market and 75% of the economic end-use component (Müller, M et al., 2016). Africa has a rich deposit of transition minerals, of which South Africa has its share of metric tons of critical minerals. These resources could contribute to South African production of clean energy technologies, low-emission development strategy and much-needed local content for renewable energy manufacturing, not only by mining exploration but by enhancing research and development (R&D). Renewable energy as a primary source is expected to increase by ten per cent per year by 2035 (Zhou et al., 2017). The growing pressure for renewable energy means REEs applications used in permanent magnets for electric cars, wind turbines, fuel cells, and energy-efficient lighting are essential to limiting climate-change greenhouse gas emissions to achieve 1.5°C above pre-industrial levels, as set in the Paris Agreement (Zhou et al., 2017). REEs ore processing and separation into individual Rare Earth Oxides (REO) before being sold also has environmental and social implications for South Africa, which calls for sound governance frameworks. The governance of these minerals and their added value chain is imperative considering the current legislative framework of mineral resources in the country, where mineral ores are traded as commodities under the Mineral and Petroleum Resources Development Act of 2002 (MPRDA). Governance contributes to understanding how certain actors manipulate the value chain to exert power over others. Often, there are conflicts within the South African renewable energy sector between requirements for national economic development, care for the environment and commercial priorities. The government is under pressure to create jobs and push for the local manufacturing industry, and big business calls for the least costly technology (Baker & Sovacool, 2017). By implementing policy directives, the Chinese

government monopolised the rare earth mineral market by implementing certain policy directives. China follows a dual-pricing policy for the REEs market, in which prices for REEs exports are much higher than those used by Chinese companies (Müller, M et al., 2016). Value chain governance of strategic minerals such as rare earth elements is key to the developmental opportunities of the renewable energy sector in South Africa. These technologies wholly depend on minerals and metals, which could offer South Africa the potential to revitalise its value chain of extractive industries to achieve sustainable development and its Nationally Determined Contributions (NDCs) (WWF SA, 2018).

Because of its socioeconomic trajectory, the Global Value Chain (GVC) framework is employed in this study to examine issues relating to workers, gender, and greening the value chain. “The GVC focuses on the sequences of value-added within an industry - from conception to production and end-use” (Gereffi & Fernandez-Stark, 2011, p.2). This research report explores the value chain governance by applying the political economy lens as an analytical framework.

1.1. Research Problem

The increasing global demand for REEs due to the transition to renewable energy presents opportunities for South Africa to leverage its transition minerals, build the REEs industry and mitigate the decline of its fossil fuel sector. Because the renewable energy sector will not be comparable to the coal sector in terms of volumes of contribution to the economy, notable concern remains that the renewables-based energy transition will entail trading the dependency on the abundance of South African fossil fuel resources for dependency on imported green energy components. South Africa has transition mineral reserves, including rare earth minerals at Namakwa Sands, Tronox and Steenkampskraal mine, that could be value-added. Of the three, Steenkampskraal Mine in the Northern Cape has the highest grade of REEs. A value chain approach to REEs can facilitate this leveraging process. Value addition is a strategic value chain governance in South Africa because monazite is critical for producing rare earth permanent magnets. Monazite sands are invariably composed of Monazite-(Ce), explained in great length in ***Chapter 2.*** On the other hand, South Africa has a host of transition mineral deposits critical for lithium-ion batteries and

complementary to produce renewable energy at an industrial scale. South Africa needs an effective governance structure regarding the mining and beneficiation of REEs. The problem is the need for an integrated value chain with sufficient capacity to translate the ore mined in the country into valuable end-products needed for a low-carbon future, including regulating the end-use of recycling components.

The REEs contribution to renewable energy has not received research traction as other global players in the RE mining sector because it is thus far treated and traded as a commodity. The area of governance of the value chain of REEs in South Africa lags behind countries that beneficiate minerals used to produce energy due to the current governance regimes and geopolitics on minerals. This situation is an anomaly given South Africa's strategic regional positioning in Africa as a mineral-rich region and the leader of the working group of 12 countries, in which South Africa is the project leader according to the African Mining Partnership (AMP) (DMRE, 2021a). The USA and European Union (EU) are looking for alternative sources of REEs supply away from China due to the ongoing threats to cut the supply of REEs by China and the lessons learnt from the Russian-Ukraine war on energy dependency. Furthermore, China is already acquiring concessions for rare earth mineral exploration and mining in Africa and South America through its new Belt and Road Initiative (BRI). Poor governance of the rare earths and other transition mineral resources value chain means the value addition will benefit the economies of other countries while environmentally damaging to the African continent and South Africa in the case of REEs. The Chinese control of the rare earth mineral market and the increased policy decisions of the G7 countries can expose South Africa to anti-competitive practices. The Russia-Ukrainian war, which started in March 2022, demonstrated how monopolies and geopolitics of minerals can plunge economies into crisis. EU reliance on Russian natural gas interrupted supply and put pressure on energy requirements.

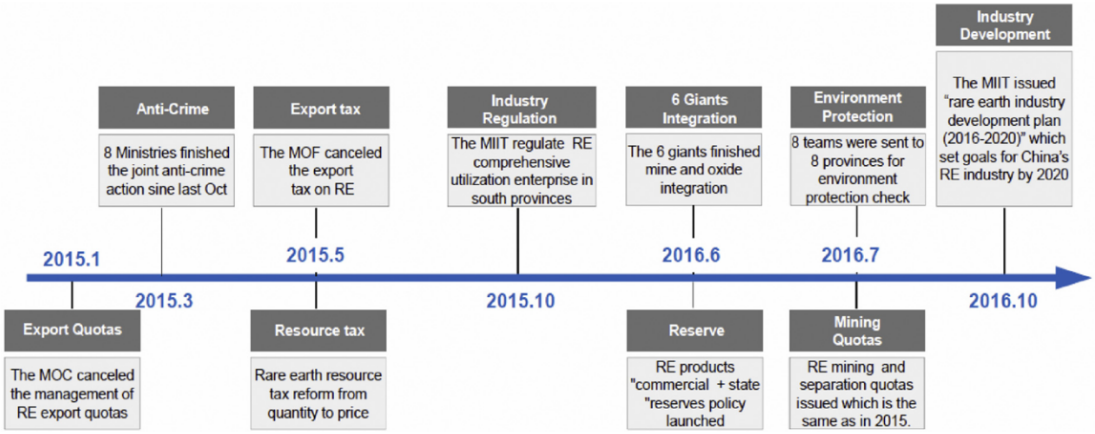
The REEs value chain, divided into a value addition process (upstream, midstream and downstream), can stimulate economic growth and contribute to the realisation of a socially sustainable future through local content manufacturing. Mining and processing REEs can promote the development of green technologies, research and development, and technology transfer, resulting in the creation of millions of jobs. "There are no plans in Africa for further development of the value chain of REEs for

product manufacturing of magnets or battery manufacturing" (African Natural Resources Centre (ANRC, 2021). There have been obstacles in South Africa's renewable energy potential, leading to some reservations in the sector and an inability to leverage clean energy technology holistically, at affordable rates for addressing energy supply shortages, the labour market, and contributing to the national climate change obligations (Celeste et al., 2020).

The literature on rare earth minerals is dominated by Chinese literature due to the country's advanced technology in the global REEs industry, the established value chain and advanced research and development of the renewable energy sector (Mancheri et al., 2019). The European Union is also putting more work into research and development as a strategy to move away from Chinese reliance. The value addition of minerals in South Africa is purported to be realised through the coordination of several government institutions and departments, in particular the Department of Mineral Resources, Department of Trade, Industry and Competition, Department of Science and Innovation, Department of Energy and the National Treasury and other government business entities such as the Industrial Development Corporation of South Africa (IDC), Council for Geoscience and Mintek. The Mineral and Petroleum Resources Development Act of 2002, Act 26 of 2002 (MPRDA), gives a determination to the Minister of Mineral Resources and Energy to endorse the beneficiation of minerals to be value-added in consultation with the Minister of Trade, Industry and Competition (DMR n.d.). Several studies have explored the complexity of renewable energy in South Africa, highlighting the efforts to transition into a low-carbon future (Baker & Sovacool, 2017; Baker, 2015). These views are taking a different direction from the historical mineral energy complex (MEC) that has dominated the country's economy and energy sector for decades to the new renewable energy sector. This research expands the scope by linking the transition minerals' contribution to the value addition of energy and clean energy initiatives such as the Clean Development Mechanism (CDM). South Africa is eligible to host CDM projects whose negotiation position is in line with that of the G7-China block (Kim, 2004). According to the United Nations Framework Convention on Climate Change (UNFCCC), "CDM allows a country with an emission-reduction commitment under the Kyoto Protocol to implement an emission-reduction project in developing countries" (UNFCCC, 2021). The mineral energy complex has gripped South African energy generation for years,

a system of accumulation that has benefitted the powerful and connected individuals and firms under the apartheid regime that has left a foundation of inequality. The new renewable energy sector is also at risk of global production networks (GPNs), which may hinder South Africa from realising local renewable energy technologies (Baker & Sovacool, 2017). These dimensions cut South Africa and the regional transition minerals from the fully integrated value chain. The sustainability of China's rare earth sector is determined by the entire rare earth lifecycle, from sourcing renewable energy minerals to the point when the material can no longer be used and enters the recycling sector. China uses “31 indicators to construct the sustainable rare earth resource development evaluation index system” (Liang et al., 2018).

Figure 01: REE policies that China has implemented since 2015



Source: Mancheri et al., 2019, p.10

The South African government is still mulling a collaboration between the Industrial Development Corporation (IDC) and Mintek undertaking the feasibility of the value chain of the manufacturing of rare earth magnets according to the presentation made by the Department of Trade, Industry and Competition (the DTIC) to the portfolio committee on trade and industry (*National Industrial Participation Programme – The Department of Trade Industry and Competition*, 2021).

Africa’s most prominent EVs-related minerals and metals are exported. This research also explores the contribution of these minerals to South African renewable energy as a growing sector. According to Bonfante et al. (2021, p.1), “research and developments with Neodymium-Iron-Boron (NdFeB) - based Rare Earth Magnets (REM) have intensified” due to its metal components in EVs, wind generators and

electric motors, requiring improved magnetic properties. REMs were introduced into the market in the 1960s as a significant technological advancement based on the tetragonal compound Neodymium-Iron-Boron (NdFeB) (Bonfante et al., 2021). China's complete value-adding chain through various independent entities dedicated to REEs research and production is the source of current success (Barakos et al., 2018). These entities are governed by the China Ministry of Industry and Information Technology to ensure an uninterrupted supply. The government plays a crucial role in identifying companies that can add value by making technologically advanced products rather than exporting raw materials (Mancheri et al., 2019).

The African Mining Vision (AMV), to which South Africa subscribes, is the central policy that guides mineral extraction and development. It recognises the importance of the mineral value chain of REEs to create a competitive edge over other global players (ANRC, 2021).

This research seeks to close the knowledge gaps articulated in the problem statement on governance by drawing from the insights of key industry stakeholders and document analysis by investigating governance of the value chain of rare earth minerals from exploration, mining, and fabrication to final products and their recycling. This study uses political economy analysis to evaluate the effectiveness of governance structures on the impact of REEs mining on socioeconomic, environmental, and climate change mitigation.

1.2. Research purpose

The purpose of the study is to critically conduct a sector political economy analysis of the governance of the value chain of rare earth minerals (REEs) in South Africa and their contribution to the global renewable and just energy for sustainable development. The researcher's goal is to raise awareness about the role transition minerals play as a critical input for renewable energy.

1.3. Research Objectives

1. To establish the role of South African transition minerals in the value chain of the renewable energy sector.

2. Explore the political economy of the governance structure of the value chain of rare earth minerals in the renewable energy sector in South Africa;

3. Critique key governance challenges in the REEs value chain, from mineral exploration to end-of-life recycling.

1.4. Research question

This study aims to answer the research question *infra*, presented through (Gereffi & Fernandez-Stark, 2011) GVC framework whose analytical focus rests on the governance structures organising international production networks. The framework is in sync with the political economy, which aims to probe key actors in the transition minerals sector as an analytic method:

What governance structures exist for the South African transition minerals value chain for sustainable development?

The study specifically answers the following questions:

1. How does South African governance of transition minerals contribute to renewable energy and sustainable development?
2. What are the political, economic, and social governance structures driving the rare earth minerals sector in South Africa?
3. What are the perceptions of the REEs value chain in South Africa, and how do these affect the geopolitics of critical minerals?

1.5. Context of the Study

The focus of the study is the governance of the value chain of rare earth minerals in South Africa. Rare earth minerals and metals are crucial to developing renewable technologies to mitigate climate change, which has resulted in an upsurge in demand for the production of wind turbines, solar PV, electric vehicles and battery storage. The rapidly growing energy technology has attracted new investments in the extractive industry to meet the demand for metals and infrastructure for green energy and achieve UN SDGs. Companies are also implementing Environmental, Social and Governance (ESG) standards as investment guides for businesses to comply with the global effort to resolve the climate crisis and achieve carbon neutrality and a net-zero economy. ESG investing refers to investor standards for measuring a company's behaviour, which traditional investment consulting agencies overwrite. These firms have for many years buried environmental considerations within corporate social responsibility initiatives of multinational corporations that are at the centre of global warming and today claim to be the vanguard in our collective mission to save the planet (Mazzucato and Collington, 2023). It is against this context that this study is being carried out to explore the effectiveness of governance structures on REEs mining, processing, and separation. The effectiveness of such governance in social, economic, environmental, and climate change is critical, as Mazzucato and Collington (2023) warn governments may hire these consulting agencies not to reduce their climate footprint but to convince others of their commitment to mitigating the climate crisis.

The technology, such as the wind turbine, uses tons of minerals sourced from the most remote areas of the Global South, which makes the transition to carbon-neutral challenging because it involves mining exploration and extraction. Due to poor global governance structures, different from the current regimes, poor communities suffer as the green sacrifice zone (GSZ) in the global effort to achieve the global good. The logic of sacrificing a certain ecological space to power low-carbon transitions, along with end-of-life treatment for related materials waste, will impact the populations of these regions in the future (Zografos and Robbins, 2020).

1.6 Justification of the Research

The importance of doing this research is to highlight the impact mining has on electromagnetic technology and the need for accountability on minerals' need to power renewable technology. The infrastructure needed to provide sustainable and clean energy relied primarily on minerals. Wind turbines and electric vehicle motors rely upon rare earth permanent magnets, which, together with battery technology, will see many parts of the world achieving their zero-emission targets. While many societies will enjoy the advanced green energy technology, most countries will likely suffer from pollution from mining minerals to satisfy the hunger for the green energy revolution. It is necessary to link the extractive industry and the renewable energy infrastructure to ensure that the manufacturing and use of wind turbines and batteries do not create irreversible social and environmental harm in the mining communities by breaking the value chain. Mining in South Africa has a notorious history of violating the rights of workers and communities. As South Africa and the world strive to achieve a Net-Zero economy by 2050, it should do so with full credit to minerals deployed to achieve carbon neutrality, the environment, workers and their communities. The rapid deployment of RE and energy storage technologies is said to reconfigure the world's carbon footprint in which industrialised countries are shifting processes other than manufacturing to nations whose economies are least able to govern the cycles of boom and bust, environmental degradation and displacement (Kramarz et al., 2021).

Having a better understanding and recommendations for better governance of rare earth minerals is a justification for conducting this study to encourage a sound ethical framework for every stage of the value addition of Rare Earth Minerals. This will ensure that the ESG criteria aimed at mitigating greenwashing are not circumvented by corporate greed. Furthermore, institutions in the Global North are more concerned with the sustainable supply of raw materials and the potential risks of the geopolitics of minerals, with less regard to the social and environmental effects of mining of minerals often taking place in the Global South. The EU has passed the Critical Raw Material Act, which ensures that the EU has access to a secure supply of sustainable critical raw materials (European Commission, 2020a). The inconsistency and the absence of a universal standard for The ESG standards suggest that there is no unified effort to

fight climate change. Governments in the Global North are adopting market-driven climate governance, which is “neoliberal because it favours the least intervention in the decision making and promotes the development of institutions that provide a framework for individualised private decision making in responding to climate change” (Mazzucato and Collington, 2023, p. 218).

1.7. Outline of the Report

This report comprises six chapters outlined as follows:

The first chapter introduces the study by providing a background and a problem statement that identifies a knowledge gap justifying the research. It also briefly introduces the research methodology followed in carrying out the study.

Chapter two undertakes the literature review on rare earth minerals, governance of the value chain of REEs and sustainability development. The chapter gives a detailed review of the rare earth elements sector and its value chain governance to offer a comprehensive understanding of the contribution of RREs to sustainable development. It then gives a summary of a theoretical and conceptual framework that guides the study.

Chapter three presents the methodology employed in conducting the study, outlining the research approach, design, procedures, and methodology for collecting, processing, and analysing data that this research followed.

Chapter four presents the research findings of the study based on the data collected from the perspectives of governance experts and documentation sourced from government institutions and organisations on the governance of the rare earth industry.

Chapter Five discusses and interprets the findings based on theoretical and empirical findings of the governance of rare earth elements for sustainable development research in South Africa.

Chapter Six presents critical recommendations for the study and concludes the research findings.

1.8. Summary of Chapter 1

The report's first chapter presents the background, research problem, aims, and objectives and sketches how the research has unfolded.

Chapter 2. Literature Overview

Introduction

This section reviews and discusses academic literature as part of developing and supporting a conceptual framework for this study. This is achieved through a literature review of the concept of governance, the value chains and rare earth minerals based on the established international governance mechanisms, and the governance of critical and rare earth elements and their contribution to sustainable development in South Africa. We explore the literature on rare earth minerals relevant to the research topic to determine their findings based on their research purpose, methodology and theoretical framework. This is followed by an in-depth theoretical framework of the Global Value Chain (GVC) to seal a clear understanding of the governance structures of the value chain of rare earth minerals with well-established facts on the contribution of the so-called “critical minerals” to sustainable development. This chapter concludes by presenting a global value chain framework and the political economy conceptual analysis framework that guides this study based on the literature and research gaps identified.

2.1. The concept of governance

The concept of governance can be defined in many ways, making it a difficult subject to comprehend. Katsamunska (2016, p.134) presents a broad abstract that provides a common ground for many other approaches, defining governance as the capacity of a government or organisation to provide public goods and services as requested by its citizens or representatives effectively, transparently, impartially and with accountability. Another take by Schrage & Gilbert (2021) considers governance to be a multilateral process in which governments, international institutions, civil society organisations, and business firms contribute knowledge and resources to define and implement global rules and provide global public goods. An outlook that leans towards a view that governance has experienced remarkable elevation that has inspired the emergence of international institutions working towards improved sector governance (Addison & Roe, 2018). This outlook is in sync with the UN SDG 17, which provides a framework for partnerships for sustainable development. The increasing complexity of

global value chains, including rare earth value addition, has led to governance gaps that cannot be fixed by any single actor alone (UNECE, 2021). Furthermore, the geopolitics of critical minerals has categorised rare earth minerals as a security issue, a move away from economic or technological innovation to mitigate climate change, which has heightened the complexity.

This is because minerals and metals are necessary for producing many essential goods in contemporary society and are frequently feeding competitive and complex global supply chains, in which raw materials move from resource-rich countries to the manufactured components in China and then sold to industrial countries in Europe, where finished goods are perfected (Christmann, 2021). Christmann (2021) further argues that the process requires effective, verifiable governance by application of laws, regulations, voluntary initiatives and institutions.

This study looks at governance frameworks that govern various stages of the value chain of rare earth minerals in South Africa because governance is the force that drives the convergence of sustainable development's economic, environmental and social dimensions. Governance should then result in sustainable development, as the critical aim of this study is in unison with the UN SDGs, hence its political economy lens.

Developing renewable minerals as a resource to mitigate climate change demands an international governance framework that reflects its social and economic diversity. Dou et al., (2023) suggest a global governance system for critical minerals to provide a consultative platform for multi-stakeholder rights. The current governance systems suffer from power struggles led by rich countries. These systems, such as - the Social License to Operate (SLO) meant to protect indigenous communities and the conflict minerals ban as a solution to armed conflict and human rights abuses; the Extractive Industries Transparency Initiative (EITI) to discourage rent-seeking, albeit providing workable solutions individually, are not cohesive to deal with the value chain of critical minerals (Dou et al., (2023). The value chain is a double-edged sword because the environmental and social impacts of the supply of critical minerals and products are frequently overlooked when assessing the transition from fossil energy. These result in the global net-zero goals being elusive due to global political response to climate

change, clean energy and transport technologies that are not transparent and drought with national agendas (Dou et al., 2023).

Dou et al., (2023) propose a three-point agenda for the sustainable supply of critical minerals. The first is the establishment of a global cooperative mechanism for critical minerals governance run by NGOs to scale down political implications, bringing together resource, manufacturing, and consumer countries in a UN format to deal with the myriad of problems, especially in the extractive industry. This will act as a global mediation body that could double as a mediator in geopolitical conflicts related to critical minerals, as observed between China, the G7 and Global South Countries.

The second mechanism is establishing a big data platform for the international critical minerals supply chain to achieve supply chain transparency that will contribute to environmental, social, and corporate governance (ESG) criteria reporting in extractive and downstream industries.

Thirdly, a negative list of key mineral supply chains should be established to increase the identification and regulation of environmental and human rights issues in the supply chain. Dou et al. (2023) see such a Conflict Minerals Disclosure as a ground-breaking effort to ensure that mineral raw materials are responsibly sourced. The introduction of the Conflict Minerals Supply Chain Negative List will change how supply chains are understood and, ultimately, how they operate as a requirement for assessment criterion.

Below is an examination of the value chain of Rare Earth Minerals and their high-tech metals and products. Taking a closer look at the value chain will enable governance to mitigate the negative effects of the global energy revolution and new technologies.

2.2. Critical Minerals

South Africa is among 34 countries identified with transition mineral deposits significant to participate in the global governance of the REEs value chain and geopolitics of minerals (Dushyantha et al., 2020). Its reserves are found in peralkaline and vein deposits in which enriched heavy rare earth elements (HREEs) are critical to

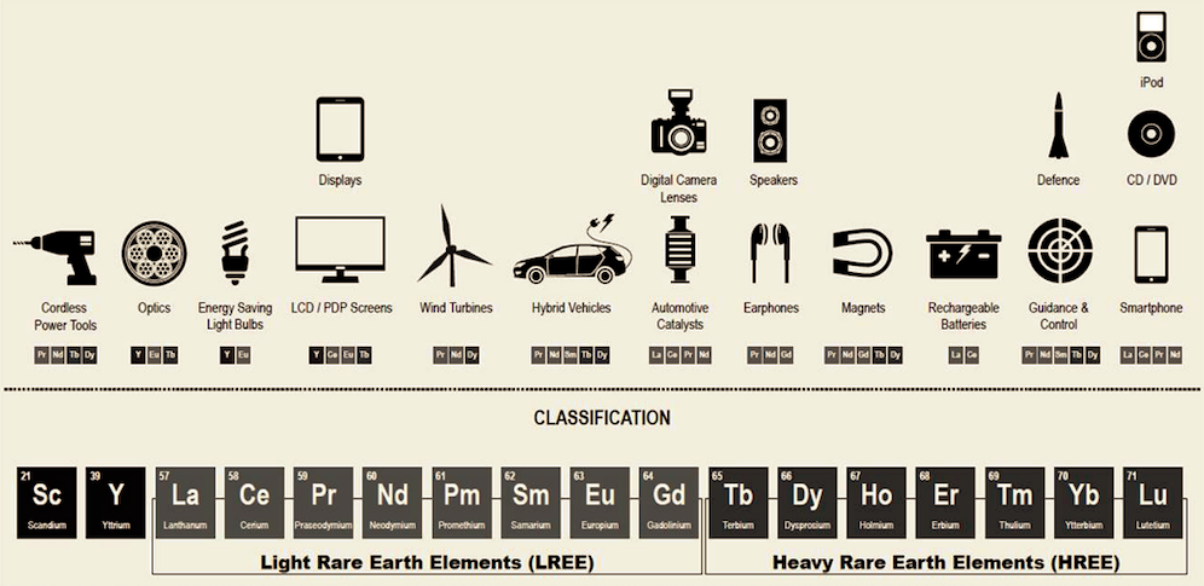
the global clean energy transition. The generally accepted term for this mineral is called “strategic mineral” because it refers to the supply chain risk and the linkage to the growing green technology (Khan et al., 2022). In addition, the country is endowed with other strategic materials which have become a source of energy and international diplomacy, such as platinum group metals. Due to their geographic concentration, critical minerals production and processing pose resource security and geopolitical challenges (IRENA, 2023). The term critical minerals is not a globally accepted jargon, but there is also a consensus that it refers to minerals and metals that are critical for renewable energy transition, such as rare earth elements, copper, cobalt, manganese, graphite, vanadium, lithium and platinum group metals. The Natural Resources Management and Investment Centre (ANRC, 2022) and its partners opted for more subtle terminology to describe the transition minerals as “green minerals” to counter developing countries’ strategies that may hinder African countries from reaping the benefits of their green minerals. It is for this reason that a need arises to augment the existing body of mineral development policies with a strategy that focuses on the transition minerals value chain (ANRC, 2022).

2.3. Value Chain of Rare Earth Elements

The rare earth elements (REEs) refer to the group of 17 metallic elements grouped in the periodic table. The group includes 15 elements, Yttrium (Y) and Scandium (Sc) monazite rock. These monazites typically contain 45–48 per cent cerium, 24 per cent lanthanum, 17 per cent neodymium, 5 per cent praseodymium, and trace amounts of samarium, gadolinium, and yttrium (ANRC, 2021; (Zhou et al., 2017); (Leal Filho et al., 2023).

It forms an important part of medals categorised by the European Union as critical minerals essential to meet carbon neutrality, the net-zero economy and sustainable development goals. More importantly, its role in the defence manufacturing industry. REEs, also called rare earth metals (REMs), are critical for producing high-technology equipment, as illustrated in ***Figure 03*** below. REEs are used to make storage batteries, radar instruments, portable electronics (such as smartphones), improved television sets, electric vehicles, energy systems, and permanent magnets (Bonfante et al., 2021; Chen et al., 2017; Leal Filho et al., 2023; (Machacek et al., 2017).

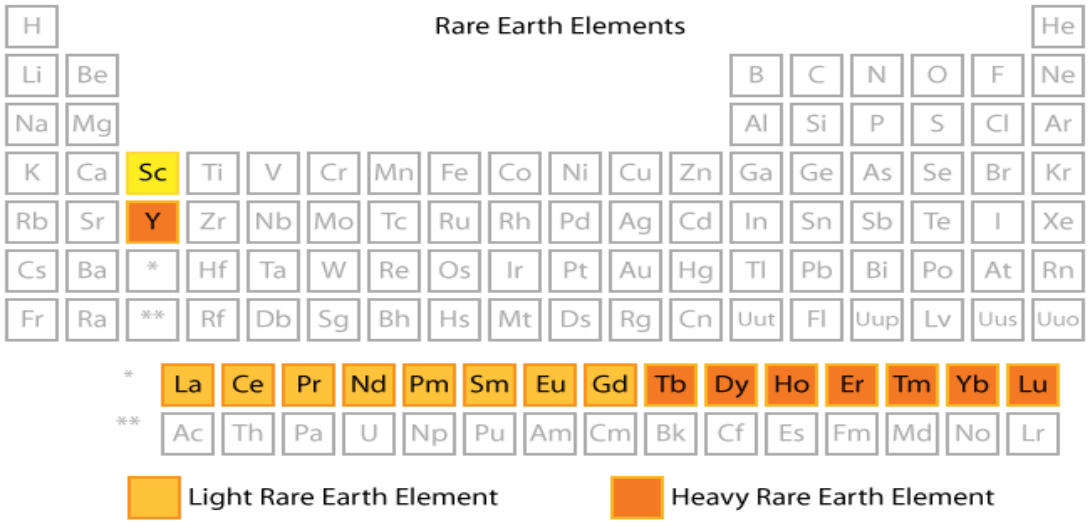
Figure 02: Rare Earth Metals Applications and Uses



Source: China Water Risk Report, Rare Earth: Shades of Grey, June 2016

They are highly sought-after materials for innovative technologies as additives to achieve advanced material performance characteristics. Rare Earth Metals are as follows: scandium (Sc), lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), yttrium (Y), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), ytterbium (Yb), lutetium (Lu), and thulium (Tm) - 17 metals in total grouped for their similar physical and chemical properties (Leal Filho et al., 2023).

Figure 03: Periodic Table of Elements



Source: Sciencenones.org, Rare Earth Elements, December 2023

Rare Earth Minerals are often processed as the by-product of other minerals or sold as marginal mining commodities (Dou et al (2023). They are found as solid minerals and regularly with radioactive traces of uranium that are challenging to handle due to health-related hazards (Leal Filho et al., 2023). The Northern Cape Provinces have high-grade rare earth from the mineral compliments of monazite rock. Over 50 per cent of the global REEs resources are hosted by carbonatite-related deposits, of which monazite is one of the most important rare earth minerals, it dominates more than 30 carbonatite-related REEs deposits around the world, including those currently exploited at Steenskampskraal rare earth mine in Northern Cape (Chen et al., 2017).

Their primary extraction process varies from opencast to underground mining, each with its challenges of cost, environmental and safety implications, followed by a process of separation from rare earth oxides and purification, according to Leal Filho et al., (2023):

> "*The extensive and resource-intensive processing involving mechanical, flotation, chemical, and thermal steps. After mining, REEs must undergo several water, chemical, and energy-intensive steps for processing, from crushing, milling, cracking, and separation through froth flotation into dissolved concentrates in the first phases. Then purification is necessary, involving several complex chemical reactions to either produce rare earth oxides or to merge those with other elements to produce either metals or alloys*" *(Leal Filho et al., 2023, p. 4).*

Figure 04 below illustrates the value chain and process involved in the production of minerals, which is at the core of this study, to look at each stage and including the political economy of recycling the products that are currently in operation in South Africa.

Figure 04: Value Chain of Minerals

Source: Canadian Critical Minerals Strategy

2.4. The empirical studies of governance of rare earth minerals for renewable energy technology

Rare earth elements and related critical minerals have attracted attention due to their heightened demand and contribution to renewable technology. As a result, various stages of producing technological infrastructure are being scrutinised by interest groups, including end-of-life recycling as an activity and a key element of the Circular Economy (CE). The CE maintains the value of resources compared to using materials to make products and dispose of them at the end of life. Recycling is a governance issue because the current generation of wind turbines and solar panels needs to be regulated to avoid dumping at their end of life.

Literature on the rare earth minerals sector and its governance is highly concentrated in the Chinese and Global North scholarships. With limited information on South African literature, a research gap this study is looking to contribute to address. As the world's mining system transitions from a top-down single model among nations to a hybrid model involving multiple actors, non-state actors and regional cooperation are gradually raising flags about the implication of critical minerals extractives (Dou et al., 2023). Minerals and metals used in the production of renewable energy require more processing, often carried out in more than one country. A configuration of coordinated

activities divided among firms and with a geographic scale is known as a global value chain (GVC), which poses a risk for inequality and economic shocks (Foster-McGregor et al., 2015).

There are several international governance mechanisms currently regulating global mineral supply chains, such as the Dodd-Frank Act, including the SLO and EITI above, whose scope is now being extended to critical minerals. These governance mechanisms focus on voluntary standards and practices that regulate just a few minerals associated with armed conflict, not all the minerals essential to the renewable energy industry (Kramarz et al., 2021). Another similar mechanism, the Due Diligence Guidance for Responsible Supply Chains of Minerals of the Organization for Economic Cooperation and Development (OECD), which has been working in countries like the DRC to regulate trade originating from its member states for years, has not been able to prevent the widespread violations synonymous with the DRC. This has resulted in governance gaps, as identified by Schrage & Gilbert (2021), in which more and more NGOs, community organisations and other stakeholders are starting to question companies over governance gaps in the global value chain. They demand that these gaps be addressed to maintain the legitimacy of company practices in the GVCs to meet the expectations of workers and their communities. (Dou et al., 2023) call for the international community to establish a global governance framework for critical minerals to serve as a platform for coordinating the interests of all stakeholders and guaranteeing the supply necessary to achieve net-zero commitments. Gaps that need to be addressed involve trade inequality, human rights violations, pollution in production processes, and violation of worker rights by firms in the value chain operating in developing countries (Schrage & Gilbert 2021).

Governance in GVCs occurs through governance mechanisms defined as formal and informal rules and instruments designed to coordinate the behaviour of actors in GVC contrary to the international mechanisms that often focus on specific minerals or countries, such as the Initiative for Responsible Mining Assurance (IRMA) standard. To address the governance gaps, there should be an interplay between the social, private and public sectors.

2.4.1 Supply Chain Risks

Because of supply constraints, REEs may become commercially rare or possibly troublesome. Leal Filho et al. (2023) asserted that REEs, like other critical resource materials (CRMs), have substantial supply chain risks and unique features that are generally difficult to replace or recreate using contemporary technology or traditional methods. The EU and Germany have adopted draft supply chain laws with strong "protective measures" and a trend of rising trade protectionism within the EU. In many developing and highly underdeveloped countries, mining has historically been plagued by corruption, pollution, and human rights violations, a phenomenon that is likely to continue to plague renewable energy minerals (Dou et al., 2023). The global supply of minerals is likely to remain uneven due to its geopolitics. Although a country could host a mine or a company interested in processing goods that require REEs, that country would still need to import REEs from China or rely on China for processing the minerals (Leruth et al., 2022), thereby creating power asymmetry. Against this background, South Africa will have to look into the circular economy to compensate for resource scarcity (Khan et al., 2022).

2.4.2. Geopolitics of Rare Earth Minerals

The role of critical minerals in national economic systems is becoming more politically important than traditional minerals, sparking geopolitical conflicts and international competition (Dou et al., 2023). REEs can also cause significant corporate social responsibility headaches for multinational companies due to disruption to global trade networks, growing resource nationalism, non-market factors in countries with severe conflicts and human rights violations, such as the forced displacement of communities, unsafe labour conditions, and environmentally harmful features typical and historical to mining and production of mineral resources (Leal Filho et al., 2023). Another dimension not yet fully resolved is the waste hierarchy issues related to recycling, which starts at the production and ends with consumptions that can be attributed to dumping by industrialised countries (Leal Filho et al., 2023; Dou et al., 2023). These issues are challenging for the Global South and also cause dislocations and national security problems for the US, Japan, Korea, and the European Union. The traditional industrial global actors are now pitted against global economic giant China and its

global Belt and Road Initiative (BRI), which sets out to unite Eurasia and Africa and loop in South America into a seamless space of high connectivity by land, maritime, air, cyberspace and trade (*Kalantzakos*, 2019). South America is the most significant region in terms of large lithium deposits, the top ingredient of Lithium-ion batteries. Three countries known as the "lithium triangle," Argentina with 14.8 million tons, Bolivia boosting 9 million tons of untapped resources and Chile with 8.5 million tons, are likely to align with China through the BRICS trading bloc (Kalantzakos, 2019). These developments occur against the backdrop of a Chinese quasi-monopoly in the critical mineral sector and as a leading country that produces and processes over 90 per cent of these materials.

In September 2010, Japanese authorities arrested the captain of the Chinese fishing trawler for fishing in the disputed Senkaku Islands in the East China Sea (*Kalantzakos*, 2019). Chinese authorities retaliated by blocking exports to Japan, first by reducing export quotas of the rare earth elements by 40 per cent and boycotting exports to Japan over the incident. This incident marked in history an epoch of the geopolitics of critical minerals and a sticking agenda in the sustainable supply of transition minerals. The case was reported to the World Trade Organisation (WTO), and the subsequent due processes were undermined by the Chinese authorities. This trade war has since weakened the WTO's importance, limited scientific collaboration, and revealed a clear battle of economic and leadership ambitions between China and the Western countries, jeopardising the UN SDGs. These developments prompted scholars, researchers, policymakers and industry specialists to identify many other critical inputs (Kalantzakos, 2019). To boost its competitiveness in the renewable energy sector, the European Commission developed the Green Energy Deal, a counter to the China Build Road Initiative (BRI), which led to the Critical Raw Material Act being developed in the EU. The Act ensures that the EU has access to a secure supply of sustainable critical raw materials (European Commission, 2020a). The European Commission defines raw material criticality as materials that face a high risk of access such that a disruption in supply could have a major impact on the economy. Recognising the competition to access transition minerals towards a low-carbon society and China as the largest supplier of several critical raw materials, the EU has engaged in a criticality assessment approach to assess 83 individual materials and their origins to improve their access (European Commission, 2020b). The US, on the other hand, has released

what is called the Critical Mineral Resources Inventory, which has shifted the mineral supply from an economic priority to security.

According to Kalantzakos (2019), China stands out for its attempts to secure a position of influence over the industry because it is a strong proponent of technical solutions such as recycling and substitution. These developments prompted scholars, researchers, policymakers and industry specialists from the EU to identify other critical inputs that will transition from the grips of Chinese domination.

“Patents and intellectual property rights (IPRs) are important to the Chinese, and they expect major technology actors to merge into a few dominant corporations. IPR protects innovation, but it has caused friction between Europe, the US, Japan and China, viewed as “industrial espionage” (Kalantzakos, 2019, p. 8). This concern arises despite the US being the holder of the high-end technologies and patents.

This context explains why mineral resource nationalism is spreading everywhere and affecting free trade agreements, as demonstrated by the ongoing trade wars initiated by the US and spreading globally. The US is said to support creating a rare earth chain without the participation of Chinese companies (Dou et al., 2023)

2.4.3 Environmental and Human Rights Risks

Historically, mining communities and their well-being have been profoundly impacted by extractive industries, a phenomenon known as the "resource curse." The rhetorical question is whether transition minerals will provide a “resource blessing”. Mining consists of open pits, impoundments, milling infrastructure, waste rock dumps, and tailings storage facilities, features that are difficult to avoid disturbing the surrounding environment (Dou et al., 2023). Therefore, pollution, ecological degradation, and environmental damage are inevitable challenges for the mining sector, irrespective of good intentions for clean energy. Rare earth minerals mining has become notorious for resource rent-seeking in less developed regions due to poor institutions. Minerals supplied by companies using cheap labour, low social responsibility, and lax environmental standards are accepted by advanced economies while trying to cover themselves with self-help due diligence laws (Dou et al., 2023). Though critical raw

materials and metals are vital to the global effort to resolve climate change, their extraction and processing pose a danger to the climate system, biodiversity, and Mother Earth's ability to care. There is limited environmental regulation and formalisation that can effectively control environmental losses from extractive industries (Dou et al., 2023).

In addition to environmental problems, the extractive industry has contributed to human rights-related conflicts in mineral-rich countries due to power struggles by various interest groups to control resources. Despite institutional interventions such as the Extractive Industries Transparency Initiative (EITI), Social Licence to Operate (SLO), and attempts at formalising artisanal and small-scale mining, poverty, inequality, violent conflicts, gender animosity and epidemics continue to impact communities negatively (Dou et al., 2023). Policymakers have long hoped they will address these social and environmental challenges of extractive activities.

South Africa mines monazite from conventional mineral production meanwhile, the mineral is known to require high material and energy amounts with environmental consequences, such as radioactive loaded dust and tailings or impacts on human health (Schreiber et al., 2016). It is against this background that the renewable minerals sector should be approached differently with new governance regimes.

The most adequate method acknowledged in ISO standards 14040 for a holistic evaluation of the environmental effects of the production of rare earth elements is the Life Cycle Assessment (LCA). In the cycle, all the energy and material flows that occur during the mineral extraction, renewable energy components production, operation and end-of-life of products such as wind turbines are quantified and evaluated in terms of environmental impacts (Schreiber et al., 2016). Human toxicity is always the dominant environmental impact once the assessment is done, followed by aquatic ecotoxicity.

The mining of rare earths has an environmental impact that is synonymous with its value chain, and its governance should play a crucial role until the product is recycled. Though there has been an expansion of the renewable energy sector during the last ten years, toxicological investigations on REEs-induced health problems are not

available (Dushyantha et al., 2020); therefore, environmental governance structures are vital in understanding the value chain of REEs impact to mining communities and just transition measurements. The mining and extraction of rare earth minerals, the principal raw material for rare earth elements, are associated with substantial environmental and social effects because of the heavy chemicals used during their extraction, including radioactive co-products such as thorium and uranium (Bonfante et al., 2021). Environmental impacts have led to social unrest in China and India due to exposure to rare earth dust (Dushyantha et al., 2020). The chief contributor to environmental damage is the consumption of chemicals and energy. The damage to the environment and industrial exposures to rare earth mining and all other stages of the production of renewable energy infrastructure should be attributed to the entire value chain so that the proper accountability is meted out to correct actors in the renewable energy sector chain.

2.4.4 Recycling

Recycle is the secondary supplier of critical minerals, including rich reserves of rare earth minerals, that can close the supply gap while resolving sustainable consumption and production patterns. A scholarly focus has been drawn to recycling because critical minerals appear to be characterised by dynamics that differ from those of conventional linear models (Machacek et al., 2017). Poor management of the recycling of batteries and solar and wind energy infrastructure will be catastrophic for South Africa. Resource extraction from mineral-rich countries is always criticised for environmental and human rights abuses by human and environmental activist organisations, and poor governance of recycling can add to the criticism. According to estimates (Dou et al., 2023), urban cobalt reserves in China could reach 186,500 tons, equivalent to the cobalt consumption of 12 million electric vehicles. There is a challenge with the accuracy of governance when it comes to recycling as a segment of the value chain because its demand is dependent on the end-of-life (EoL) of minerals. It is a brokered form of recycling governance rather than a formal system of control that standardises rare earth minerals in terms of quality or that adjudicates disputes in cases of unsatisfactory exchanges (Machacek et al., 2017).

2.5. Policy and Legislative Framework

The minerals exploration and mining in South Africa have been regulated in terms of the Mineral and Petroleum Resource Development Act - the MPRDA (Act 28 of 2002) since the dawn of democracy. This act was reformulated in 2002 after the African National Congress (ANC) government came into power as part of the sweeping changes to address the injustices of Apartheid. The act initially was to move away from the apartheid mineral governance and shift from a system where private ownership of mineral resources was possible under the Minerals Act (50 of 1991). Until the Minerals Act of 1991 (Act 50 of 1991), mining companies behaved irresponsibly without considering the effects of their mining activities on the environment and people (Odeku, 2015). In addition to MPRDA, there is the National Environmental Management Act (1988) (NEMA), which regulates the water and air quality laws of the mining sector. It was to achieve the internally accepted standard in which the state exercises sovereignty over all mineral and petroleum resources (Van Der Zwan, 2013). The Act grants the Minister the right to ensure the sustainable development of South Africa's mineral and petroleum resources within a framework of national environmental policy, norms and standards while promoting economic and social development (MPRDA). Minerals in South Africa, except coal, are traded as commodities, and the environmental and social impact of their production is often overlooked when assessing the transition of fossil energy economies. Section 26(3) provides any person who intends to beneficiate any mineral mined in the Republic outside the Republic may only do so after written notice and in consultation with the Minister.

2.7. Governance of Sustainable Development

The concept of sustainability according to Purvis et al., (2019) remains an open concept with a variety of interpretations and contexts, including economic, social, and environmental or ecological goals. These three competing terms are primarily used interchangeably as is observed in climate change debates between various interest groups such as trade unions, and business and environmental organisations. The three pillars are explicitly embedded in the Sustainable Development Goals (SDGs), although much of contemporary sustainability literature focuses on the UN's more

diverse set of sustainable goals (Purvis et al., 2019). Critical mineral extraction and its end products, which are used in renewable energy, are linked to the SDGs' goals of ‘poverty eradication (2); health and well-being 3; gender equality 5; social equity; sustainable cities and communities 11; climate action 13; affordable and clean energy 7’ (Dou et al., 2023). These goals represent an international platform for development, based on the UN Agenda 2030’s principles of peace and partnership, prosperity, the planet and its people. The overall emphasis is placed on synergies and connections between the goals and the willingness to bridge the environmental, social and economic divide which opens up the imperative and potential for natural and social scientists and other actors to achieve a net-zero economy. (Arora-Jonsson, 2023).

To achieve the net-zero and sustainable development goals, there is a high demand for transition energy minerals as a result of global economic and technological advancements. The call for sustainable development and a green economy is also one of the main factors driving up demand for REEs in the sector, as they are critical components in the wind power industry for the manufacture of turbines using neodymium (Nd), praseodymium (Pr), and dysprosium (Dy), as well as in the manufacture of solar panels - indium, selenium, and tellurium (Leal Filho et al., 2023). However, a lack of science-based indicators, flaws in monitoring and evaluation, and problems with technology transfers and development aid are all cited as implementation hurdles and therefore impediments to governance (Arora-Johnson, 2023).

A historical overview of sustainability is necessary to understand governance issues in sustainable development. It is critical to understand sustainability from the perspective of two historical events, one is the Brundtland Commission, initially the World Commission on Environment and Development, which was a United Nations (UN) sub-organization that attempted to bring countries together in the pursuit of sustainable development (Kono, 2014). It published a report that is widely recognised for popularising the notion of sustainable development by integrating it into international policy discourse. It defined "sustainable development" as "development that meets present needs without compromising with future generations' ability to meet their own needs" (Purvis et al., 2019).

Secondly, Agenda 21 is one of the major documents that came out of the United Nations' Rio Summit on Environment and Development in 1992. It is a comprehensive plan of action, recommended by the UN summit to be taken globally, nationally, and locally by organisations of the United Nations System, governments, and major groups in every area in which humans impact the environment (Momtaz & Kabir, 2013).

These events come as a result of the rising concern that the early economic growth-based development programmes failed to deliver the promised results. The 1972 United Nations Conference on the Human Environment in Stockholm was the first global summit that examined human impacts on the environment, as well as the first significant attempt to reconcile economic progress and environmental integrity, which were previously seen to be irreconcilable (Purvis et al., 2019).

Dou et al., (2023) discuss the need for a global governance system for critical minerals to maintain the supply chain's stability, as the world is waking to accept the concept of equitable development of SDGs. Through this international governance mechanism, residents, communities, companies, resource countries, NGOs, and others can coordinate their demands (Dou et al., 2023).

As alluded to above, resource extraction is linked to air, water, health, cleanliness, and pollution, the environmental issues that are an obstacle to achieving UN SDGs. The General Assembly adopted the finalised SDGs in 2015, in which the Net zero is a significant consensus reached in the human pursuit of sustainable development. By the end of 2021, 136 countries, 115 regions, and 235 major cities worldwide have set net-zero targets. According to Dou et al., (2023) equity is an essential element for achieving sustainable development, including in the supply of critical minerals for energy transition and industry development. Currently, less developed countries are treated unjustly by international economic and political orders. It is stated that the SDGs are integrated and indivisible and balance the economic, social and environmental, however, according to Purvis et al., (2019, p. 687) "these three dimensions of sustainable development – economic, social, and environmental – are not specifically outlined in the overall structure of the 17 goals." Though there are contrasting versions of sustainability, the International Union for Conservation of Nature (IUCN) which has become an authority on sustainability matters, avoids the

use of the three pillars, preferring instead a model of sustainability that focuses on the goals of improving the ecosystem and human well-being.

When resource-owning countries receive more substantial rights and benefits are fairly distributed, SDGs can be realised in poor regions as critical minerals become increasingly important in economic and political terms (Dou et al., 2023).

2.8 Knowledge gap identified by literature

The knowledge gap identified in this literature review is the limited research on the integrated value chain of REEs and the sector in general in South Africa, which can be studied and framed through Gereffi's Global Value Chain (GVC) framework. In this research report, we use governance structures of the global value chain (GVC) to demonstrate that a focus on transactions in the GVC can provide useful insights for sustainable development. The value chain describes the full range of activities that firms and workers perform to bring a product from its conception to end use and beyond. This includes activities such as research and development (R&D), design, production, marketing, distribution and support to the final consumer (Gereffi & Fernandez-Stark, 2016).

2.9. Theoretical Framework

A framework is a conceptual model in which deduced relationships can be formed to conform to the core of the system under investigation (Ansari & Kant, 2017). The subject under investigation in this research is the governance of the value chain of rare earth elements. By applying Gereffi's GVC framework, we can better understand how global industries are organised into economic and social upgrading ideologies. Analysis of the Global Value Chain (GVC) examines how firms interact at particular processing steps, namely at their transactional characteristics (Machacek et al., 2017). The evolution of GVC in renewable energy sectors will have significant implications in terms of global trade, production, environment, employment and how developing country firms, producers and workers integrate into the global economy (Gereffi & Fernandez-Stark, 2016). "GVC further examines shifting global production patterns, links geographically dispersed activities and actors of a single industry and determines

their roles in developed and developing countries alike" (Gereffi & Fernandez-Stark, 2011, p. 02).

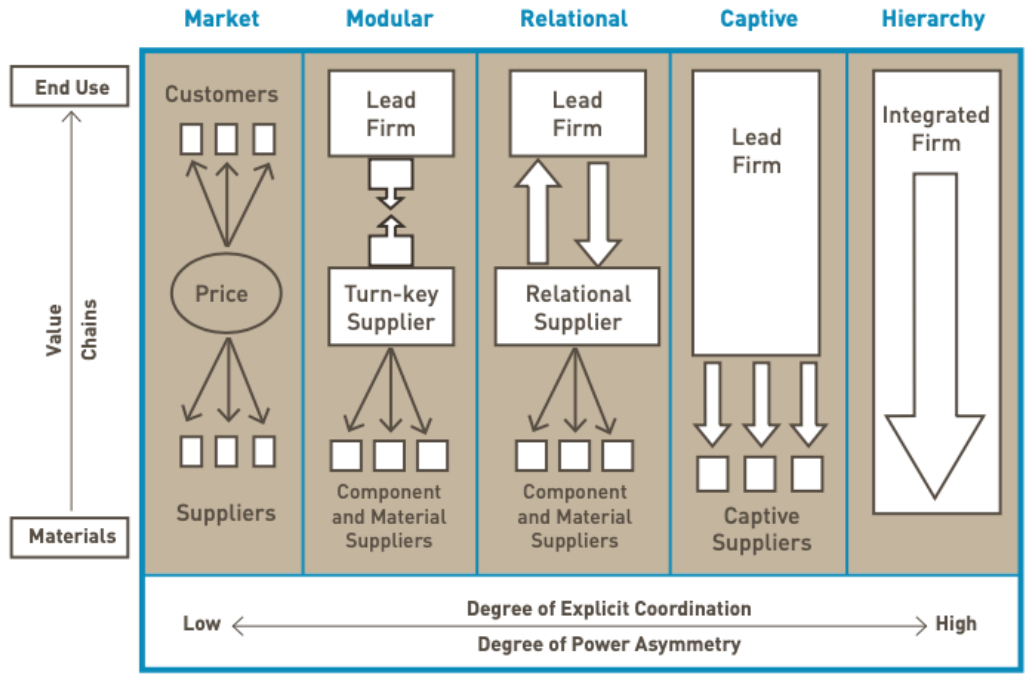
The GVC model will help the researcher identify the policy instruments to facilitate the transformation of value chains from one type to another (Inomata, 2017), from rare earth mineral mining to industrial upgrading, recycling and the GVC-driven growth of South Africa as a developing country. GVCs play a crucial role in access to knowledge and innovation for companies (Lee & Gereffi, 2021). Machacek et al., (2017) highlight the importance of GVC analysis in answering questions such as how and why materials flow and who is impacted positively or negatively by them. The GVC framework therefore enables us to identify governance for possible redress or policy recommendations. A value chain is composed of inter-firm networks on a global scale. Focused on the sequence of tangible and intangible value-adding activities, from mining exploration to product end-of-life use. Gereffi & Fernandez-Stark's (2016) analysis of GVC provides the top-down and bottom-up view respectively - examining how leading firms manage their global-scale affiliate and supplier networks and examining the impact of these business decisions on economic and social upgrading. There are six basic dimensions that GVC methodology explores **(Figure 05)** which are divided into global (top-down) and local elements (bottom-up).

Figure 05: Six Dimensions of the GVC Analysis

Source: Gereffi & Fernandez-Stark, (2016), Global Value Chain Analysis: A Primer

The third dimension above - ***Governance Structure: Lead Firms and Industry Organisation*** - explains how firms control the value chain. This research explores the governance structures of REEs through the global value chain (GVC) framework to understand the governance of the value chain of REEs in South Africa. The study will be mainly guided by Gereffi's GVC analysis model's governance dimension, which together with the literature review, contributes to the conceptualisation of this study. When certain actors in the chain have more power than others, governance analysis allows us to understand how the chain is controlled and coordinated (Gereffi & Fernandez-Stark, 2011). Governance analysis involves identifying the leading firms in the sector, their locations, how they interact with their supply base, and their sources of influence and power. It is an investigation by Gereffi and Fernandez-Stark (2016) that elaborates on a typology of five governance structures **(Figure 06):** market, modular, relational, captive, and hierarchy.

Figure 06: Five Global Value Chain Governance Types



Source: Gereffi & Fernandez-Stark, (2016), Global Value Chain Analysis: A Primer

2.10. Conceptual Framework

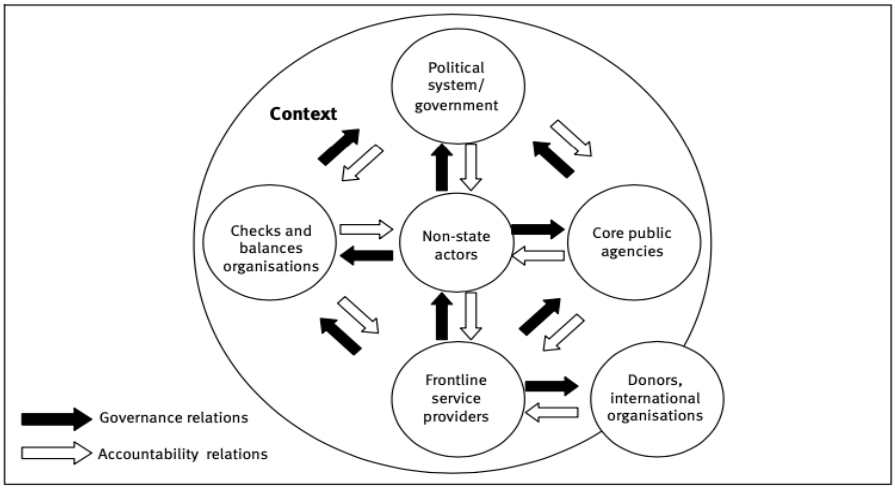
The conceptual framework is a guiding foundation for a research project that identifies concepts from the literature review and theoretical framework of the study. According

to (Jabareen, 2009), they are used to clarify concepts, organise ideas, and identify relationships upon which a study is framed with graphical illustration. The focus of this study is to explore the governance of rare earth minerals, and how renewable energy minerals elements can contribute to sustainable development. As the literature has shown three aspects of sustainable development — social; ecological; and economic — factors are not held up as a framework, therefore there are no governance structures in place to hold the new energy sector accountable for transitional mineral exploitation and failure to catch up with EU and China. As a result of this scenario, Purvis et al. (2018) conclude that current development policies prioritise only economic objectives. The conceptualisation of this research is applied to each segment of the value chain of rare earth elements to make sense of the contribution of governance structures to sustainable development. Governance, according to Mayer et al., (2017) is used to refer to the exercise of power by lead firms over suppliers or consumers within the global value chain.

Most studies on sustainable development focus on renewable energy components and infrastructure to resolve climate change, disconnecting the mining that contributes immensely to the first tier of renewable infrastructure laying bare a knowledge gap in the sector. The political economy of minerals in South Africa has been shaped by commodity markets rather than commodity chains. The demand for transitional minerals has drawn the sector into the global value chain of renewable energy, in which the governments increasingly emphasise GVCs as a part of their economic and development strategy (Mayer et al., 2017). To understand why technical reforms often fail to deliver the expected development outcomes, governance serves as a means of reflecting on the political economy of government policies and decision-making (Addison & Roe, 2018). The conceptual analysis adopted for this study is illustrated in **Figure 07** as a sector of political economy to look at the governance of the exploration, mining, manufacturing, and recycling of REEs. State, mines, labour, civil society, multinational companies, and organisations will be analysed using the sector governance analysis framework. “The framework guides a systematic analysis of governance issues related to formal and informal rules, interests, power, and resources to understand better how a sector functions (Edelmann, 2009. p.7) It attempts to understand the political economy that underpins the functioning of the

transition minerals sector by going beyond legal frameworks, formal institutions and processes.

Figure:07 Sector Governance Analysis Framework



Source: David Edelmann (2009), Analysing and managing the political dynamics of sector reforms

2.11. Summary of Chapter 2

This chapter presented a literature review on the governance of the Value Chain of rare earth minerals to identify the knowledge gaps, and to support political economy as a conceptual framework. It presented a comprehensive overview of the concept of governance and the critical mineral that underpins rare earth minerals. The chapter then details the empirical literature on the governance of the value chain of rare earth elements to support the link between minerals and renewable energy. It details the current governance frameworks of various stages of the value chain to deepen an understanding of why critical minerals should be governed differently. It concludes by introducing Gereffi's Global Value Chain as a framework for understanding how global industries are organised into economic and social upgrading. And a sector political economy as the conceptual guide to clarify concepts, and ideas and identify power relations amongst actors.

Chapter 3: Research Methodology

Introduction

The purpose of this research was to explore the governance structures of the value chain of rare earth elements (REEs) in South Africa. By choosing the governance of REEs, the researcher wanted to understand the power relations at play, the integration of renewable minerals in the value chain of the critical mineral sector and its subsequent contribution to sustainable development. The researcher believes the understanding of the value chain and the role of key actors will contribute to strengthening South Africa's position on the geopolitics of 'critical minerals' and deliver a truly just transition. The transition is not only finance and technology-centred but also mineral and metals-intensive with environmental and socio-economic implications. The researcher found in the preliminary investigation that the sector had no added value chain for REEs in South Africa as is the case with developed countries. Based on this background, we have developed a qualitative analysis approach for political economy case studies, since qualitative analysis helps transform data into reliable findings. Shifting from key informant interviews, this case study relies on documentary data (policy proposals, speeches, newspaper clippings). According to Patton (2015), documentary analysis findings are formed like an artistic mural composed of collages that combine in new ways when viewed in context to make sense of a greater whole.

Toward a better understanding of the governance of REEs as a case study, three research questions were addressed: 1. How does South African governance of transition minerals contribute to renewable energy and sustainable development? 2. What are the political, economic, and social governance structures driving the rare earth minerals sector in South Africa? 3. What are the perceptions of the REEs value chain in South Africa and how do these affect the geopolitics of critical minerals?

This chapter discusses the research methodology applied to the study of the governance of rare earth elements' value chain, presented as follows: a) rationale behind qualitative case study analysis as a research approach; b) research design; c) population and sampling procedures; d) data collection methodology; e) documentary

analysis; f) Validity, reliability, dependability, credibility; g) Limitations, feasibility and positionality; h) ethical consideration.

3.1. The Rationale Behind Qualitative Research Approach

Patton (2015) argues that qualitative inquiry explores questions as a research method, compared to quantitative enquiry, which requires standardised measures so that people's varying perspectives and experiences can be fitted into a limited number of predetermined response categories to which numbers are assigned. These research methods aim at achieving the desired outcome. Bryman & Bell (2019, p. 369) define the term "research methods" as a kind of catchall for several things that need to be outlined, such as "research design; sampling approach; specific procedures used, the nature of the questionnaire, interview schedule, documentary analysis, participant observation, observation schedule, or coding frame".

This study opted for the qualitative research method to allow the researcher to analyse content and, together with the assistance of participants' opinions and perspectives, co-create knowledge. Qualitative research adopts different theoretical assumptions drawn out of its various approaches. These theoretical concepts, as listed by (Bohnsack et al., 2010), are positivism, post-positivism, constructivism and critical theory. This research adopts a critical theory as a research paradigm to explore the governance of the value chain of transition minerals. The researcher applies an inductive approach to analysing the value chain theory and its governance structure. Bryman & Bell (2019) argue that if the qualitative strategy is mainly adopted, the research becomes an inductive approach to the relationship between theory: global value chain (GVC) and the research. The traditionally held assumption is that the practical information should generate a theory rather than test an existing theory (Wotela, 2017). This view is due to limited research on RREs in South Africa. The narrative that renewable technology equals a clean environment needs to be critically examined. According to critical theory, reality exists, but it's shaped by gender, religion, politics, ethnicity and cultural factors that construct a social structure (Abdul Rehman & Alharthi, 2016). The need to use clean energy to achieve the net-zero goals has gained momentum much to the detriment of historical debates that mining is destructive, therefore environmental and social impacts are overlooked in assessing

the transition of fossil energy economics. The geopolitics of security of supply of critical minerals supersede the problems of mineral-rich countries.

When asking embarrassing questions and making pointed arguments (Bryman & Bell, 2019), social scientists uncover exploitation, expose hypocrisy, and reveal the nature and extent of their oppression to the general populace. Against this background, the research will follow a qualitative strategy to explore the governance of the value chain of RREs.

Findings from this research contribute to the growing debates about a Just Energy Transition and the role that minerals play in the renewable and green economy. The subsequent sections outline the design, procedures, and methodology for collecting, processing and analysing data that this research will follow to explore the governance structures of value addition of REEs.

3.2. Case Study Research Design

Several forms of research designs allow a researcher to frame a study, either as an experimental design, a cross-sectional or survey design, a longitudinal design, a case study design, or a comparative design (Bryman & Bell, 2019). The design must demonstrate strong theoretical and conceptual rigour and be credible. It must be appropriate to the inquiry question, the available resources, the context for the study interests and more importantly the capacity and capability of the researcher to carry out the research (Patton, 2015, p.373). The inquiry question looks at the political economy as a research focus, because adopting the political economy style makes policy analysis realistic and useful. (Goodsell, 2017) argues the style does not try to remove problems from their contexts, but harvests the far-reaching significance of defined problems and their proposed interventions. Case studies have illuminated subjects studied by political economists such as policy decisions on critical minerals, interest group pressures on economic regimes and organisations, multinational corporations and governments (Odell, 2001).

This research opts for a single case study design as a framework because it can provide a comprehensive analysis of a case such as the REEs. The basic case study

design according to Bryman & Bell (2019) should entail a detailed and intensive analysis of a single case such as a sector of the economy. An argument which is in line with the conceptual analysis of this study. This study is qualitative and will use a purposeful sampling strategy using a technique of a single significant case in which one case is studied in depth to provide a rich and deep understanding of the subject with distinct standout importance (Patton, 2015). A qualitative case study of REEs will capture and interpret the context of the value chain of the mineral from exploration to end of life, interrogating actors and their interests. “The concept of context encompasses cultural, political, economic, historical, geographical, and institutional considerations" (Patton, 2015: 48).

3.3. Population and Purposive Sampling

The sampling technique used in this study combines content analysis sampling and purposive sampling to achieve the study's goals and triangulation. A number of phases are involved in selecting content analysis sampling in mass media, and these methods have also found applications in other fields (Bryman & Bell, 2019). While content analysis sampling examines featured documents, purposive sampling aims to find individuals who can provide valuable information about the study topic (Bryman & Bell, 2019). While content analysis sampling examines featured documents, purposive sampling aims to find individuals who can provide valuable information about the study topic (Bryman & Bell, 2019). To enhance triangulation, "key informants, key knowledgeable, and reputational samples" of a population based on their characteristics as governance experts were considered. The researcher extended an invitation to interview governance experts and specialists in mineral governance, including an analysis of the work of expert institutions in the sector to guide or provide access to documents to be analysed. The researcher opted for documentary analysis from organisations that were targeted as the population of the study such as trade, industry and competition, Industrial Development Corporation (IDC), Mintek, Council for Geoscience and Monazite Mines. Guided by Patton (2015) that there are no rules for sample size in qualitative inquiry, the sampled documents of this study depended on the purpose of the research and what will be useful to the researcher. The study relies on the available secondary data because the REEs sector is a new area of work in South Africa. By so doing the study archives content thematic analysis to control

and experiment with group patterns determined by informational considerations (Patton, 2015).

3.4. Data Collection Methods

The methods of data collection and analysis focus on qualitative approaches such as observation, interviews, quotations, and excerpts from documents and narratives (Adams & Lawrence, 2019; Patton, 2015). The decision on the data collection method lies in the design of the study such as document analysis in the case of this research. This study involves collecting different types of documents, such as books, newspaper articles, academic journal articles, and institutional reports, and any document containing text can be used for qualitative analysis (Morgan, 2022). Documents from key targeted government departments and their entities as outlined above in the population and sampling sections were collected and reviewed. The literature review and information provided by key informants helped in the decision of data collection. In addition, face-to-face and zoom semi-structured interviews with key informants were conducted. An interview guide was prepared with open-ended questions to gain answers. The interview guide contains questions about their understanding of the value chain governance; their current governance framework or processes in the value chain of REEs and related transition minerals; What organisation or departments are involved in REEs sector value chain; the impact of REEs mining on the environment, economic, social and labour issues.

3.5. Documentary Analysis

There are three clusters of types of thematic analysis (TA) approaches, namely reflexive thematic analysis, codebook TA and coding reliability TA is a method for identifying, analysing and reporting themes within the collected dataset (Trainor & Bundon (2021). The study uses a reflexive thematic approach to analyse the collected documents solely because it can be deployed with various theoretical and conceptual frameworks (Braun, Clarke, & Joy, 2023). A reflexive thematic analysis is widely used in education, social work, and counselling research to explore and interpret qualitative datasets and tell a story about patterns of meaning (Braun, Clarke, & Joy, 2023). Reflexivity in qualitative research relates to how the researcher's values, history,

characteristics, and decisions made during the research affect the results in which the researcher investigates their interpretations (Morgan, 2022). Patton (2015) emphasises reflexivity and calls for the need to be alert to the social, political, cultural, and economic factors that influence the researcher's perspectives on the case under investigation. The documentary methods seek to reconstruct the implicit knowledge that underlies everyday practice and are used to provide an orientation for repeating actions independent of individual motives and intentions (Bohnsack et al., 2010).

This study uses predetermined themes in the value chain of REEs as thematic analysis to capture various ideas and meanings expressed by the documents and key informants. Therefore, this study follows the reflexive thematic analysis process (Braun et al., 2023) which provides a six-phase process to guide the researcher through the different aspects of analytical engagement: a) Familiarising yourself with the dataset; b) Coding; c) Generating initial themes; d) Developing and reviewing themes; e) Refining, defining, and naming themes; 6) Writing up. This process will be exercised rigorously to probe the governance under the following thematic areas mineral exploration, extraction, processing, manufacturing, assembly and recycling.

3.6. Validity, reliability, dependability, credibility

The study's validity means it must be accurate, while its reliability translates to consistency. To assess the reliability and validity of any measurement instrument, we must clearly define the measures we are using (Adams & Lawrence, 2019). Here qualitative validity translates into the researcher checking for the accuracy of the findings by utilising triangulation and member checking as procedures (Creswell, 2018). The research validity will be achieved by examining evidence of governance experts and documentary evidence to establish a coherent justification of themes, according to Creswell (2018). In addition to triangulation, the parts of the report will be shared with the interviewed people to determine if they feel the information presented in the report is an accurate description.

The rationale of qualitative research is to examine evidence applicable to the sampled population of study to be utilised as external validity, which means the study can be generalised to the entire population. External validity is the validity of applying the

findings of a study outside the sample of that study. This study fulfils the requirement of a Master's degree and will not achieve external validity.

In this study, qualitative reliability techniques will be used to document as many steps as possible to ensure that others interested in studying the governance of the value chain of REEs can follow the same procedure. Several qualitative procedures will be followed as advised by Creswell (2018).

3.7. Limitations, feasibility and positionality

The study involves explorative research on policy uncertainty and clarity, because the research uses a one-point time approach that involves one interview per person on one site visit per place, and the interviewees are reluctant to speak with authority on a topic that has no clear policy direction. Another limitation is finding experts who understand the entire value chain of RREs. It looks like it is an emerging body of work in South Africa from the literature review in this proposal. This limitation was mitigated by adopting a snowball approach increasing the number of independent experts and finally settling on documentary research. The researcher has an extensive background working in organisations that liaise with the extractive industry and the energy sector and has contacts that can lead to interviewing the right respondents for the study, therefore contributing to the feasibility of the study.

3.8. Ethical Consideration

Ethics are an important consideration at every stage of a research project, including the writing up of research results, according to Bryman & Bell (2019). Moreover, they advise that once a research design is selected, in this case, a case study, the researcher should submit a proposal that will handle ethical considerations in each phase of the study to the ethics committee. The Belmont Report (Bethesda, MD, 1978: 4) advises researchers about the general rule that if there is an element of research in an activity, that activity should undergo review to protect human subjects.

The Research Ethics Guidebook (Boddy et al., 2010) also demonstrates the importance of building ethics in all stages of the study. This researcher has read the

critical literature on ethics and is confident that ethical issues have been adhered to by assuring the documents collected and people approached, their answers or the information is treated with utmost confidentiality to protect their reputations and jobs. Based on the selected informant identified through purposive sampling an email is sent to the interview requesting the participant to participate in the study.

The researcher sought and was granted ethical clearance by the University of Witwatersrand before proceeding with the study. An undertaking in the form of a participant information sheet was done to provide participants security that their information will be treated with the utmost confidentiality, anonymity if they so wish and the right to withdraw from the study.

Participants were contacted through cold calling to organisations and individuals deemed suitable for the study, followed by an email once the conduct of the study was established. Participants were then provided with a detailed participant sheet outlining the study's purpose and procedures. It details the research project on critical minerals and that it is investigating the supply chain of transition energy minerals. Informing participants that the research project explores the governance structures of the value chain of rare earth minerals in the renewable energy sector in South Africa.

3.9. Summary of Chapter 3

Chapter Three presents the qualitative research methodology and the critical theoretical paradigm used in the study. The study adopted an inductive approach by collecting data that is relevant to the case study and the analysis of the value chain of REEs as a single case study. A purposive sampling technique and also drawing samples from selected documents was employed to develop themes for the study. The collection of data was done by reviewing documents and conducting personal interviews. The collected data was then analysed through reflexive thematic analysis which involves coding, constructing, refining, defining and naming themes that guide the writing of the report. The study ensured that reliable documents and persons of interest were consulted to increase the validity of the information gathered and analysed.

Chapter 4: Presentation of Research Findings

Introduction

This Chapter presents the research findings of this study from collected data sourced from various documents and key knowledgeable informants on critical minerals governance and the REEs case study. Using sector political economy case analysis, it maps the key actors and their interests, power and incentives, analyses governance and accountability relations and evaluates governance reform readiness in the sector. This conceptual framework complements, in practice, Gereffi & Fernandez-Stark's (2016) analysis of governance as it identifies lead firms in the sector, their location, their engagement with resource material countries, and how they influence and gain power over them.

To successfully carry out this research, the topic of governance of the value chain of transition minerals, as well as the developmental impact of their exploitation, is based on the consensus that 'government matters', which led to the inspiration behind this study. This consensus has developed on the back of the need to explain why producer countries of the Global South have experienced negative outcomes, but the countries in the Global North, including China, have experienced better outcomes in building renewable infrastructure (Addison & Roe, 2018).

As discussed in Chapter One, the purpose of this study is to conduct a sector political economy analysis of the governance of the value chain for rare earth minerals (REEs) in South Africa and their contribution to sustainable development. From mineral exploration to the end of the use of products and recycling, the value chain describes the entire process of bringing a product to market. This includes activities such as "research and development (R&D), design, production, marketing, distribution and support to the final consumer" (Gereffi & Fernandez-Stark, 2016: 7), that have informed the conceptualisation of this study and its measurement instrument. The findings can contribute to the government capitalising on the expertise of various entities, to harness the value chain of REEs to compete and participate in the global value chain.

The emerging key findings from the documentary analysis relating to the case study from relevant government departments and its entities in addition to the information provided by key informants, indicate divergent and unilateral decisions that are not in sync with each other. Several interviews with experts on governance and unions representing mine workers are presented in this chapter. As Bryman & Bell (2019) advises more data collection continued until no new information could be sourced from the targeted organisation. Additional information from key informants who could not participate in the study and recommended readings from government agencies and experts developing strategies on these minerals were also considered.

This section presents findings from documents and interviews conducted with key informants. The report presents the documents and organisations analysed as well as participants and their designations. It is followed by themes predetermined by the researcher as part of the conceptual framework.

4.1. Document and Participant Rate

Documents were sourced from internet searches and referrals by key informants. A search engine combination of keywords of REEs plus organisation was performed (i.e., REEs and DMRE). The data collection process continued until no new information was found in connection with the specific organisation (Bryman & Bell, 2019). All documents were then downloaded and filed in a case file for each organisation.

Table 1: Overview of Documents Surveyed

Organisation	Document
DMRE	● The exploration strategy for the mining industry of South Africa ● South African Economic Reconstruction and Recovery Plan ● South African Renewable Energy Masterplan
DFFE	● National Waste Management Strategy 2020
CSIR	● South Africa's resource availability as a driver for transitioning to a Circular Economy
Mintek	● Mintek Annual Report 2022/23
Council for	● CGS Annual Report 2022/2023

Geoscience	
IDC	● Towards rapid, sustainable and inclusive development
News	● Council for Geoscience has a major role to play: Integrated Report 2023

Access to interview participants was difficult due to the developing nature of the sector as an emerging technology. Starting with the DMRE which supposedly should be central to mineral governance was fruitless. Comments from a senior member of the ministry included:

> "First, yes, there is awareness of the importance of what the DMRE tends to refer to as 'the minerals of the future' (see Minister's budget speeches). Two, in terms of your reference to the governance structures, the department could not link. So, it is just a word. Third, yes, there are entities of the DMRE that have scientific expertise to talk about the matter. You should look up Mintek and Council for Geoscience" (DMRE Senior Official 28/11/2022).

The study envisages interviewing 20 key informants. During the piloting of the study, it became clear that the value chain and integrated policy on renewable minerals in South Africa is lacking, hence the decision to conduct a documentary analysis. Several letters were sent to key informants after identifying them in the organisation. The fewer interviews conducted serve for the triangulation of the study.

Table 2: Study Key Informants

Organisation	Designation	Name
Mintek	Key Informant (KI)	Nozuko Mani
Mintek	KI	Wonder Nyanjowa
SAIMM	KI	Rasoul Hassanalizadeh
Economist and Author of Africa's Green Mineral Strategy for the AfDB	KI	Richard Goode
United Association of South Africa (UASA) CEO	KI	Jacques Hugo

4.2. Thematic areas from the data

The study analysed the document in line with the following predetermined themes informed by empirical literature review and the value chain of Rare Earth Minerals. Thematic analysis (TA) as a qualitative approach gives the researcher accountability to articulate methodological decisions (Trainor & Bundon (2020). These decisions are inspired by Braun and Clarke's (2019) emphasis that the method requires an active and reflexive practitioner to produce knowledge. Therefore, the following thematic areas, patterns within and across data about the documents' views and perspectives are analysed to decide about governance structures: a) Mineral exploration and mining; b) Environment and Groundwater governance; c) Manufacturing and end-user production; d) Regulation of Recycling Economy; e) Critical Minerals Diplomacy and Geopolitics. In conclusion of the chapter, we look at practical governance analysis, which, according to Gereffi & Fernandez-Stark (2016), calls for the identification of the lead firms in the sector, their location, how they interact with their supply base and their source of influence and power over them.

4.3. Governance of Mineral Exploration and Mining

A competitive mining exploration regime is in place in South Africa, as spearheaded by the Council for Geoscience (CGS). The governance of mining exploration has a clear historical mandate, and its objectives and challenges are well articulated. Key stakeholders understand the government's mandate on exploration, but its contribution to a just transition and the need for transition mineral exploration is not clearly defined as the critical stage of the value chain of the renewable energy sector.

The Council for Geoscience (CGS) was established in terms of the Act of Parliament, Act (No. 100 of 1993) as the national custodian of geoscientific data (CGS, 2023). The council, apart from conducting geoscientific research, is responsible for bringing to the attention of the Minister the prospecting and mining of minerals that can benefit the country such as REEs. The perceptions on exploration of renewable energy are stated thus:

> "CGS is investigating the geothermal research potential of South Africa, the early positive results of which will augment the country's sustainable renewable energy programme in the medium to long term as well as continued focus in characterising mineralising systems for 'battery minerals' and 'minerals of the future" (*CGS, 2023. p24)*.

This investigation forms part of the CGS's contribution to the country's energy security and just energy transition and is founded on the numerous projects that constitute its Geoscience Technical Programme (GTP). This sentiment demonstrates the exploration endeavours of the country on just transition are not congruent with the global strategic demand for minerals such as REEs. It is an indication that there is no policy to integrate the sector, as they are still investigating. The Minister of DMRE's assertion below that the CGS needs to play a more preeminent role in addressing challenges in society related to climate change complements this initial finding that energy transition is not connected to green mineral exploration. Hence, there are varying contributions on what needs to be done:

> "As we develop various technologies, minerals that will be used are in this country. A variety of minerals that will be used even in developing the green economy of the future – hydrogen energy, and various minerals including rare earth elements – are in this country and only geoscience can unravel all those minerals and bring them to the fore" - The Minister of DMRE (SANews, 2022).

> "Renewable energy technologies that Mintek is involved in include the development of hydrogen and platinum fuel cell and battery storage technologies. At any point in the value chain, some organization or institution sets and enforces parameters under which others in the chain operate; …. but the weak capacity of the state to monitor and enforce its laws and regulations has held back the continued growth of the industry." (KI)

> Since 2010, Mintek has been investigating the technical feasibility of establishing a centralised REE processing facility in South Africa to produce separated REE at a globally competitive cost and enable the country to become a processing hub for REE in the Sub-Saharan African region. (KI)

As the "custodian of minerals beneath the earth in South Africa" (KI), the DMRE has the responsibility to put together a comprehensive policy package for the interest of

the renewable energy sector. The core mandate of the DMRE as the state department is to ensure the regulation of South Africa's mineral resources and mineral industry and, in the process, secure and provide energy to support socio-economic development.

South Africa has developed an exploration strategy for the mining industry to bring back the fortunes of the yesteryear brought by gold resources by venturing into the green economy through the development of clean technologies (DMRE, 2022b). The strategy indicates that:

> "The country hosts a diverse mineral base, both tapped and untapped, such as Platinum Group Metals (PGMs), chromium, iron ore and base metals, which feature prominently in the renewable energy space and the minerals of the future. Unlocking the potential presented by these natural resources may usher in a new generation of the mining industry that is responsive to current and future market demands" (*DMRE, 2022b, Exploration Strategy, May 2022).*

The strategy lacks content in terms of explicitly identifying key minerals that are critical for renewable energy. Furthermore, documentary analysis of the exploration strategy uncovers the traces of unreadiness and backwardness as outlined in the body of the DMRE exploration strategy, in which legislation and policies across the government departments are not in synergy with each other and the government's overall objective. This presents a threat and barrier to the value chain and a challenge to the governance of rare earth minerals as a sought-after and contested resource.

> "The National Environmental Management Act (NEMA) has open-ended appeal and objection procedures that further stretch the prospecting timelines; The implementation of the Protected Areas Act and the Spatial Planning and Land Use Management Act (SPLUMA) does not sufficiently take into account the needs for mineral development, particularly in geological settings with the best potential; The possibility of mining and agriculture coexisting is threatened by the Preservation and Development of Agricultural Land Bill; Long wait times for water use license applications under the National Water Act further impede the advancement of bulk sampling and advanced exploration, which support feasibility studies and allow the conversion of prospecting rights into mining rights" (CGS, 2023, p.7).

> "South Africa lacks a minerals cadastral system that lists available mining or prospecting rights, properties currently under a mining or prospecting right and the expiry of currently held rights and the ownership thereof. This has often led to double allocation of exploration and mining rights on the same piece of land, resulting in court battles between mining companies and the government." (KI)

4.4. Environment and Groundwater Governance

The mining industry in South Africa is governed by the MPRDA 28 of 2002 and related legislation such as the Mining and Biodiversity Guideline and the National Environmental Management Act (Waste Act 59, 2008) to promote the ethical mining sector. NEMA promotes legitimate economic and social development while ensuring ecologically sustainable development and natural resource utilisation (DFFE, 2020). On the other hand, the Waste Management Development Strategy claims to provide a coherent framework for the implementation of the Waste Act for socio-economic development. A contradiction to the 2018 State of Waste Report is that "South Africa is experiencing huge constraints in terms of the availability of landfill space, therefore generating Greenhouse Gases and is not compliant with licensing conditions" (DFFE, 2020). The non-compliance with the licensing conditions is a huge risk to environmental governance because is highly toxic.

> "REEs are mined by digging vast open pits in the ground, which can contaminate the environment and disrupt ecosystems. When poorly regulated, open-cast mining can produce wastewater ponds filled with acids, heavy metals and radioactive material that might leak into groundwater. Processing the raw REE ore into a form useful to make magnets and other technology products is a lengthy effort that takes large amounts of water and potentially toxic chemicals as well as produces voluminous waste that can pollute the air and drinking water sources, harm wildlife and habitat as well as permanently damaging the natural landscape". (KI)

> "The extraction process, often involving large-scale open-pit mining, leads to the destruction of natural habitats and ecosystems. This clearing of vegetation and soil disruption results in soil erosion and loss of biodiversity, adversely affecting local wildlife and plant species". (KI)

The Application of groundwater modelling is a developing field in the CGS and finding expression in various projects such as regional groundwater assessments and the IRMC [Integrated Research into Mine Closure] (CGS, 2023).

With these interventions in place, the findings indicate that “the implementation of these policies cannot be quantified because of poor levels of monitoring” (DMRE, 2023b)

4.5. Manufacturing and End User Products

The policy disconnect alluded to by the exploration strategy above is further expanded by the trajectory taken by the Industrial Development Corporation of South Limited (IDC), which introduces another dimension to renewable energy. The IDC is one of the central government agencies established to lead the development of domestic industrial capacity (IDC, 2013). It is established by an Act of Parliament (Industrial Development Corporation Act, No. 22 of 1940). The IDC, as the implementation agency of the government, follows the prescriptions of the government policy on the New Growth Path’s (NGP) Industrial Policy Action Plan (IPAP), which aims to identify opportunities for sector development (IDC, 2013). Mining and manufacturing, as one of its core strategic business units, focuses on mining and beneficiation of new technology-related minerals such as lithium and rare earth elements. This area of focus operates independently from the Green Industries business unit, which focuses on renewable technology. The comment below captures the disconnect between green minerals and green technology by key informants.

> “South Africa's failure to develop downstream industries for rare earth elements hampers its economic potential. By focusing solely on raw material extraction and exports, the country misses’ opportunities for value addition and job creation. The lack of downstream capabilities leaves South Africa vulnerable to global commodity price fluctuations, weakening its position in the market. (KI)

> We are involved with mining via the DMRE, Mine Health Safety Council, and MQA *[Mining Qualification Authority],* you know, those normal bodies that we are well represented, but I

> am not certain if there is a focus on training technicians on necessary skills to be able to help the country on beneficiation of this minerals. (KI)

The Department of Minerals Resources and Energy is embarking on another draft policy document, the South African Renewable Energy Masterplan (SAREM). It provides a promising direction for an integrated value chain of transition minerals in line with the National Development Plans and a move away from utility-scale government-led procurement through the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP). REIPPPP was established at the end of 2010 as a government intervention to increase the country's power generation capacity.

The plan acknowledges "the growing global market for renewable energy which is expected to grow from 5.4 trillion to 10.8 trillion by 2030 as decarbonisation efforts continue and new demand sources like green hydrogen and New Energy Vehicles (NEVs) rises. Similar to this, the global market for battery storage is expected to expand dramatically, from 700GWh in 2022 to 4.7TWh annually by 2030" (DMRE, 2023c).

The master plan is focused on battery storage for industrial development opportunities, and its target is not predetermined as it was undergoing public comments when writing this report. It is not clear on the minerals it is proposing for the renewable energy value chain. The plan is threatened by regulatory reforms that have opened up the private sector market, by first loosening in August 2021 and then removing the licensing requirements for Independent Power Producers (IPPs) by the president in December 2022 (DMRE, 2023d).

Another government intervention, the South African Economic Reconstruction and Recovery Plan, which aims to achieve the National Development Plan goals to reduce poverty, unemployment and inequality, offers intervention that is inconsistent with the other green economy and mining initiatives. The strategy acknowledges that investment in research, development and innovation (RDI) is the driving force for economic recovery (SAGov, 2020). It argues that a continued long-term investment

into RDI will contribute to economic reconstruction in three areas - agriculture, manufacturing, mining and minerals beneficiation.

In mining and minerals beneficiation, the strategy focuses on the Platinum Group Metals (PGM), again missing the most critical minerals that form the cornerstone of the green economy, which the strategy argues is an important intervention to address sustainable solutions to climate change and economic competitiveness (SAGov, 2020). The strategy situates research and development on mining within the Department of Science and Innovation (DSI), which launched the Hydrogen South Africa (HySA) programme in 2007 to develop fuel cell technology.

The Department of Science and Innovation, together with the Minerals Council South Africa, runs a Mining Precinct which focuses on RDI to support the longevity and sustainability of the mining sector (SAGov, 2020). Apart from missing critical minerals for beneficiation, such as rare earth minerals, it also does not connect the sector to two critical entities, the Council for Geoscience and Mintek, responsible for exploration and research.

Mintek encompasses research, development and innovation throughout the minerals value chain from end-user consumer products to physical and virtual solutions, its services fringes on:

> "Supporting exploration services through sample analysis and ore characterisation, mineral processing, extraction, refining, and production of metal-based products, process development, and post-mining support" (Mintek, 2023, p. 22)

4.6. Regulation of Recycling Economy

Khan et al. (2022) at Council for Scientific Industrial Research (CSIR) posit that the implementable circular economy opportunities in the mining sector are aligned with the principle of keeping the raw materials in the country rather than exporting them. Exporting the materials means that South Africa has very little control over the downstream circularity (Khan et al., 2022). This tells us that rare earth minerals which are currently being exported, play no role in the circular economy of South Africa. In

201,7 South Africa accounted for 1.6% of Mineral Waste (DFFE, 2020). The circular economy in South Africa is the competency of the Department of Environment, Forestry and Fisheries (DFFE) as mandated by Section 24 (Environment) of the Constitution of the Republic of South Africa (Act 108 of 1996). The Act requires the department to ensure everyone has a right to an environment that is not harmful to their health and to have the environment protected for the benefit of present and future generations. These rights are guaranteed by diverting waste from landfills while building a secondary resource economy based on the beneficiation of waste as part of the circular economy and the last stage in the value chain of minerals (DFFE, 2020).

4.7. Critical Minerals Diplomacy and Geopolitics

The 17 elements of rare earth minerals are becoming a geopolitical issue due to their technological applications as a strategic input, not only in renewable energy technology but also in the defence industry. The CGS of South Africa occupies a regional seat as the permanent Secretariat of the Organisation of African Geological Surveys (OAGS) (CGS, 2023). The approach does not use the position to leverage the green mineral resources and connects it holistically to the global value chain and the geopolitics of minerals. The CSG reports in the 2023 report are as follows:

> The CGS Geoscience Diplomacy Programme aims to undertake integrated and multidisciplinary geoscience research and development across Africa in support of allied developmental imperatives (CGS, 2023).

Another organisation playing an important role in the Rare Earth Mineral sector is Mintek, an implementation agency of the DMRE that has a global footprint in international sales has overcome obstacles in the supply chain and is a partner in the area of pyrometallurgy (Mintek, 2023).

It stated in its annual report that it collaborates with commercial partners to optimise technology and enhance capacity for the extraction and purification of battery materials and REEs.

> "Our Cynoprobes[1] has gained traction throughout the year among customers in the Democratic Republic of Congo, Canada, Ghana, Turkey, Australia, Tanzania, and Mexico, expanding our global footprint. Additionally, our Lab Cynoprobes have attracted customers in Tanzania, Australia, India, Canada and Russia" (Mintek, 2023, p. 33).

Some key informants expressed strong sentiments about the disadvantage of settling on a commodity producer position to feed the domination of China and, subsequently, the EU as it seeks to exit the Chinese market in the sector.

> "In the case of REEs the main issue is that mining and processing is dominated by China and that dominance has only recently, say from 2015 onwards turned into a political and economic issue in important developed country markets that are scrambling to respond. Witness the newness of critical minerals strategies coming out of end-user markets" (KI)

> "South Africa as a commodity producer will have to accept the terms of trade set by China rather than compete with it. China is consolidating its lead position in the REE industry through the enforcement of production and export quotas. Also significant, is China's policy of deliberately using export restrictions to leverage non-Chinese prices and induce foreign downstream producers to relocate REE production to China". (KI)

4.8. Summary of the Chapter 4

Chapter 4 presented findings based on the five thematic areas. The researcher identified themes from the collected data and interviews based on the chain rare earth elements value addition. The findings also include perceptions and information about the geopolitics of critical minerals. The information is presented as extracts from documents and quotations from responses.

The main finding of the study is the misalignment in policy and interlocking projects lacking a cohesive governance structure detrimental to the country's just transition and sustainable development objectives. These findings are derived from the exploration strategy's lack of inclusive participation of all key stakeholders, the Council for

[1] The Cynoprobe, is Mintek's state-of-the-art online cyanide analyser that facilitates online monitoring and control of cyanide in the gold recovery process

Geoscience (CGS), Mintek and the Council for Scientific and Industrial Research (CSIR) for example, resulting in the misclassification of REEs as the mineral of the future, meanwhile, the minerals are currently at the heart of geopolitics of critical minerals. This also resulted in these entities undertaking their projects, such as Mintek undertaking a technical feasibility study to establish an REE processing facility in South Africa. Furthermore, government regulations of the renewable energy mineral sector are insignificant tools for governance instruments as they do not support each other.

Chapter 5: Discussion and Interpretation of Findings

Introduction

The main focus of this study is on governance, which is one of the six dimensions of GVC analysis illustrated in Chapter 2. It explores the governance structures of the value chain of rare earth elements (REEs) in South Africa. Using documentary analysis and information from experts, an understanding of the value chain of rare earth minerals as a case in South Africa is sought. Employing a critical paradigm, the study looks at how governance of transition minerals can truly deliver a just and sustainable transition to renewable energy.

The critical paradigm sought to critique the role of various actors through the political economy lens by studying how various actors involved in the value chain influence and control it. As highlighted in the literature review by Schrage & Gilbert (2021) governance is a multilateral process in which stakeholders contribute knowledge and resources to define and implement global rules and provide global public goods. Data was collected from identified government entities and was processed through reflexive data analysis to answer the overall research question of what governance structures are in place in the context of the South African transition minerals value chain for sustainable development.

Upon selection of the documents for analysis, a reflexive thematic analysis process was conducted based on the topic codes and a conceptual framework analysis was conducted. In addition to the overall research question, the study purported to answer the following research questions a) How does South African governance of transition minerals contribute to renewable energy and sustainable development? b) What are the political, economic, and social governance structures driving the rare earth minerals sector in South Africa? c) What are the perceptions of the REEs value chain in South Africa and how do these affect the geopolitics of critical minerals?

Chapter four outlined the governance frameworks for presumable chains of the value chain of South African rare earth minerals - Mineral exploration, Governance of critical minerals, Environment and Groundwater, Land Use, Manufacturing and End User

production, Recycling, and Geopolitics. The purpose was to present the documentary evidence and perceptions of informants and critically apply sector political economy juxtaposing the existing empirical literature on critical minerals. This Chapter discusses and interprets the findings based on empirical findings of the governance of rare earth elements in the literature and documentary and key informants' perspectives.

5.1. Key finding of the study

The main research question of this study was to find what governance structure(s) exist for the South African transition minerals value chain for sustainable development. This study concludes that the governance structure for South African rare earth value chains is the Market type global value chain governance. The typology, as elaborated extensively by Gereffi & Fernandez-Stark (2016), is one of the five types of governance structures - markets, modular, relational, captive, and hierarchy - illustrated in the theoretic framework in Chapter 2.

The governance structures explain how the value chain is controlled by certain key actors, such as the lead firms. Given the fragmented governance frameworks that purport to regulate an equally fragmented South African value chain of RREs, the lead firms, mainly from China, will dominate the South African critical minerals sector. This gives credence to the (Baker & Sovacool, 2017) argument that South African renewable energy is at risk from global production networks preventing the country from realising local renewable energy technologies.

The government has various documents and strategies analysed in Chapter Four that commit to renewable energy and Just Transition, focusing on minerals but making it easier for exploitation of the resources in all identified projects, namely Steenkampskraal, Zandkopsdrift, Rainbow Minerals, Tronox and Namaqua Sands due to misalignment of policy. Though the Market type GVC governance provides arm's length exchanges requiring little cooperation between actors and the cost of switching to new partners is low for both producers and buyers, according to Gereffi & Fernandez-Stark (2016), Chinese firms have the upper hand due to the domination of the country on the sector. Producing a natural commodity such as rare earth minerals

does not require any specific investment in production facilities. Therefore, customers and suppliers have the choices for alternative markets (Inomata, 2017). Through its new Belt and Road Initiative (BRI), China is already aggressively purchasing concessions for the discovery and mining of rare earth minerals in South America and Africa.

South Africa is caught in a captive value chain governance structure in which mineral exploitation is determined by a buyer-driven chain. This highlights the powerful role of China despite several policies and legislation governing energy and the mining sector in South Africa. The documents analysed provide compelling evidence that South Africa's renewable energy initiatives are making progress. However, they do not articulate a comprehensive strategic direction that is inclusive of its renewable energy minerals to capitalise on the growing demand for renewable technology, such as the intensified need for Neodymium-Iron-Boron (NdFeB)-based Rare Earth Magnets (REM).

Another major finding in South Africa is the misalignment of various legislation and policy documents of various entities that we have studied that all seek to intervene in Just Transition and renewable energy while contradicting each other is a source of its stagnation. The requirements for mineral development are not adequately taken into consideration by the application of the Protected Areas Act and the Spatial Planning and Land Use Management Act (SPLUMA), especially in geological settings with the greatest potential.

The main research question was to understand the governance structures that exist for the South African renewable energy minerals value chain to support sustainable development. This will then help in addressing the three research questions asked for this study. These questions were addressed under the following themes:

5.1.1. Governance of Mineral Exploration and Mining

The challenge with the governance of REEs is that renewable energy is less centrally managed than fossil fuel energy, where the state-owned company Eskom is in charge of producing energy according to central government directives using the plentiful

supply of coal as a national resource — the task of controlling the price of electricity fall to the National Energy Regulator (NERSA). The governance is, therefore, clearly defined in the case of the value chain of coal, from coal mining to transport and power generation. Meanwhile, the governance of renewable minerals is made complex by different governance regimes that stretch outside the parameters of the country to include mechanisms such as the UN Paris Accord to reduce greenhouse gases. As Kramarz (2021) posits, the consolidation of renewable energy has become increasingly dependent upon an international division of labour that shifts the dirtiest and most harmful forms of extraction to countries and regions whose governments are least able to regulate the environmental impacts of resource degradation and toxic waste. The GVC governance focuses on the sequences of value-added within an industry - from exploration and extraction of minerals up to production products and end-use. Which calls for ethical leadership to ensure suppliers receive fair treatment and equitable share of the market price (Gereffi & Fernandez-Stark, 2016).

The documents analysed on the exploration of critical minerals show that the government is waking up to the realisation that minerals play a role in the renewable energy sector; hence, the various initiatives to cater for minerals beneficiation. The Council for Geoscience, as an entity of government responsible for the exploration and investigation of new minerals, has numerous projects that constitute its Geoscience Technical Programme (GTP) as CGS's contribution to the country's energy security and just energy transition. The Just Transition programme's main focus is on hydrocarbon, geothermal systems and natural gas in the Karoo. The exploration expedition is the prerogative of the CGS and not a national policy. Hence, the entity is focusing on geothermal research. The Exploration Strategy cites rare earth minerals as the "mineral of the future" and a category of the minerals in demand for the internet era with a high reliance on battery storage, artificial intelligence, robotics, electric vehicles, and clean energy. This sentiment underscores the current uses of REEs in renewable energy technology.

As the literature review has shown in the case of China, all the entities are governed by the China Ministry of Industry and Information Technology to ensure an uninterrupted supply. The Chinese governments play an essential role in identifying companies that can add value by producing technologically advanced products One

of the research questions asked of key informants was about the political, economic, and social governance structures driving the rare earth minerals sector in South Africa. As noted in the findings, the core mandate of the department is to ensure the regulation of the mineral sector to secure and provide energy to support socio-economic development. However, key informants point out that the weak capacity of the state to enforce laws and regulations is holding back the REEs industry from growing. Mintek has conducted a feasibility study which shows the country can produce rare earth elements processing facility at a globally competitive scale, but it is not supported by an exploration capacity This is evidenced by the government's mineral exploration strategy, which state categorically the lack of coordination between departments. The exploration strategy further mentions that the implementation of laws remains a great concern and hinders the growth of mineral exploration.

5.1.2. Environment and Groundwater Regulations

The opening question of this study seeks to uncover the governance framework of transition minerals' contribution to sustainable development. The purpose was to establish a direct linkage of South African REEs contribution to sustainable development initiatives in South Africa. One of the key findings of the study is that the environmental assessment of the impact of rare earth mining is based on old information based on the treatment of wastewater and sludge treatment in the extractive industry, which makes the regulation unsuitable for regulation of the REEs sector.

Section 5(1)(d) of the MPRDA states the National Water Act, 1998 (Act No. 36 of 1998) uses water from any natural spring, lake, river or stream situated on or flowing through such land or from any excavation previously made and used for prospecting, mining, exploration or production purposes, or sink a well or borehole required for use relating to prospecting, mining, exploration or production on such land. This piece of legislation will be cumbersome as the REEs have high toxicity volumes and also given the problems experienced in the National Water Act enforcement.

As noted by Cessford (2004), the Department of Water Affairs takes a long time to approve applications for Environmental Management Programme Reports (EMPR) and Water Usage Licences (WUL). One key informant warned that poor regulation of

REEs mines can result in radioactive materials that might leak into groundwater. Rare earth mineral mining involves open pits in the ground, which can interfere with the ecosystem.

The documentary analysis proves that South Africa has problems with compliance with licensing conditions, posing a risk to environmental governance. On the other hand, the application of groundwater modelling cannot be quantified due to poor monitoring. This element creates sacrifice zones, as alluded to in the literature review. A condition in which South Africa suffers environmental conditions at the expense of the global effort to combat climate change.

5.1.3. Manufacturing and End User Products

The domestic industrial capacity of renewable energy is the downstream capability of the value chain that should address core economic and social issues in the country that require a clear political direction on skills development. This answers the question of the political, economic, and social governance structures of the value chain. Manufacturing is the key component of the beneficiation of minerals, a role that is played by the IDC in South Africa to drive the development of domestic industrial capacity. The REEs sector falls under its core strategic business, focusing on the beneficiation of new technology-related minerals, including lithium, which works on collaborations with other entities and interested parties.

The IDC also runs a separate business unit called the Green Industrial Development, which highlights the disconnect from the minerals responsible for green technology. Trade unions organising in the mining sector are not aware of skills development or the extractive activities underway on green technology developments connected to the sector. This led to one participant (KI) arguing that South Africa lacks downstream capabilities and focuses mainly on the extraction and exports of rare earth minerals. The policy direction which comes closer to the integration of critical minerals is the South African Renewable Energy Masterplan (SAREM). The plan is likely to be hampered by different legislations and policy frameworks co-governing the sector and a lack of dedicated research. There are many governments and mineral resource department entities undertaking individual research on the sector dedicated to

individual minerals. The unlikelihood of local mining companies not selling materials to local markets makes it expensive to benefit locally. This hampers the country to meaningfully contribute to the job market

5.1.4. Regulation of Recycling Economy

Though the literature has shown that we export most of our resources, South Africa has gone on a massive procurement of renewable technology through with little trace of how it will recycle the solar panels and wind turbines that are currently in operation. The removal of the licensing requirements for Independent Power Producers in 2022 by the President will add to dumping that will result in Greenhouse Gases. The massive development of renewable energy projects will mean an increase in dumping.

Zografos (2022, p.44) supports support this by noting that the “first generation of wind turbines and solar photovoltaic is reaching the end of its operational life and in light of blade recycling solutions being either not available on an industrial scale”. South Africa will face challenges that will reverse the incentives of having renewable energy in the first place. As we have already learned, South Africa experiences difficulties with landfills due to a lack of awareness that hinders waste management (DFFE, 2020).

5.1.5. Critical Minerals Diplomacy and Geopolitics

The analysis of strategic governance documents and information provided by some participants also wanted to address the question of the political economy of the governance structure of the value chain of rare earth minerals. This is important to understand the significance of the country’s strategic involvement in the international sphere in which China dominates the value chain in terms of research and innovation. The South African approach to geographical mineral activities is purely for commercial purposes, putting it firmly on commodity producers and providing mineral exploration services. As uncovered in the empirical literature review, the Global North is behind by at least a decade to catch up with China. One participant opined that South Africa will have to accept the terms of trade set by China. The failure to leverage the regional position as the Secretariat of the Organisation of African Geological Surveys and the project leader of 12 mining countries in the Sub-Saharan African region. As the

European Union strategically enter the upstream of the REEs, South Africa and the region will be negatively affected by competition between developed countries.

5.2. Summary of Chapter 5

This chapter discusses and interprets the findings from the documentary evidence that was analysed, including information from respondents. Findings from these documents diagnose multiple-pronged strategies and projects running concurrently by the government and its entities. On the exploration of minerals for renewable energy, the Council for Geoscience is exploring certain minerals as part of its Just Transition programme, while Mintek is also enhancing its capacity for extraction and purification of battery minerals. These efforts help the researcher conclude that the governance structure for the South African REEs value chain is the market-type governance structure. Although the typology views the relationship between the sellers and buyers as arm's length in which both have options to look for other markets, it has a twist of captive governance type in which lead firms have power over suppliers. This is because China is the leading country in the rare earth mineral sector. This finding is relevant to the entire value chain of South African critical minerals; therefore, these findings can be generalised to other green minerals.

Chapter 6: Conclusion and Key Recommendations

Introduction

The purpose of this study was to critically conduct a sector political economy analysis of the governance of the value chain of rare earth minerals (REEs). This study comes out of the researcher's interest in learning about the contribution of South Africa's so-called transition minerals contribution to the value chain of renewable energy and their contribution to the global renewable and just energy for sustainable development. The researcher's goal is to raise awareness about the role transition minerals play as critical inputs for renewable energy and their implications for the geopolitics of transition minerals.

Transition minerals are becoming increasingly sought-after minerals to resolve the global climate change crisis. This study was designed as a case study on transition minerals to look specifically at the value chain governance of rare earth minerals elements consisting of 17 medals. The conclusions of the study are based on the identified themes by the researcher to explore governance frameworks of rare earth minerals. The following are the themes identified to probe the governance of the sector:

a) Mineral exploration and mining
b) Environment and Groundwater governance
c) Manufacturing and end-user production
d) Regulation of the Recycling Economy
e) Critical Minerals Diplomacy and Geopolitics

Chapter 5 and the final chapter of this study discuss conclusions drawn from the key findings based on the identified themes above, the chapter concludes with recommendations from the researcher for policy and further studies.

6.1 Key Findings

The information gathered in this study is dominated by the social, economic and environmental impact of minerals, which agrees with the empirical evidence of this study identified by the literature review. The REEs, as the subcategory of renewable energy minerals, or what the EU Commission terms critical minerals, is an emerging sector in South Africa not clearly defined by the organisation beyond the commodities market. Its participation in the Global Value Chains (GVC) is largely limited to upstream activities and is being value-added elsewhere.

In addition to potential risks to national energy independence resulting from the geopolitics of critical minerals, including rare earth elements, Mintek and other respondents are worried about guaranteeing a consistent supply of rare earth minerals needed for RE. China supplies medals to industrialised countries as the leading producer of rare earth metals; it has been a significant source of worry on the governance of the value chain throughout these discussions. Despite this paradox, the goal of renewable energy is to mitigate global warming to the benefit of everyone. Minerals such as monazite, which contributes to 17 Rare Earth Metals, have an exceptionally high value. Key to their value addition is their application element to the renewable energy sector.

6.2. Recommendations

The recommendations presented in this chapter are drawn from the analysis and conclusions reached by the researcher. They present governance and policy to achieve a governance framework for transitional minerals. The beneficiation of minerals in South Africa is a shared responsibility of different government departments and institutions. The Mineral and Petroleum Resources Development Act of 2002, Act 26 of 2002 (MPRDA), gives a determination to the Minister of Mineral Resources and Energy to endorse the value addition of minerals in consultation with the Minister of Trade, Industry and Competition (DTIC). The DTIC should capitalise on the powers vested in it to coordinate all critical minerals to mitigate the position of market-type governance. The market typology gives the buyer the liberty to choose the market. Given the current domination of the value chain of REEs by China, South Africa continues trading rare earth minerals as raw materials as China sets prices. The international community has also moved to categorise critical minerals as a security

issue, an emerging trajectory away from technological innovation to solve the climate crisis to geopolitics. This requires governance measures to prevent negative environmental and social impacts. This study recommends anticipatory governance[2], a concept developed by the South African Institute of International Affairs (SAIIA). Anticipatory governance addresses uncertainties and challenges for the future of critical minerals and can benefit the value chain of all of the transition minerals in South Africa in threefold:

- Predicts future scenarios based on emerging trends to give strategic direction that policymakers and stakeholders can identify.
- Emphasise sustainable resources management practices by assessing critical mineral reserves
- Investment in research and alternative extraction methods to foster a sustainable, resilient sector.

6.3. Policy Recommendations

Based on the findings that government entities are engaging in inconsistent projects on renewable energy minerals and using different terminology, there is a need for policy directives on governing the sector with clear definitions of terms and objectives, such as the Chinese model. The Chinese government was able to achieve its current quasi-monopoly of the sector by dedicating the China Ministry of Industry and Information Technology to govern all entities involved in the REEs value chain to ensure an uninterrupted supply. South African government should:

Develop a Critical Mineral Masterplan to articulate a clear vision and objectives to supply national industrial development by incentivising local value addition, fostering research and development in rare earth processing, investing in a skilled workforce, and establishing a stable regulatory framework. Strategically trade all critical raw materials differently from other commodities. Dedicate a directorate within the DTIC to

[2] **Anticipatory governance** is the "systematic embedding and application of strategic foresight throughout the entire governance architecture, including policy analysis, engagement, and decision-making: SAIIA https://saiia.org.za/wp-content/uploads/2023/09/SAIIA_PB_279_AnticipatoryGovernanceCriticalMinerals.pdf

coordinate the activities of all government departments and entities and act as a strategic convenor of the sector. This foresight institution provides culture and framework in the form of networks and committees that legislate and draw up policy.

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Appendix: Interview Guide

Interview Schedule for a Study on the Governance of GVC of RREs for Sustainable Development

Governance and/or rare earths key knowledgeable

Interviewee name/pseudo name:
Interviewer:
Organisation:
Date:

I. Opening

This interview aims to fulfil the Master of Management in Governance research work on the governance of the value chain of rare earth minerals in South Africa for sustainable development. I will first ask you some questions about your background, education, and experiences to comply with the research sampling criteria.

The information you provide in this interview will help draw an informed conclusion from my research and contribute to the literature on the REEs sector in South Africa. I hope the information and this research contribute to the debate on the renewable energy sector in South Africa.

The interview will take about 60 minutes of your time to complete.

II. Main Questions

1. Give me a brief background of your involvement in mineral governance, including the renewable minerals in South Africa and the region.
2. What do you understand about Value Chain Governance?

Governance of Minerals

1. What are the current governance frameworks or processes in the value chain of REEs and related rare earth minerals?
2. What is your observation of the impact of REE mining (Mining of the so-called transitional mining)?

    a. on the environment,
    b. on social and labour issues and

c. On economic impact?

3. Does mining RE minerals in SA contribute to UN SDG goals?

(a) How does it differ from mining other resources, i.e., gold, oil, coal and gas (resource curse)?

4. What challenges are there in the governance of mineral resources in South Africa and (transitional minerals) REEs in particular?

Value Chain of Rare Earth Elements

1. What role is the government playing in the research and development projects REEs sector?

Value Chain of Permanent Magnets in SA

1. What is the contribution of South African transitional energy minerals to the value chain of permanent magnet production and/or renewable energy in South Africa?

2. Is there a direct linkage between monazite minerals mined in South Africa to the production of lithium batteries in the country?

3. In the country, why is no integrated value chain capable of converting mineral products (similar to SA coal-producing electricity) that make REEs into value-added renewable energy products?
4. What governance framework are in place for the South African REEs (transitional minerals) value chain for sustainable development in the following segments?

a. Exploration
b. Mining
c. Mineral processing
d. Metal trading
e. Fabrication
f. Circular economy

Sustainable Development

1. Greening of the value chain: Are renewable energy minerals mined responsibly and differently from historical fossil fuel minerals?

2. How is SA leveraging its endowment of rare earth minerals to develop a clean energy sector?

3. What is your organisation or department’s involvement in the RREs sector value chain?

III. Closing Question?

I appreciate you taking time from your busy schedule to take part in this interview. Are there any other details you'd like to elaborate on? Are there any other details you'd like to elaborate on? Do you have any documents, organizations, or legislative materials you would like to share with me?