



Investigating climate change mitigation and adaptation measures in integrated water and waste management plans: The case of coal mines in Mpumalanga

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ABSTRACT

Despite initial disagreements on climate change, there is now a widely accepted consensus that the phenomenon exists. Owing to escalating greenhouse gas emissions (GHG), the Intergovernmental Panel on Climate Change (IPCC) predicts that the world's temperature will rise above preindustrial levels, which will lead to variation in rainfall patterns, increased intensity of floods and droughts and the alteration of hydrological cycles, which will harm human and natural systems. The mining industry will suffer severe consequences from climate change, especially the coal mining industry in South Africa. Given the country's heavy dependence on coal for electricity generation, this situation could have adverse socio-economic consequences. It is, therefore, crucial for the mining industry to integrate climate change adaptation and mitigation strategies into its business approaches. Integrated water resource management (IWRM)—the basis for Integrated Water and Waste Management Plans (IWWMPs), is a promising instrument for mainstreaming climate change mitigation and adaption measures into water management. Considering this background, this research investigated whether climate change mitigation and adaptation measures are considered in IWWMPs for coal mines in Mpumalanga. A case study approach with document analysis was implemented for the research. Seven case studies were selected based on predetermined selection criteria. Two key performance areas (KPA's) with 21 associated key performance indicators (KPIs) were developed based on relevant policies, legislation, and guideline documents related to climate change mitigation and adaptation. The content of each IWWMP was evaluated against the developed KPIs and allocated a score namely, A - adequately, B – partially, and C - inadequately considered. Based on the evaluation, the primary study findings indicate that climate change mitigation and adaptation measures are disregarded in the IWWMPs for the selected cases in Mpumalanga. It is, therefore, recommended that coal mines in Mpumalanga incorporate climate change mitigation and adaptation measures in IWWMPs to manage climate risk. Furthermore, interviews should be conducted with the three significant participants involved in the drafting and approval of IWWMPs to establish the reasons why climate change mitigation and adaptation measures are omitted in IWWMPs as required by policies, legislation, and guidelines.

Keywords: climate change, Integrated Water and Waste Management Plans, coal mines, mitigation measures, adaptation measures

ABBREVIATIONS AND ACRONYMS

AMD	Acid Mine Drainage
CDM	Clean Development Mechanisms
CMA	Catchment Management Agencies
COP	Conference of the Parties
CSP	Concentrated Solar Plants
DEA	Department of Environmental Affairs
DEFF	Department of Environment Forestry and Fisheries
DFFE	Department of Fisheries, Forestry and the Environment
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water Affairs and Sanitation
EIA	Environmental Impact Assessment
EWULAAS	Electronic Water Use License Application and Authorisation System
FNASREC	Faculty of Natural and Agricultural Sciences Ethics Committee
GHG	Greenhouse Gas
GNR	Government Notice Regulation
IA	Impact Assessments
IAP	Interested and Affected Parties
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resource Management
IIWUL	Integrated Water Use Licence

IWWMP	Integrated Water and Waste Management Plan
KPA	Key Performance Areas
KPI	Key Performance Indicators
LTAS	Long-term Adaptation Scenarios
NCCRP	National Climate Change Response White Paper
NCOP	National Council of Provinces
NDC	Nationally Determined Contribution
NDP	National Development Plan
NAE	National Energy Act 34 of 2008
NEMA	National Environmental Management Act 107 of 1998
NEMAQA	National Environment Management: Air Quality Act 39 of 2004
NWA	National Water Act 36 of 1998
NWRS	National Water Resource Strategy
NWU	North-West University
PTN	Portion
ROM	Run-of-Mine
SDG	Sustainable Development Goals
SWAF	Standardised Water Accounting Framework
SWAT	Soil and Water Assessment Tool
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
WC/WDM	Water Conservation and Water Demand Management

WMA	Water Management Area
WUE	Water Use Efficiency
IWUL	Water Use Licence
IWULA	Water Use Licence Application
WRC	Water Research Commission

KEY DEFINITIONS

- **Integrated water resource management (IWRM)**

The process determines the optimal way of managing water within a catchment by analysing the change in water demand and evaluating various supply-side and demand-side management measures. IWRM supports the Integrated Water and Waste Management Plan (IWWMP) for a mine (DWAF, 2008).

- **Water conservation**

Minimising water loss or waste, the care and protection of water resources, and efficient and effective water use (DWS, 2016).

- **Water demand management (WDM)**

The development, adaptation, and implementation of a strategy, programme, or plan by a water institution or water consumer, such as a mine, to influence the water demand and use to meet the following objectives: economic efficiency, social development, social equity, environmental protection, sustainability of water supply and services, and political acceptability (DWS, 2016).

- **Water conservation and water demand management (WC/WDM) plan**

A documented procedure presenting the results of a process experienced to develop a computerised water balance and site-specific indicator targets (volumetric and water use efficiency targets). This plan also includes specific management actions, budgets, schedules, and responsibilities to meet those targets over the defined lifespan of the plan (typically five years). The plan may be constructed and submitted as a summary as required by the standardised water accounting framework (SWAF) (DWS, 2016).

- **Water management area (WMA)**

An area established as a management unit in the national water resource strategy where a catchment management agency conducts the protection, use, development, conservation, management, and control of water resources (DWAF, 1998).

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CHAPTER 1 INTRODUCTION AND BACKGROUND

1.1 Introduction

Climate refers to the average and fluctuating weather conditions, such as temperature, rainfall, humidity, and wind patterns in a specific area over a prolonged duration (Werndl, 2016). Before human existence, Earth experienced fluctuating climatic conditions due to natural causes, such as the intensity of the sun, volcanic eruptions, and alterations in naturally occurring quantities of greenhouse gas (GHG) emissions (Mason, 2013). However, over the recent past, an increase in natural disasters, such as floods, cyclones, droughts, fog and mist, hailstorms, wildfires, and extreme snowfall have been experienced, creating new challenges and risks for various countries, regions, economic sectors and industries (Mason, 2013). Compelling evidence links these unprecedented extreme weather events to human-induced climate change (Coumou, 2012). Despite the compelling evidence, the concern about climate change and its potential influences have been debated for decades, from the First World Climate Conference of 1979 to the Paris Agreement (COP21) in 2015 (Headrick, 2019) and the most recent climate change conference (COP 28) at the end of 2023 in the United Arab Emirates.

Myers *et al.* (2021) confirm a consensus among scientists that climate change is a reality. Parliamentarians are also learning of the need to take concrete action to reduce global GHG emissions, considered the main drivers behind climate change (Nachmany *et al.*, 2017). A severe increase has been observed in the number of climate change-related statutes passed by governments internationally, with an estimated number of over 1,800 signed statutes globally. The passing of climate-related statutes is also prominent in developing nations becoming increasingly engaged in enforcing climate change legislation, particularly in becoming climate resilient (Nachmany *et al.*, 2017). Climate change legislation is a crucial component of environmental governance, seeing that effective action against climate change requires a legal foundation and emission commitments compelled by targets and measures rooted in law (Eskander *et al.*, 2021).

Alterations realised by climate change led to the increasing complexities observed within global hydrological cycles, complicating the prediction and management of these systems (Ludwig *et al.*, 2014). To guide and manage the causes of climate change on the complex systems and associated changes, governments adopted and implemented policy-based instruments. These include regulatory instruments, fiscal-based instruments, civil-based instruments, and voluntary

agreements (Barrow, 1998). Regulatory-based instruments are the most widely adopted and used devices for achieving environmental policy objectives (Pacheco-Vega, 2020) and may include mechanisms, such as licences, authorisation, permits, and norms and standards. For example, atmospheric emission licences require the licence holder to adhere to strict conditions or specified processes and operate equipment under national air quality regulations or norms and standards. Waste management licences require that waste management activities that may adversely affect the receiving environment are regulated with site-specific conditions to mitigate residual influences and protect the environment (Maila *et al.*, 2018).

The global demand for finite resources, such as water, oil, and coal, is anticipated to rise (Headrick, 2019); however, the challenges realised by climate change have led to implications related to, for example, water availability, which may affect energy production in countries dependent on hydropower, pump-storage, or coal-generated electricity (Mathetsa *et al.*, 2019). It is, therefore, crucial to understand how climate change may affect human activities for a society to fulfil its socio-economic needs. These socio-economic needs include, for example, the availability of jobs, a primary financial income, and electricity (Headrick, 2019). The mining industry falls within this category because it provides *inter alia* the essential raw materials for the generation of electricity and provides millions of people with jobs and a basic financial income required for daily existence (Phillips, 2016); however, it is well-documented that mining-related activities, such as water abstraction and water pollution, generating waste, blasting, hauling, and product refinery are primary contributors to climate change, therefore placing the mining sector under the spotlight (Van der Bank & Karsten, 2019). This was emphasised when El Salvador's Legislative Assembly unanimously approved legislation prohibiting metal mining in 2017, owing to its climate change-related influences (Odell *et al.*, 2018). The El Salvador scenario, although extreme, illustrates the importance of climate change for the future of the mining sector, especially in locations with limited water resources (Odell *et al.*, 2018).

South Africa is frequently criticised for its reliance on burning fossil fuels, including coal, to generate electricity and is the highest emitter of GHGs on the African continent (Omarjee, 2019). Coal is one of South Africa's most significant exports by value, accounting for ZAR 63 billion in 2021 (Minerals Council 2021) and 92,000 people are employed within the coal mining sector (Minerals Council 2021). A further 42,000 individuals are employed by Eskom (South Africa's primary electricity supplier) in its fleet of primarily coal-fired power stations (Eskom, 2022). The socio-economic benefits of coal mining and coal-use for electricity generation cannot be underestimated within a country with an unemployment rate of 31.9% (Statistics SA [StatsSA], 2023); however, the coal mining sector in South Africa has a role to play, especially regarding its

contribution within a climate change context. Mining and coal-use will not end within the near future in South Africa, leading this research to investigate the integrated approaches to climate change management measures within coal mines.

1.2 Problem statement and rationale for the study

The initial research on climate change focused on the influences and mitigation strategies to reduce greenhouse gas (GHG) emissions (DEAT, 2007). Mitigating climate change means cutting down on and/or sequestering emissions of GHGs to prevent further increases in their atmospheric concentrations (Lackner *et al.*, 2015). Examples of such activities include emission elimination, emission reduction and enhancing carbon sinks (VijayaVenkataRaman *et al.*, 2012). This is achieved *inter alia* through implementing carbon tax, trading and clean development mechanisms (CDM) (VijayaVenkataRaman *et al.*, 2012); however, it has become clear that changes in the climate system are inevitable, and a need exists for climate change adaptation (Ziervogel *et al.* 2014). Adaptation means finding ways that can help reduce the influences of climate change on society, the diverse sectors of the economy, and habitation (Ziervogel *et al.* 2014). Adaptation measures can be implemented in processes, practices, and structures to minimise damages or to benefit from climate change-associated opportunities (Matangira, 2017). VijayaVenkataRaman *et al.* (2012) emphasise the importance of the synergies between mitigation and adaptation and state that it is inadequate to concentrate on mitigation or adaptation but that a combination of these will result in the most sustainable outcomes.

Population growth and modern industries, such as mining, forestry, and energy generation, are the two main factors contributing to increasing GHG emissions and are considered the primary drivers of climate change (Wu *et al.*, 2019). Owing to rising GHG emissions, the IPCC predicted that the world's temperature would rise above preindustrial levels (IPCC, 2018). It is anticipated that this expected increase will cause climate-related risks for human and natural systems as it will lead to variations in rainfall patterns, increased intensity of floods and droughts and the alteration of hydrological cycles (IPCC, 2018).

The realisation that climate change will influence natural systems, which may lead to irregular water supply and flood hazards, has sparked an international debate on whether climate change mitigation and adaptation measures are considered in policy-based instruments and decision-making processes (Ludwig *et al.*, 2014).

In South Africa, one such regulatory policy-based implementation instrument adopted to approach water supply management, floods, and sustainable water use is an integrated water-use licence

(IIWUL). Regulations published concerning the National Water Act No 36 of 1998 (NWA), specifically require mines and industries to apply for an IIWUL by submitting an IWWMP (DWS, 2017). IWRM supports the IWWMPs for a mine (DWAF, 2008).

Integrated water resource management is an ideal policy-based implementation instrument to regulate water supply and flood hazards associated with an ever-changing climate (Stuart-Hill & Schulze, 2010); because IWRM supports the IWWMP, an assumption can be made that IWWMPs address climate change mitigation and adaptation measures; however, literature suggests that climate change mitigation and adaptation measures are not readily considered and included in these IWWMPs (Mathetsa *et al.*, 2019). This research, therefore, aimed:

To investigate whether climate change mitigation and adaptation measures are incorporated in IWWMPs in coal mines in Mpumalanga.

1.3 Research aim

The subsequent research aim has been formulated to guide the problem statement:

- To investigate whether climate change mitigation and adaptation measures are incorporated in IWWMPs in coal mines in Mpumalanga.

1.4 Structure and outline of the research

The organisation of this research revolves around the following five chapters:

- Chapter 2 comprises the literature review, providing the theoretical support of the research. The first section discusses how climate change is anticipated to influence water resources and the challenges encountered by the mining sector owing to climate change. In the second section, information is provided on current climate change policy and legislation, focusing on water management in the mining industry.
- Chapter 3 concerns the research approach and methodology adopted to achieve the research aim. The chapter includes research procedures for collecting, analysing and presenting the data. The chapter concludes with a discussion of limitations associated with the study and an overview of the research ethics.
- Chapter 4 presents an overview of the research results obtained by following the research methodology adopted in Chapter 3. The chapter also discusses the results compared to existing literature.

- Chapter 5 presents the research conclusion and reflects on achieving the research aim. It concludes with recommendations while suggesting future research.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

This chapter examines the predicted climate change influences and the critical global and national challenges. The chapter summarises these challenges within the mining industry. It also reviews the policy and legislation related to climate change, focusing on water management in the mining industry. The chapter discusses international and national climate change mitigation and adaptation policies and legislation in response to climate change.

2.2 Anticipated climate change effects

General agreement exists that increasing atmospheric GHG levels owing to human activities is the main cause of climate change. This leads to an increase in the frequency of extreme weather events, such as storms, significant rainfall events, droughts, and rising sea levels (IPCC, 2008). The IPCC's Sixth Assessment Report (AR6) (2023) details the many observed changes and influences on natural systems across the globe caused by climate change; for example, hundreds of losses of local species and mass mortality events recorded on land and in the ocean, influences of hydrological changes resulting from the retreat of glaciers, and changes in mountain and Arctic ecosystems compelled by permafrost thaw. Adverse effects on humans include reduced water and food security, increased mortality and morbidity, economic damages, and the destruction of homes and infrastructure (IPCC, 2023). As the temperature continues to rise, all areas are expected to encounter more frequent and simultaneous shifts in factors affecting the climate (IPCC, 2023).

Attributable to its anticipated low adaptive capability and extensive poverty and sensitivity, the African continent has been emphasised as sensitive to climate change, with South Africa as one of the most vulnerable regions (IPCC, 2007). Although uncertainty and differing observations on the exact changes to South Africa's climatic characteristics exist, there is certainty that climate change will affect the availability of water-use resources (Delpla, 2009). Provided the variability in rainfall patterns within the region, aggravated by limited water supply in certain areas, climate change is inclined to harm human well-being, including food and energy production, flood management, municipal and industrial water supply, and wildlife management (Kusangaya *et al.*, 2014).

In the attempt to regulate these projected influences, the then Department of Environmental Affairs (DEA) embarked on a long-term adaptation scenarios (LTAS) flagship research programme—a multi-sectoral research programme mandated by the *South African National Climate Change Response White Paper* (NCCRP) (DEA, 2011). Fundamental climate modelling, sector-based consequences, and adaptation scoping were undertaken during the project's first phase, concluding in June 2013 (DEA, 2013b). Stakeholder involvement, scoping of influences, alternatives for adaptation, and future research needs were conducted for primary major sectors identified in the NCCRP. These comprised water, agriculture, forestry, human health, marine fisheries, and biodiversity. This research created six technical reports summarising the results from Phase 1. These reports focus on climate trends and scenarios specifically for South Africa and five studies summarising the consequences of climate change for the critical sectors identified (DEA, 2013b).

The LTAS Phase 1 project used the six hydrological zones in South Africa

Figure 2-1), developed for the national water adaptation strategy process to model South Africa's climate future up to 2050 and beyond. Based on water management areas (WMAs), the zones are divided into groups depending on their meteorological and hydrological features, ensuring their effects on the water sector and corresponding indirect effects on other sectors can be accurately modelled and examined (DEA, 2013b).

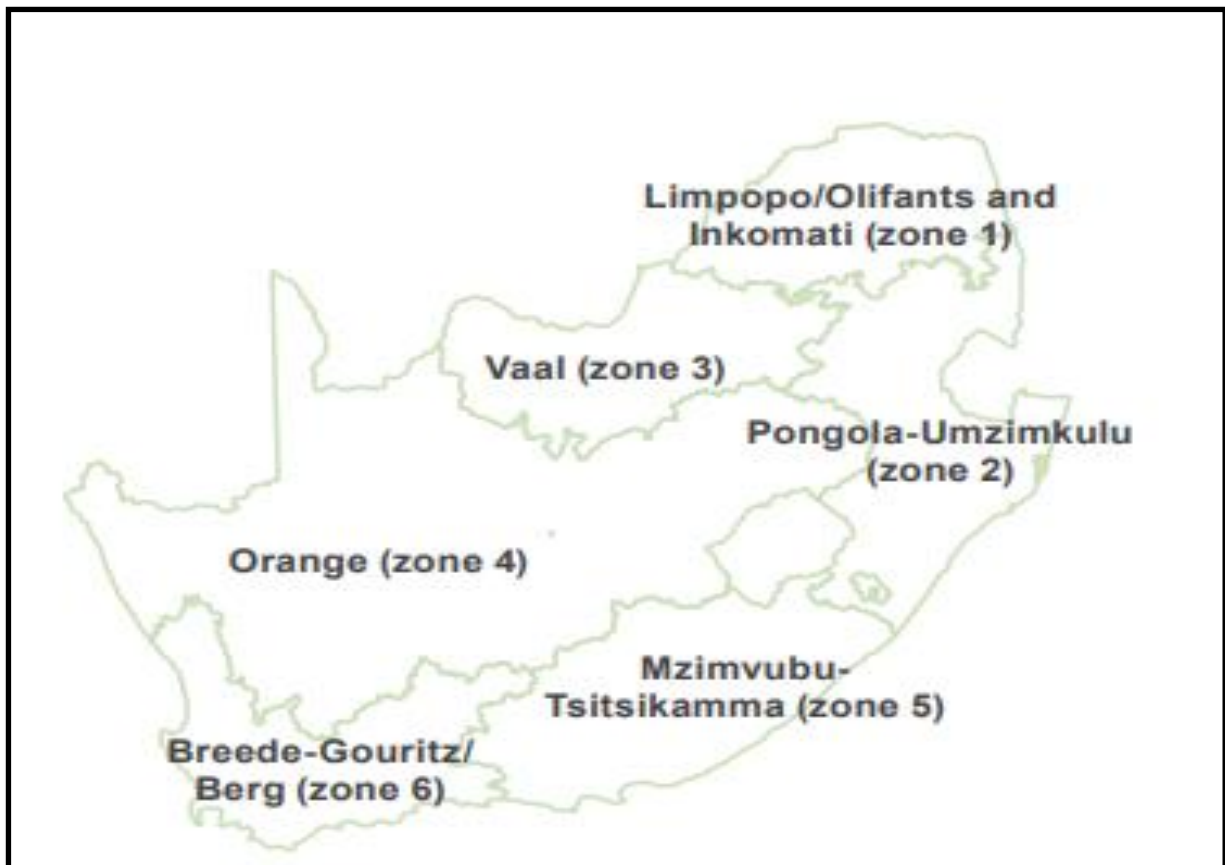


Figure 2-1: The six hydrological zones in South Africa (Source: DEA, 2013b)

From the LTAS Phase 1 findings, South Africa's climate future from 2050 and beyond can be described using four fundamental climate scenarios at a national scale:

1. *"warmer and wetter (3°C above 1961-2000 and increased rainfall)"*,
2. *"warmer and drier (3°C above 1961-2000 and decreased rainfall)"*,
3. *"hotter and wetter (>3°C above 1961-2000 and greater frequency of extreme rainfall events)"*
4. *"hotter and drier (>3°C above 1961-2000 and with a substantial increase in the frequency of drought events)" (DEA, 2013b).*

Figure 2-2 below illustrates the projected climate future for the six hydrological zones from 2025 and beyond (DEA, 2013b).

cenario	Limpopo/ Olifants/Inkomati	Pongola- Umzimkulu	Vaal	Orange	Mzimvubu- Tsitsikamma	Breede-Gouritz/ Berg
: warmer/ wetter	☔ spring and summer	☔ spring	☔ spring and summer	☔ in all seasons	☔ in all seasons	☔ autumn, winter and spring
: warmer/ drier	☀ summer, spring and autumn	☀ spring and strongly ☀ summer and autumn	☀ summer and spring and strongly ☀ autumn	☀ summer, autumn and spring	☀ in all seasons, strongly ☀ summer and autumn	☀ in all seasons, strongly ☀ in the west
: hotter/ wetter	Strongly ☔ spring and summer	Strongly ☔ spring	☔ spring and summer	☔ in all seasons	Strongly ☔ in all seasons	☔ autumn, winter and spring
: hotter/ drier	Strongly ☀ summer, spring and autumn	☀ spring and strongly ☀ summer and autumn	☀ summer and spring and strongly ☀ autumn	☀ summer, autumn and spring	☀ all seasons, strongly ☀ in summer and autumn	☀ all seasons, strongly ☀ in the west

Figure 2-2: Projected rainfall and climate conditions for South Africa's six hydrological zones (DEA, 2013b)

Conclusions from the LTAS Phase 1 research programme indicate:

- South Africa stands to benefit much from the successful execution of mitigation measures; however, even with practical mitigation efforts, vulnerable people and communities in South Africa remain at risk to have severe socio-economic consequences in wetter and drier climatic scenarios.
- Most climate change implications would be due to the influences on water resources as higher demand for water resources will be observed in hotter and drier scenarios, and an increase in floods and droughts will be experienced in wetter and drier conditions.

The research emphasises the need for purposeful collaboration among diverse stakeholders and sectors. It is advised that the potential for ecological infrastructure to provide adaptation benefits and assist in achieving development aspirations be included in policy planning and implementation as soon as possible (DEA, 2013b).

Due to the significance of water for the South African economy, the country developed highly sophisticated water resource planning devices. The primary instrument used is reconciliation studies, defined as “an assessment of the use and future requirements for water, and how these can be ‘reconciled’ with the available sources through various strategies for the next two to three decades” (DEA, 2013a). Water resource planning involves unpredictable data, such as growth,

rainfall, and runoff, of which the predictability only improves with time and historical data collection and considering the climatic variability brought on by climate change.

It is crucial that knowledge about the components of the hydrological cycle affected by climate change is determined, and trends distilled from historical records (DEA, 2013a). There are 13 water reconciliation studies for South Africa, which should be updated annually with the latest information available. Only eight of the 13 reconciliation studies have been completed, and most omitted climate change considerations apart from mentioning that it should be monitored (LTAS water technical report (DEA), 2013a). This is unfortunate as reconciliation studies would be a valuable method for adaptation planning under ongoing and future climate change challenges. Conclusions specifically related to the water sector from the LTAS Phase 1 research programme indicate:

- Preliminary forecasts for national runoff range from a 20% reduction to a 60% increase by mid-century. If global emissions are controlled to stabilise at 450 ppm CO₂, these changes are projected to lie between a 5% decrease and a 20% increase in annual runoff (DEA, 2013a).
- For all four future climate scenarios, a higher frequency of drastic flooding and droughts is projected. Under a wetter future climate scenario, significant increases in runoff would result in increased flooding, human health risks, ecosystem disturbance, and aesthetic influences. Drier future climate scenarios would result in less surface water availability but would not exclude the risk of extreme flooding events (DEA, 2013a).
- Areas in KwaZulu-Natal, parts of southern Mpumalanga, and the Eastern Cape indicate the highest risks in extreme runoff-related events, which include flooding. Specific areas at risk of increase in evaporation, decrease in rainfall, and reduction in runoff include the southwest and western regions, the central region, and the extreme northeast (DEA, 2013a).

Regarding the projected climate change influences in South Africa, it is necessary to examine how these projections affect the mining industry.

2.3 An overview of climate change challenges related to the mining industry

The mining industry is vulnerable to climate change influences, primarily owing to the assumption during the construction of mining facilities that the climate would remain stable (Odell *et al.*, 2018). Phillips (2016) identifies and emphasises two significant consequences of climate change on the mining industry. One consequence is changes in hydrological systems. The potential influences of rising sea levels on coastal mining operations encompass inundation, while other mining areas

may encounter water scarcity, presenting operational difficulties and potentially leading to confrontations with neighbouring water consumers. Climate change can augment the likelihood of unexpected mass displacement of mining-related mass storage facilities, causing the collapse of tailings dams, stockpiles, and similar structures.

Based on interviews in five case studies on Canadian mines, Pearce *et al.* (2011) determined that mining operations are affected by climatic changes; however, a lack of preparedness among the mining companies was observed. The lack of concern among the companies regarding this critical issue amplifies this situation. In 2012, a simulation was conducted by Damigos (2012) to estimate the financial implications of climate change on the Greek mining industry. The study determined that the costs could reach a cumulative figure of US\$ 800 million by 2050. These costs were attributed to various climate change influences, including reduced water supply, damage to equipment during extreme weather events, and a decrease in productive labour hours owing to elevated temperatures. Implementing essential adaptation measures would still incur a cumulative figure of US\$ 312 million, indicating a financial incentive to invest in adaptation.

In addition to the aforementioned international challenges, the South African mining industry's fundamental challenges are trade risk and reduced demand. The South African economy is anticipated to encounter increasing trade pressure. This is owing to the implementing of low-carbon commitments by its vital trade partners. Two of the four most prominent minerals in South Africa's commodity footprint namely thermal coal and platinum group metals, encounter potential challenges concerning diminished demand in the near future owing to the uptake of clean-energy technology (Bour *et al.*, 2022).

Mining companies responded to climate change by implementing measures to improve energy efficiency, ensuring the availability of water resources, and strategically adjusting their portfolios to divest from commodities with adverse environmental effects (particularly coal) (Bour *et al.*, 2022). Evidence suggests that mining companies should prioritise two key areas: formulating a business strategy mindful of climate considerations based on scenario analysis and implementing measures to safeguard their operations against climate-related risks (Bour *et al.*, 2022). To approach the climate change challenges and related influences on the mining industry, national governments developed various climate change policies and legislation, discussed below.

2.4 National climate change policy and legislation

Huq and Hugé (2012) caution that the rapid approach of climate change and its effects necessitate urgent policy reconfiguration and adjustment to effectively address the challenge. The

pre-Kyoto Protocol era presented a limited national legislative response to climate change, but by the end of 2016, a considerable and extensive corpus of climate change legislation was passed globally (Nachmany *et al.*, 2017). The Grantham Research Institute climate database identified over 1,800 climate laws and policies at the national level in 200 countries globally, with over 450 climate change cases filed before courts and tribunals (Grantham Research Institute, 2023).

Climate change court cases is growing worldwide which demonstrates that climate change litigation is essential for ensuring climate action and justice as the judiciary has been used to interpret climate legislation, and filling enforcement voids (Nachmany *et al.*, 2017).

Some of the most important international agreements on climate change are summarised in the sections below.

2.4.1 Montreal Protocol on substances, depleting the ozone layer

Although the primary objective of the Montreal Protocol on 16 September 1987 was not to address climate change, it is widely regarded as a significant environmental agreement that has served as a blueprint for subsequent diplomatic efforts in this area. It is the first treaty to achieve universal ratification by all countries in the world, mandating the cessation of producing ozone-depleting compounds and achieving a 90% success rate (Maizland, 2023).

2.4.2 United Nations Framework Convention on Climate Change

This Convention, which explicitly addressed climate change, was ratified by 197 nations, including the United States, in 1992. The Conference of the Parties (COP) to the UN Framework Convention on Climate Change (UNFCCC) is an international climate summit, which is held annually unless the Parties (the countries involved) decide otherwise. At COPs, world leaders gather to work together on solutions to tackle climate change. The COP established the Kyoto Protocol and the Paris Agreement (Maizland, 2023).

2.4.3 Kyoto Protocol

The Kyoto Protocol was adopted in December 1997 in Kyoto, Japan, by over 160 parties to the 1992 United Nations Framework Convention on Climate Change (UNFCCC). This landmark agreement introduced legally enforceable restrictions on carbon dioxide and other greenhouse gas emissions for developed nations while establishing a system to monitor progress (Breidenich *et al.*, 1998). Developing nations were asked to voluntarily comply.

2.4.4 Paris Agreement

The Paris Agreement was adopted in 2015 and regarded as the most consequential international climate accord so far, mandates that all nations establish commitments for reducing emissions and governments establish objectives, referred to as nationally determined contributions (NDCs), in order to mitigate the increase in global average temperatures from rising 2°C from preindustrial levels, and to actively strive towards maintaining it below 1.5°C. Additionally, the objective is to achieve worldwide net-zero emissions, wherein the quantity of greenhouse gases released is equivalent to the quantity that is extracted from the atmosphere (Maizland, 2023).

2.4.5 United Nations Sustainable Development Goals

The 2030 Agenda for Sustainable Development was adopted with 17 Sustainable Development Goals (SDGs) in the same year as the signing of the Paris Agreement took place by the COP. The SDGs are aligned with the Paris Agreement, emphasising the need to regulate climate change and SDG 13: *“Take urgent action to fight climate change and its consequences”*, expressly emphasises this issue. The targets set for SDG 13 are: Strengthen resilience and adaptive capacity to climate-related disasters, Integrate climate change measures into national policies, strategies and planning, Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning, Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly \$100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible, Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities.

Climate change is recognised as a crosscutting concern integrated into several other SDGs, such as SDGs 1 and 2 (eradicating poverty and hunger respectively), SDG 7 (affordable and clean energy), SDG 11 (sustainable cities and communities), SDG 15 (on ‘life and land’, including managing forests and maintaining biodiversity). SDG 13 explicitly includes goals for enhancing resilience and adaptability, corresponding to the adaptation objective outlined in the Paris Agreement (UN, 2015).

2.5 Climate change policy and legislation in South Africa

South Africa's national climate change governance results from over two decades of policy evolution and a complex landscape of executive policies, strategies, regulations, and institutions (Averchenkova *et al.*, 2019). South Africa signed the Paris Agreement, Kyoto Protocol, Montreal Protocol and is a party to the UNFCCC. The Department of Forestry, Fisheries and the Environment (DFFE) is responsible for devising climate change policy, response, and implementing legislation (Madondo & Nkwana, 2021).

South Africa's national climate policy is based on the 2004 National Climate Change Response Strategy and the 2011 *National Climate Change Response White Paper* (NCCR). In 2012, climate change also became an integral part of the National Development Plan, which is the action plan for securing the future of South Africans as charted in the Constitution. the country's blueprint (Averchenkova *et al.*, 2019). The NCCR has two primary objectives namely: effectively managing climate change impact through interventions and making a fair contribution to the global effort to stabilise GHG concentrations (NCCR, 2011). The mitigation strategies outlined in the NCCR include:

- Setting performance benchmarks using the National GHG emissions trajectory range
- Introducing carbon budgets
- Establishing a GHG inventory (Madondo & Nkwana, 2021).

The National Climate Change Adaptation Strategy (DEFF, 2019) was approved in August 2020 and will lead South Africa towards a shared vision of creating a climate-resilient economy and society (Madondo & Nkwana, 2021).

While the DFFE oversees climate change matters, other government agencies also have essential responsibilities in governing climate change and are crucial stakeholders in assisting the DFFE in developing and integrating climate change-related policies (Averchenkova *et al.*, 2019). The issue of policy review and alignment was supposed to have been addressed within two years of the publication of the NCCR (Republic of South Africa 2011). Unfortunately, there are policy misalignment and contradictions between the NCCR and other governmental policies as the NCCR lacks enforcement to implement its measures (Madondo & Nkwana, 2021). For example, the first objective of the National Energy Act (NEA), (34 of 2008:6) makes provision for an "*uninterrupted supply of energy to the Republic*". This objective is ambiguous and open to misinterpretation because of the country's dependency on coal for energy production. Moreover, applications to postpone and be exempt from climate change mitigating strategies by the two

largest GHG emitters, Eskom and Sasol diverts the implementation of the NCCR (Madondo & Nkwana, 2021). It is time South Africa provides a legal basis to expedite the country's climate change objectives and its implementation process (Madondo & Nkwana, 2021).

2.5.1 The Constitution

Environmental legislation in South Africa is based on Section 24 of the Constitution, known as the "environmental right", providing for the right to an environment free of harm to every citizen's health or well-being and protecting the environment against pollution and degradation. Section 24 of the Constitution led to substantial improvements by bringing about extensive environmental law reform, which includes the creation of foundational environmental legislation and regulations covering various aspects, such as biodiversity, marine environment, protected areas, air quality, soil management, and water resources (Du Plessis, 2018). The government is constitutionally and statutorily obligated to safeguard natural resources to ensure their availability for future generations. This responsibility provides all public authorities with the legal right to limit the actions of private entities, such as mines and heavy industries, exploiting public natural resources, including minerals, biodiversity, and marine resources (Du Plessis, 2018). The content and value of this right received indirect attention in the first court case, where a decision was taken on climate change by a South African court. The *Earthlife Africa Johannesburg v The Minister of Environmental Affairs and Others* 65662/16 (2017) high court case highlighted the intricate challenge of safeguarding human well-being when the pressing requirement for energy security in South Africa was compared with the necessity to safeguard water resources, reduce air and other types of pollution, and address climate change (Du Plessis, 2018).

2.5.2 The National Environmental Management Act

Environmental legislation in South Africa is grounded on Section 24 of the Constitution. The principal act governing activities affecting the environment is the National Environmental Management Act 107 of 1998 (NEMA).

Section 24 of NEMA requires that environmental authorisation be obtained to commence activities listed by the Minister of Forestry, Fisheries, and Environment. According to Section 24O (1) of NEMA, the competent authority must take all factors into account when considering an application for environmental authorisation. These factors include the pollution, environmental damage, or degradation that may occur whether the application is allowed or denied. The applicant must furnish the authorities with all the necessary information on the environmental impacts of the proposed activity through an environmental impact assessment (EIA) provided for by the

Environmental Impact Assessment Regulations (Government Notice Regulation 983, Government Gazette 38282 dated 8 December 2014) under NEMA.

Although there is no explicit statutory duty to consider climate change influences in NEMA, the increasing prominence of climate litigation indicates that climate litigation has the potential to positively contribute to appropriate regulation of climate change. This is evident in the judgement of South Africa's first climate change court case of *EarthLife Africa Johannesburg v the Minister of Environmental Affairs and Others* 65662/16 (2017), which overturned the DEAs' approval of a 1200-MW coal-fired power station and the minister's dismissal of EarthLife's appeal (Van der Bank & Karsten, 2019). EarthLife maintained that the DEA must assess the effect of the proposed power plant on climate change before granting environmental authorisation. The court read into section 24O that climate change should also be considered and the outcome was therefore to remit the climate change impact for re-evaluation on the ground of new evidence in the climate change report. This decision was a significant step forward as the statutory duty to consider climate change impacts can now be observed as being introduced through legal interpretation (Murcott & Vinti, 2024).

2.5.3 The National Water Act

Using water is governed by the NWA, as South Africa's water resources are in the government's trust. When undertaking any water uses listed in Section 21 of the NWA, an IWUL is required. An Integrated Water Use License (IWUL) is granted by the DWS after taking all the factors listed in Section 27 of the NWA into account. Mines and industries that engage in water uses listed in Section 21 must apply for an IWUL. The integrated water-use licence application (IWULA) process for mines and industries is regulated by the *Water use licence application and appeals regulations* (Government Notice Regulation 267, Government Gazette 40713 dated 24 March 2017). Government Notice Regulation (GNR) 267 stipulates that an IWWMP must support an IWULA for all mines and industries. Once an IWUL has been issued, the IWWMP will be subject to an annual review, which is normally included as a condition of the IWUL or as stipulated in the *Operational Guideline: Integrated Water and Waste Management Plan for the preparation of the Water Quality Management Technical Document to support the Application for Licences for Mining and Industries in Terms of the Requirements of the NWA* (DWAF, 2010). All operating coal mines should, therefore, have IWWMPs available with the latest updated information on water and waste management measures implemented on site.

GNR 267 sets out the requirements that must be included in the IWWMP. Annexure D of GNR 267 lists the required table of contents for all technical reports, indicating the minimum information requirements to be submitted. None of these table of contents list climate change as a requirement to be considered in the technical reports. Climate change requirements are also not listed as part of Annexure C of GNR 267, which contains a checklist for DWS officials to evaluate the application before acceptance. Climate change mitigation and adaptation measures can, therefore, easily be excluded from applications because it is not explicitly listed.

Although climate change impacts are not explicitly listed in Section 27 of the NWA or required to be included in the IWWMP, the need to regulate climate change influences as part of IWUL applications was raised in two cases before the Water Tribunal. Section 148 of the NWA confers authority on the Water Tribunal, a quasi-judicial agency, to hear appeals against various water-use decisions in South Africa (Murcott & Vinti, 2024). In the first case of *GroundWork Trust v the Acting Director-General: Department of Water and Sanitation* WT02/18/MP (2020), GroundWork (a nonprofit environmental justice organisation) pursued an appeal against granting a IWUL to Khanyisa for a new coal-fired power station in South Africa, provided the contribution of coal-fired power to climate change (Murcott & Vinti, 2024).

Although GroundWork’s appeal succeeded owing to other factors, the importance of this case was that the duty to consider climate change was read into Section 27 of the NWA through transformative adjudication (Murcott & Vinti, 2024). In the second case, *Thungela Operations v Department of Water and Sanitation & Others* WT04/22/GP (2023), the Water Tribunal dismissed Thungela Operation’s IWUL application under the National Water Act, 1998, owing to:

“... failure to consider climate change in the mitigation measures in the environmental impact assessment process or under the IWUL application process and non-alignment with national policies on climate change” (Rapson et al., 2023).

No explicit statutory duty to consider climate influences is provided for in the NWA or its regulations; however, such a duty can be inferred as having been introduced through legal interpretation.

2.5.3.1 Operational Guideline: Integrated Water and Waste Management Plan

The Operational Guideline: IWWMP for preparing the water quality management technical document to support the application for licences for mining and industries concerning the requirements of the NWA (DWAF, 2010) explains the required content of an IWWMP. No mention

of climate change mitigation and adaptations measures that must be considered and addressed in an IWWMP is made in this document.

2.5.3.2 Guideline on Water Conservation and Water Demand Management plans

Water conservation and water demand management plans are not mentioned explicitly in GNR 267, besides the requirement to include water and waste management plans in the IWWMP. The Department of Water and Sanitation (DWS) has, however, published the Guideline for the Development and Implementation of Water Conservation and Water Demand Management (WC/WDM) Plans for the mining sector in 2016.

According to this guideline, mines must develop a WC/WDM plan to set and achieve water-use efficiency (WUE) targets below the mine's current WC/WDM situation or WUE benchmarks within a defined timeframe. The Department of Water and Sanitation (DWS) is working towards the establishment of an on-line WC/WDM reporting system that would be integrated with the Electronic Water Use Licence Application and Authorisation System (EWULAAS). Definite timeframes have not been provided of when this will be implemented but it is indicated in this guideline that regulations requiring WC/WDM implementation within the mining sector will be incorporated into the *Regulations on use of water for mining and related activities aimed at the protection of water resources* (Government Notice Regulation 704 Government Gazette 20119 dated 4 June 1999), currently undergoing revision.

2.5.3.3 The National Water Resource Strategy

According to Section 5 under the NWA, the minister must develop a National Water Resource Strategy (NWRS), the legal instrument to implement and operationalise the NWA by responding to new strategic drivers, challenges, and priorities (DWAF, 2013).

The third edition of the NWRS was published in September 2023. The NWRS-3 comprises three overarching goals, namely that water must be protected, used, developed, managed and controlled sustainably and equitably, that water and sanitation must support development and the elimination of poverty and inequality, and contribute to the economy and job creation. Within these goals are focus areas with one of the primary focus areas being managing water and sanitation services amidst a shifting climate. This area remains one of the constant challenges since the second edition of the NWRS was published in 2013. Six strategic objectives with associated actions were developed for this focus area: 1) To improve and enhance water management and sanitation for enhanced adaptive capacity, 2) To integrate climate change

considerations into short, medium and long-term water and sanitation planning processes, 3) To develop appropriate adaptation measures to maximise water security and resource protection under changing climate conditions, 4) To enhance internal capacity and provide resources for improved resilience to climate change impacts, 5) To increase awareness of and build capacity on climate change issues, 6) To ensure inter-linked climate and hydrological scenario projections representative of the complex inter-related natural systems.

2.5.3.4 The Water and Sanitation Sector Policy on Climate Change

After the approval of the *National Climate Change Response White Paper* (NCCR) in 2011, government departments had to assess and revise their policies, strategies, laws, regulations, and plans within two years to align with its adoption. The Department of Water and Sanitation (DWS) developed a Water and Sanitation Sector Policy on Climate Change in 2017. The focus of the Water and Sanitation Water Sector Policy on Climate Change is to advocate sector specific policy positions on: Water and sanitation adaptation to climate change, role of water and sanitation in mitigation, mainstreaming climate change into the sector and cost and subsidies.

2.5.4 The National Climate Change Bill

In June 2018, the DEA initiated public consultation on the initial draft of the National Climate Change Bill. This legislation aims to formalise the country's critical strategic climate change objectives, governance principles, and policies. Subsequently, in February 2022, the latest version of the Climate Change Bill was introduced in Parliament. The Bill underwent extensive public consultation and generated a great deal of interest, with Parliament having received approximately 13 200 written comments (People's assembly, 2023).

On 24 October 2023, the National Assembly voted to pass the Bill. The next step involves its consideration by the National Council of Provinces (NCOP). Classified as a standard Bill with implications for the provinces, the Bill falls under the purview of Section 76 of the Constitution. The NCOP must either approve the Bill, endorse a modified version, or reject it. If the NCOP approves the Bill without changes, it will proceed to the President for final approval; however, if the NCOP introduces modifications, the revised Bill will return to the National Assembly for further scrutiny. Once the National Assembly adopts the modified Bill, it will be submitted to the President for ratification.

Only a few pieces of legislation explicitly address climate change. These include the Disaster Management Amendment Act 16 of 2015, the National Greenhouse Gas Emission Reporting

Regulations (Government Notice Regulation 275, Government Gazette 40762 dated 3 April 2017) and the National Pollution Prevention Plans Regulations (Government Notice Regulation 712, Government Gazette 40996 dated 21 July 2017) issued by the DEA under the National Environmental Management Air Quality Act 39 of 2004 (NEMAQA) (Averchenkova *et al.*, 2019).

2.6 Chapter summary

This chapter describes the general projected climate change influences, focusing on South Africa. An overview of climate change challenges experienced by the mining industry is presented. A summary of the international policy and legislation regarding climate change is depicted. The chapter concludes with an overview of the South African-specific legislation and guidelines regarding climate change mitigation and adaptation within the mining industry.

CHAPTER 3 METHODOLOGY

3.1 Introduction

This chapter presents the research approach used to achieve the research aim of whether climate change mitigation and adaptation measures have been incorporated in IWWMPs in coal mines in Mpumalanga. The chapter explains the selected study area, the selection of cases used, and the evaluation methods implemented. The chapter concludes with the research limitations encountered and the ethical considerations.

3.2 Research approach

Research approach refers to the strategy or blueprint a researcher sets out to follow to guide a specific research question (De Vaus, 2006). It outlines how the research will be conducted and helps ensure the researcher collects data validly and reliably. To achieve the research aim, the research adopted a case study approach. A case study approach has been a favoured method in several studies dealing with quality reviews (Alberts *et al.*, 2021; Claassens *et al.*, 2022; Retief, 2007; Sandham *et al.*, 2013; 2020). The case study approach is supported by qualitative methodology, allowing for the in-depth examination of a phenomenon within its real-life concept using multiple data sources and a wide range of theoretical perspectives (Baxter & Jack, 2015).

3.3 Case study design

The developed theory in this study is based on replication logic in empirical case situations; for example, the same methods are always applied so findings can be compared (Yin, 1994). Using replication logic allows analytic generalisation, where a developed theory is a template with which to compare the empirical results of the case studies. According to Yin, 1994 “*two or more cases are shown to support the same theory, replication may be claimed*”. Given the comprehensive inquiry conducted, researchers employing case studies have full discretion to use any data collection approach they deem appropriate, as long as it remains feasible and ethical (Baxter & Jack, 2015).

This study employed a multiple-case research design. This approach proves effective for qualitative investigations into the interrelationships among individuals, groups, institutions, societal factors, and external elements. Examining experiences in their natural contexts through case studies ensures crucial insights into how things operate in the real world. (Yin, 1994). In a multiple-case study design, data collection includes developing detailed descriptions of the

individual cases. Even though the type and depth of the data sources may differ, this research strives for consistency (De Vaus, 2006).

3.3.1 Case selection criteria

The criteria for selecting cases were derived from the theoretical framework and anticipated outcomes. Provided that the content of IWWMPs adheres to GNR 267, it remains consistent and readily comparable. These selection criteria were also designed to enhance the replication logic. The selection criteria for the IWWMPs were:

- The IWWMP must be for existing opencast coal mines in Mpumalanga.
- The coal mine must be operating under an already approved IWUL that has not expired or been suspended.
- The IWWMP must have been conducted recently, not older than 2021 and must have been submitted to the DWS.
- Different consulting companies must have compiled each of the IWWMPs.

Requests to provide IWWMPs were distributed to seven opencast coal mining companies in the Mpumalanga area, and consent was obtained from each mine to use the documents. Background information on the seven case studies selected is presented in Table 3-1. To maintain confidentiality, the identities of the mining companies are concealed, and each case study was assigned a number. The cases are not listed in a particular order. The author retains documents related to the case studies for verification purposes if needed. IWWMPs were selected to determine if they do address climate change mitigation and adaptation measures as it is seen as a sustainable and measurable plan of a mine's water and waste management system that should be implemented, audited and monitored by water users, government and interested and affected parties (IAP) and updated and improved on a continual basis (DWAF, 2010).

3.3.2 Number of cases

Eisenhardt (1989) concludes that the ideal number of cases for research purposes is between four and 10 cases. With fewer than four cases, it is often difficult to generate a theory with much complexity, and its empirical grounding is inclined to be unconvincing unless the case has several mini-cases within it; however, with over ten cases, it becomes difficult to cope with the complexity and volume of the data (Eisenhardt, 1989).

For this study, seven IWWMPs from coal mines in Mpumalanga were selected based on the selection criteria. The chosen cases represent a wide variety of IWWMPs compiled by consultants for various-sized coal mines owned by multiple mining companies.

3.4 Description of the case study area

The second smallest of South Africa's nine provinces, Mpumalanga, contains half of the country's high-potential arable land. Beneath its grasslands and cultivated farms are massive coal seams, which not only play a vital role in generating the land's electricity but also reap significant income from the export market (Webb, 2015).

The Upper Olifants River catchment in Mpumalanga is in the centre of South Africa's coal mining industry. Coal mining operations in this area harm the environment, specifically the catchment streams of the Olifants River. Because of coal mining for power generation, resource extraction, agricultural irrigation, and urbanisation, water consumption in the area has increased in recent years. Simultaneously, water quality, including groundwater, has significantly deteriorated because of over 650 active and abandoned mines and the acid mine drainage (AMD) and mining wastewater they produce (Laisani & Jegede, 2019). Figure 3-1 presents a map of the Mpumalanga province, indicating the location of power stations, mining rights areas, and farm portions where prospecting applications have been submitted (Lötter, 2010).

Floods and storms are also becoming a concern because of climate change—another significant matter for the area. In the Olifants basin, precipitation has declined over the past 60 years; scientists expect the trend will continue, attributable to climate change (Dabrowski & De Klerk, 2013). Considering the aforementioned, Mpumalanga was selected as the study area.

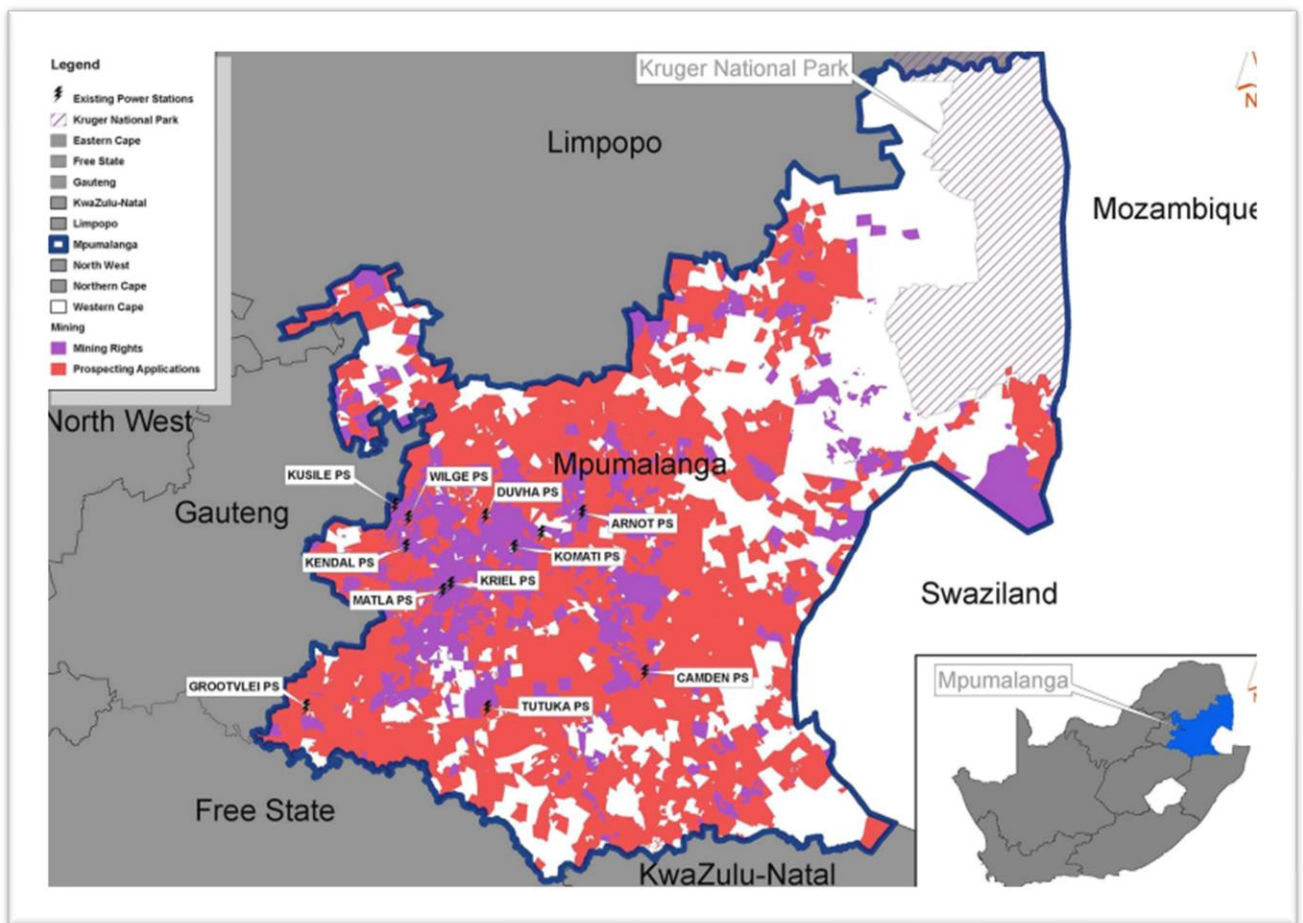


Figure 3-1: The Mpumalanga province, indicating the location of power stations, mining rights, and farm portions where prospecting applications have been submitted (Lötter, 2010)

Table 3-1: Background information on the selected case studies

Case study	IWWMP date	Description
1	March 2022	Opencast truck and shovel operations, 600,000 tonnes of run-of-mine (ROM) product produced monthly for Eskom, with no coal-washing activities
2	January 2023	Opencast truck and shovel operations, 320,000 tonnes ROM product produced monthly for export markets, no coal-washing activities
3	March 2022	Coal mining operations are completed, but rehabilitation is still in progress; coal-washing activities at 275,000 tonnes of saleable product are produced monthly for export markets. Coal is sourced from surrounding mines
4	August 2022	Coal mining operations are completed, but rehabilitation is still in progress; coal-washing activities at 300,000 tonnes of saleable product produced monthly for export markets. Coal is sourced from surrounding mines
5	April 2022	Opencast truck and shovel and dragline operations, with five coal-washing plants producing 500,000 tonnes of product for Eskom monthly and 750 000 tonnes of coal for the export market monthly
6	April 2022	Opencast truck and shovel operations produce 350,000 tonnes of Eskom product monthly: no coal-washing facilities on site
7	March 2021	Opencast truck and shovel operations produce 875,000 tonnes of coal monthly for the export market: no coal-washing facilities on site. Coal is taken off-site for coal washing

3.5 Data collection

Data for this study were collected through document analysis. Document analysis is a qualitative research method involving reviewing and evaluating documents—printed and electronic (computer-based and Internet-transmitted) material (Morgan, 2022). These can range from traditional formats, such as books, journals, newspapers, and archival materials, to less conventional materials, such as emails, blogs, social media posts, and other informal communications. The advantages of document analysis include that it is cost-effective and that documents can be reviewed multiple times.

Another significant advantage is their availability, as it does not involve direct work with subjects and, therefore, does not alter participants' responses, which is possible in observational studies. They contain exact names, references, and details that can be an excellent supplement to research (Morgan, 2022). The limitation of this method is that documents might not provide a complete or accurate representation of the context. They can be biased, especially internal documents, and may not directly address research questions. Some of the most important documents and materials might be confidential, copyrighted, or inaccessible (Morgan, 2022). When employing document analysis as the primary data collection method, researchers should refrain from accepting the content at face value. Similar to other data sources, documents require a critical approach, and their content should be interpreted within the context where they were created (Service, 2009).

3.5.1 Document review and evaluation

A review protocol was developed based on the principles of the Lee and Colley review protocol, which has been designed and successfully used to review the quality of environmental statements and environmental appraisals (Lee & Colley 1992). Document analysis is a methodical process for examining or assessing documents, including physical and digital (computer-based and Internet-transmitted) content and involves examining and interpreting material to uncover meaning, enhance comprehension, and establish empirical knowledge (Bowen, 2009).

3.5.2 Developing key performance areas and key performance indicators

Climate change mitigation and adaptation measures serve as the two essential approaches to facilitate climate change interventions (Van der Bank & Karsten, 2019). Consequently, they were chosen as the key performance areas (KPIs). These KPIs were informed by 21 key performance

indicators (KPIs) derived from policy, legislation, and guideline documents. The KPIs were developed based on these general criteria (Lee & Colley, 1992):

- It should be well-defined and unambiguous.
- It should be capable of consistent and objective application.
- It should serve a distinct purpose separate from the purposes of other criteria.
- It should be considered sufficiently important to merit influencing the ultimate assessment.
- It should be usable by reviewers who may not possess specialist environmental expertise but have a basic, non-specialist understanding of environmental appraisal methods and good practice.

Table 3-2 presents the developed KPIs with the section in relevant policy, legislation, and guideline documents from which the indicators were derived, including the strategic action to which it may be linked.

Table 3-2: Review criteria with associated KPAs and KPIs

KPI source	Strategic action	Key performance indicators (KPIs)
KPA 1: Climate change adaptation measures		
- NWA Section 2(k) - National Water Resource Strategy, 3rd edition (NWRS3), 7.4.1	Managing floods and droughts	KPI 1.1 – How extensively has flood management been considered?
		KPI 1.2 – How extensively has drought management been considered?
- National Water Resource Strategy, 2nd edition (NWRS2) Strategic Action 10.4.2.1: Increasing Water Supply - National Water Resource Strategy, 3rd edition (NWRS3), 5.4.1 <i>National climate change response white paper</i> (2011), Section 5.2 Water - Operational Guideline: Integrated Water and Waste Management Plans for	Consider all appropriate sources of water for water supply, including groundwater and alternative water supply sources. The use of these will be tested against the climate change scenarios.	KPI 1.3 – How extensively has the water supply considered all relevant water sources, including groundwater and alternative water supply sources?
		KPI 1.4 – How extensively was the water supply evaluated against climate change scenarios?

KPI source	Strategic action	Key performance indicators (KPIs)
preparing the water quality management technical document to support the Application for Licences for Mining and Industries in Terms of the Requirements of the NWA		
- National Water Resource Strategy, 2nd edition (NWRS2) Strategic Action 10.4.2.3: Flood Protection Measures - National Water Resource Strategy, 3rd edition (NWRS3), 7.4.1	Improved flood early warning systems will be implemented in critical catchments with municipalities to improve early flood warning systems	KPI 1.5 – How extensively were early flood warning systems considered?
National Water Resource Strategy, 2nd edition (NWRS2) Strategic Action 10.4.2.4: Infrastructure Safety	Increased rainfall intensity in certain areas may result in increased flood pressures on dams and other infrastructure, with concerns regarding the safety and resilience of such infrastructure. This includes urban infrastructure, such as	KPI 1.6 – How extensively have the effects of climate change on infrastructure been considered?

KPI source	Strategic action	Key performance indicators (KPIs)
- National Water Resource Strategy, 3rd edition (NWRS3), 7.4.1 <i>National Climate change response white paper</i> (2011), Section 5.2 Water	treatment works and wastewater treatment works and industrial infrastructure, such as tailings dams. All water institutions managing infrastructure must address climate change influences in their asset management plans	
- National Water Resource Strategy, 2nd Edition (NWRS2) Strategic Action 10.4.2.5: Hydro-geo-meteorological monitoring systems - Water and Sanitation Sector Policy on Climate Change (2017), Section 5.1.1.1 - National Water Resource Strategy, 3rd edition (NWRS3), 9.1 - Operational Guideline: Integrated Water and Waste	Monitoring is critical to assessing actual water-related climate change influences and trends on the ground. Therefore, the monitoring and evaluation of water and climate data must be prioritised under the coordination and leadership of the DWS, and the adequacy of the weather, environmental, hydrological, and hydrogeological monitoring systems must be substantially improved. Equally, standardised reporting protocols must be agreed on and implemented under the leadership of the DWS and DFFE.	KPI 1.7 – How extensively have standardised reporting protocols for weather, environmental, hydrological, and hydrogeological systems been considered?
		KPI 1.8 – How extensively do these reporting protocols address climate change effects?
		KPI 1.9 – How extensively was climate change considered in the monitoring of change in baseline information for surface water, groundwater, and biomonitoring?

KPI source	Strategic action	Key performance indicators (KPIs)
Management Plans for preparing the water quality management technical document to support the Application for Licences for Mining and Industries in Terms of the Requirements of the NWA		
- National Water Resource Strategy, 2nd Edition (NWRS2) Strategic Action 10.4.3.1: Scenarios, climate modelling and water availability - National Water Resource Strategy, 3rd edition (NWRS3), 9.1	The DWS will collaborate with the Water Research Commission (WRC) and relevant experts to improve climate change modelling for South Africa, particularly focusing on understanding the hydrological influences. Arising from this, the DWS will determine the availability of water under conditions of climate change.	KPI 1.10 – How extensively has climate change modelling, focusing on the hydrological effects, been considered?
National Water Resource Strategy, 2nd Edition (NWRS2) Strategic Action 10.4.3.2: Vulnerability assessment	The DWS will conduct a vulnerability assessment for the country to assess the most critical areas for implementing water and climate change adaptation measures.	KPI 1.11 – How extensively has a climate change vulnerability assessment been included in the IWWMP?

KPI source	Strategic action	Key performance indicators (KPIs)
• National Water Resource Strategy, 3rd Edition (NWRS3), 9.4.3 • Water and Sanitation sector policy on climate change (2017), Section 5.1.1.2 • Operational Guideline: Integrated Water and Waste Management Plans for preparing the water quality management technical document to support the Application for Licences for Mining and Industries in Terms of the Requirements of the NWA		
• National Water Resource Strategy, 2nd Edition (NWRS2) Strategic Action 10.4.3.3: Planning and strategies	Responses to the water-related influences of climate change must be solicited in the programmes and strategies of all water sectors and water-dependent entities and	KPI 1.12 – How extensively have the water-related effects of climate change been considered in programmes and strategies?

KPI source	Strategic action	Key performance indicators (KPIs)
National Water Resource Strategy, 3rd edition (NWRS3), 9.2	by all spheres of government to ensure resilience in their own areas.	
National Water Resource Strategy, 2nd Edition (NWRS2) Strategic Action 10.4.3.6: Water quality management	Climate change will affect water quality, but in several areas, the impacts may be masked by changes in land use or compliance with effluent standards. Some effects can be foreseen and mitigated by careful planning to include potential climate change in water quality management strategies	KPI 1.13 – How extensively have potential climate change effects been considered in water quality management strategies?
- National Water Resource Strategy, 2nd Edition (NWRS2) Strategic Action 10.4.3.7: Resource management and protection - National Water Resource Strategy, 3rd edition (NWRS3), 9.2	Aquatic ecosystems will change substantially over time because of climate change. These changes must be factored into reserve determination processes and the protection of aquatic ecosystems. This will be supported by increased research in this area.	KPI 1.14 – How extensively have climate change effects been considered in the biomonitoring management measures?

KPI source	Strategic action	Key performance indicators (KPIs)
- National Water Resource Strategy, 2nd Edition (NWRS2) Strategic Action 10.4.3.8: Disaster Management - National Water Resource Strategy, 3rd edition (NWRS3), 9.2	The potential impacts of water-related climate change will be integrated into disaster management systems and processes, and the ability to respond to unforeseen events through, for example, early warning systems and effective planning for incidences of flooding and drought will be enhanced.	KPI 1.15 – How extensively have the potential effects of water-related climate change been considered in disaster management systems and processes?
<i>National Climate change response white paper</i> (2011), Section 5.2 Water - National Water Resource Strategy, 3rd Edition (NWRS3), 9.4.6 - Water and Sanitation sector policy on climate change (2017), Section 5.1.1.3	Integrating climate change considerations in the short-, medium- and long-term water planning processes across relevant sectors, such as agriculture, industry, economic development, health, science, and technology.	KPI 1.16 – How extensively has climate change been considered in the short-, medium-, and long-term water planning processes?
National Climate Change Adaptation strategy (2019), Objective 1	Build climate resilience and adaptive capacity to respond to climate change risk and vulnerability.	KPI 1.17 – How extensively has the consideration of climate resilience and adaptive capacity to address the

KPI source	Strategic action	Key performance indicators (KPIs)
National Water Resource Strategy, 3rd Edition (NWRS3), 17.4.2		risks and vulnerabilities directed by climate change been contemplated?
- National Climate Change Adaptation strategy (2019), Objective 2 - National Water Resource Strategy, 3rd Edition (NWRS3), 17.4.3	Promote the integration of climate change adaptation response into development objectives, policy, planning and implementation.	KPI 1.18 – How extensively has climate change adaptation response been considered in development objectives, policy, planning, and implementation?
- National Climate Change Adaptation strategy (2019), Objective 3 - National Water Resource Strategy, 3rd edition (NWRS3), 9.4	Improve understanding of climate change impacts and capacity to respond to these impacts.	KPI 1.19 – How extensively has have climate change effects and management measures to address these effects been considered?
National Climate Change Adaptation strategy (2019), Objective 4	Ensure resources and systems are in place to enable the implementation of climate change responses	KPI 1.20 – How extensively have resources and systems been implemented to enable the implementation of climate change responses?

KPI source	Strategic action	Key performance indicators (KPIs)
National Water Resource Strategy, 3rd Edition (NWRS3), 19		
KPA 2: Climate change mitigation measures		
Water and Sanitation sector policy on climate change, 2017, Section 5.2.1.2	A balance is required between using renewable technologies to mitigate the potential effects of climate change while ensuring efficiency in water use	KPI 2.1 – How extensively has water use efficiency been considered in renewable technologies to mitigate climate change?

3.5.3 Evaluating performance against KPAs and KPIs

The IWWMPs were evaluated against the criteria in Table 3-2 using the evaluation scores outlined in Table 3-3 (adapted from Lee & Colley, 1992). The evaluation scores ranged from A to C and indicate the extent to which the KPIs were considered in the IWWMP. An “A” would be the most desirable rating; “B” would suggest that the KPI was not fully solicited; “C” represents the most undesirable rating (Claassens *et al.*, 2022). Colour coding was implemented to help interpret the results (Claassens *et al.*, 2022).

Table 3-3: Evaluation symbols awarded per KPI

Evaluation Score and colour code	Score description	
A	Adequately considered	This score was awarded if the KPI was adequately solicited and if adequate aspects pertaining to the KPI were considered.
B	Partially considered	This score was awarded if the KPI was only partially addressed if only a few but not all aspects pertaining to the KPI were considered.
C	Inadequately considered	The score was awarded if the KPI was poorly addressed or if no aspects pertaining to the KPI were considered.

3.6 Data analysis

Once all the IWWMPs were evaluated, the scores were consolidated using a performance score established in Table 3-4.

Table 3-4: Performance scores per KPI across all IWWMPs

Performance Score	Explanation
Good	Mostly As
Average	Mostly Bs
Poor	Mostly Cs

3.7 Ethical considerations

This research followed the North-West University's (NWU) ethics policy (2018). The NWU, Faculty of Natural and Agricultural Sciences Ethics Committee (FNASREC), approved this study without ethical risk (ethics approval number NWU-01212-23-A9).

The written consent form included the right of participants to withdraw from the study and the procedures to do so, and the commitment that all the findings will be presented in a manner that could not link responses to an identifiable company to ensure the company name is kept confidential.

3.8 Methodological limitations

- **Low retrievability:** Documentation is sometimes irretrievable. As Yin (1994) noted, access to documents may be deliberately blocked owing to concerns about participants' confidentiality and anonymity during the reporting phase. In this research, two prominent mining companies in Mpumalanga were not willing to provide documentation stating that it is company policy to no longer provide information for research unless they have commissioned the research; however, the study still collected adequate cases from various mining companies within the province.
- **Outdated information:** In some instances, the data within the IWWMPs was outdated. Some of the IWWMPs received from mining companies were dated before 2021 and could, therefore, not be used as they did not comply with the selection criteria. These specific cases were disregarded for inclusion in the research.
- **KPIs:** The KPIs developed should not be observed as an exhaustive list of KPIs relevant to climate change mitigation and adaptation measures. The KPIs developed for this research are according to the latest available information on climate change adaptation and mitigation measures for mines in South Africa; however, more KPIs may be developed based on international policies.
- **Evaluation bias:** Only one evaluator was available for this research. The evaluator relied on their knowledge and experience within the mining sector and involvement with the drafting of IWWMPs.
- **Interpreting of information:** The researcher could have interpreted some of the information in the IWWMPs better if interviews had been conducted with the authors of the IWWMPs. Conclusions were made based only on the information in the IWWMPs and the researcher's interpretation; however, owing to limited resources, the researcher abstained from

incorporating interviews within this specific research. It is, therefore, recommended that future research be conducted.

3.9 Chapter summary

This chapter describes the research approach and methodology adopted to achieve the research aim. The methodology implemented for this research incorporated qualitative methods based on document evaluation. The chapter describes the selection of cases, the number of cases selected, developing KPAs and KPIs, and concludes with an overview of the study area, ethical considerations, and limitations associated with the research.

CHAPTER 4 RESULTS AND DISCUSSION

4.1 Introduction

Chapter 4 describes the results and discussion of the two KPAs, such as climate change adaptation and mitigation measures. The KPAs and associated 21 KPIs were developed based on legislation, policies, and guidelines for water management for the South African mining industry, as summarised in Table 3-2 above. By implementing the methodology described in Chapter 3, the seven selected cases were evaluated. A summary of the performance (A–C) of each of the seven cases is presented in Table 3-4 below, followed by a discussion on each KPI.

Table 4-1: KPI consideration for the seven IWWMP case studies

Key performance indicators (KPIs)		Cases						
		1	2	3	4	5	6	7
KPA 1 - Climate change adaptation measures								
KPI 1.1	How extensively has flood management been considered?	B	B	B	B	B	B	B
KPI 1.2	How extensively has drought management been considered?	C	C	C	C	C	C	C
KPI 1.3	How extensively has the water supply considered all relevant water sources, including groundwater and alternative water supply sources?	C	C	C	C	C	C	C
KPI 1.4	How extensively was the water supply evaluated against climate change scenarios?	C	C	C	C	C	C	C
KPI 1.5	How extensively were early flood warning systems considered?	C	C	C	C	C	C	C
KPI 1.6	How extensively have the effects of climate change on infrastructure been considered?	C	C	C	C	C	C	C
KPI 1.7	How extensively have standardised reporting protocols for weather, environmental, hydrological, and hydrogeological systems been considered?	B	B	B	B	B	B	B
KPI 1.8	How extensively do these reporting protocols address climate change effects?	C	C	C	C	C	C	C
KPI 1.9	How extensively was climate change considered in the monitoring of change in baseline information for surface water, groundwater, and biomonitoring?	C	C	C	C	C	C	C

Key performance indicators (KPIs)		Cases						
		1	2	3	4	5	6	7
KPI 1.10	How extensively has climate change modelling, focusing on the hydrological effects, been considered?	C	C	C	C	C	C	C
KPI 1.11	How extensively has a climate change vulnerability assessment been included in the IWWMP?	C	C	C	C	C	C	C
KPI 1.12	How extensively have the water-related effects of climate change been considered in programmes and strategies?	C	C	C	C	C	C	C
KPI 1.13	How extensively have potential climate change effects been considered in water quality management strategies?	C	C	C	C	C	C	C
KPI 1.14	How extensively have climate change effects been considered in the biomonitoring management measures?	C	C	C	C	C	C	C
KPI 1.15	How extensively have the potential effects of water-related climate change been considered in disaster management systems and processes?	C	C	C	C	C	C	C
KPI 1.16	How extensively has climate change been considered in the short-, medium-, and long-term water planning processes?	C	C	C	C	C	C	C
KPI 1.17	How extensively has the consideration of climate resilience and adaptive capacity to address the risks and vulnerabilities directed by climate change been contemplated?	C	C	C	C	C	C	C
KPI 1.18	How extensively has climate change adaptation response been considered in development objectives, policy, planning, and implementation?	C	C	C	C	C	C	C
KPI 1.19	How extensively have climate change effects and management measures to address these effects been considered?	C	C	C	C	C	C	C
KPI 1.20	How extensively have resources and systems been implemented to enable the implementation of climate change responses?	C	C	C	C	C	C	C
KPA 2 - Climate change mitigation measures								
KPI 2.1	How extensively has water use efficiency been considered in renewable technologies to mitigate climate change?	C	C	C	C	C	C	C

4.2 Results related to KPA 1: Climate change adaptation measures

The results in Figure 4-1 regarding climate change adaptation measures for the seven IWWMP case studies delivered 0 As, 14 Bs, and 126 Cs. Of the 20 KPIs evaluated, the following performance results were achieved: none of the KPIs delivered good performance, two of the KPIs delivered average performance, and the remaining 18 KPIs delivered poor performance.

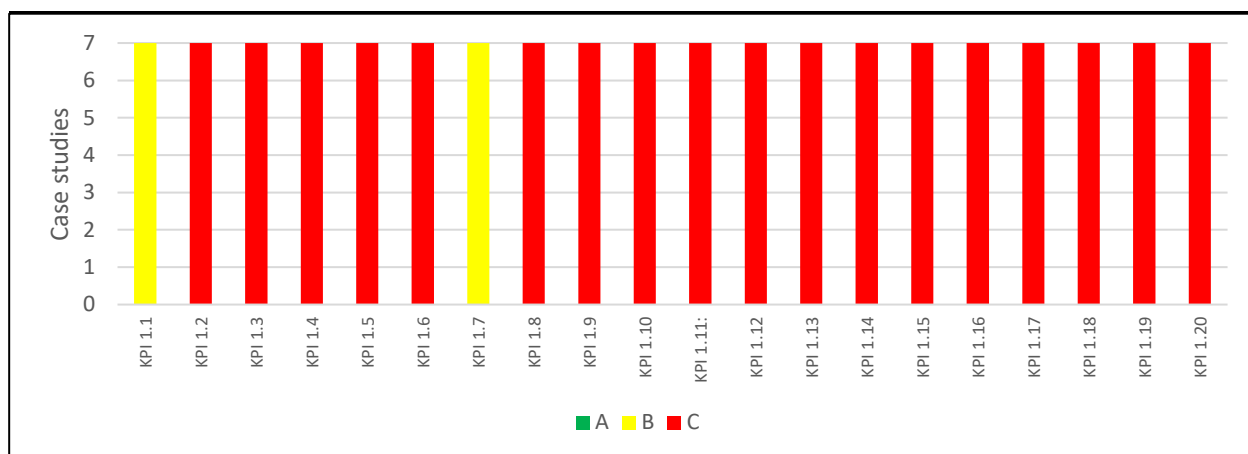


Figure 4-1: Performance of the seven IWWMP case studies as it relates to climate change adaptation measures (KPA 1)

None of the IWWMPs addressed climate change adaptation measures. What is of most concern is that only one of the seven IWWMP case studies contained the word “climate change”. Case Study 6, which included the term “climate change”, referred to the hydrological model compiled using the latest version of the Soil and Water Assessment Tool (SWAT). It was indicated that SWAT can predict the environmental effect of climate change, although this function was not used as part of the compilation of the IWWMP for Case Study 6.

The KPIs were grouped into five overarching categories: (i) Flood management; (ii) Supply and availability of water; (iii) Impact assessment; (iv) Monitoring and reporting, and (v) Planning and strategies. These categories are discussed separately.

4.2.1 Flood management

Regarding flood management (KPI 1.1, 1.5, 1.6 and 1.15), the IWWMPs addressed the essential management of floods as required by the GNR 704 (DWAF,1999) and therefore, KPI 1.1 scored average performance across all seven IWWMP case studies. Flood management or prevention, early warning systems, and infrastructure protection provided climate change adaptation measures were not considered. As part of the LTAS Phase 2 technical report, it was indicated in

2016 already that a comprehensive approach is necessary to mitigate future flood risk through adaptation measures, which should encompass soft and complex engineering solutions and institutional transformations and that a comprehensive assessment of existing design criteria for essential infrastructure, such as bridges, dams, flood lines, powerlines, treatment plants, and substations, is necessary to ensure a sustainable climate-proof future (DEA, 2016).

GNR 704 (DWAf,1999) were implemented in June 1999 and is currently being reviewed. Hopefully climate change and the recommendations made as part of the LTAS Phase 2 technical report (DEA, 2016) will be incorporated into the regulations. One recommendation by Chavalala, 2016 also indicated that to develop mines resilient to climate change, mine engineers must integrate climate change effect scenarios into the design of the mine.

4.2.2 Supply and availability of water

Concerning the results related to water supply and availability (KPI 1.2, 1.3, and 1.4), none of the IWWMPs mentioned drought management, availability of alternative water supply, and evaluating the long-term availability of the water supply against climate change scenarios. The benchmark for water usage for South African coal mines is 0.79 m³/tonne of ROM coal (DWS, 2016). Nkhonjera (2017) indicate that the literature on the effect of climate change on water resources in South Africa is limited; however, literature indicates that, in Africa, climate change will lead to an increase in climatic variability and a decrease in water resources, which will exert a significant effect on large water users, such as coal mines. It is concerning that the case studies intend to continue mining operations for the next 20 to 50 years, without considering the effects of climate change on water availability.

4.2.3 Impact assessment

Key performance indicators 1.10,1.11 and 1.17 scored poor. Climate change risk and vulnerability assessments are omitted in specialist impact assessments and therefore, no climate change adaptation measures have been considered. Regulations about the procedural requirement for IWULAs and amendments (DWS, 2017a) list the table of contents required for technical reports in Appendix D of the regulations. Neither the table of contents for the IWWMP nor the specialist studies mention climate change impacts and management measures that need to be part of the specialist reports. Impact assessments (IA) can minimise the vulnerability of projects to potential adverse consequences of climate change and its broader environmental repercussions (Jiricka-Pürrier *et al.*, 2018). Impact assessments (IA) can provide a point of entry for incorporating climate change impacts into projects by incorporating the following for example, an increased number of

storm events that may cause damage to water infrastructure or operations, an increase in water shortages which can lead to operation stoppages, increase in heat which can cause fires (Jiricka-Pürner *et al.*, 2018).

4.2.4 Monitoring and reporting

DWS (2016) published regulations about the procedural requirements for IWULAs and amendments, indicating what information is required in IWWMPs. KPI 1.7 scored average as all the IWWMPs used the reporting requirements in the regulations and standardised their reporting protocols. Unfortunately, the regulations omitted climate change requirements, leading to climate change impacts and management being disregarded in the monitoring reports (KPI 1.8, 1.9 and 1.14). Adaptation measures strive to predict unpredictable future developments by blending short-term activities with long-term alternatives to adjust if needed (Haasnoot *et al.*, 2018). It is, therefore, essential to monitor and notice significant changes, vital transitions, or tipping points promptly to ensure the proper execution and reassessment of adaptation measures (Haasnoot *et al.*, 2018). The design of a standard single industry monitoring plan that can identify and forecast changes to assist in adaptive planning would be helpful.

4.2.5 Planning and strategies

The Operational Guideline: Integrated Water and Waste Management Plan (DWAF, 2010) describes one purpose of the IWWMP as the *“Provision of management plan to guide water users regarding the water and waste-related measures that must be implemented on-site in a progressive, structured manner in the short, medium, and long term”*.

None of the plans and strategies (KPI 1.12, 1.13, 1.16, 1.18, 1.19, and 1.120) compiled as part of the IWWMPs considered climate change adaptation measures. Having a progressive, structured management plan regarding water and waste and incorporating climate change adaptation measures will significantly assist mines in dealing with the uncertainties advanced by climate change.

4.3 Results related to KPA 2: Climate change mitigation measures

Figure 4-2 outlines the performance of KPA 2: Climate change mitigation measures in IWWMPs. Climate change mitigation measures were insignificant in the policy, guideline, or legislation documents to develop the KPIs. Only one KPI could be formulated with relevance to climate change mitigation measures. None of the IWWMPs considered or mentioned the WUE of

renewable technologies used to mitigate climate change (KPI 2.1). It is not known whether these renewable technologies do not use water or their WUE has just not been considered.

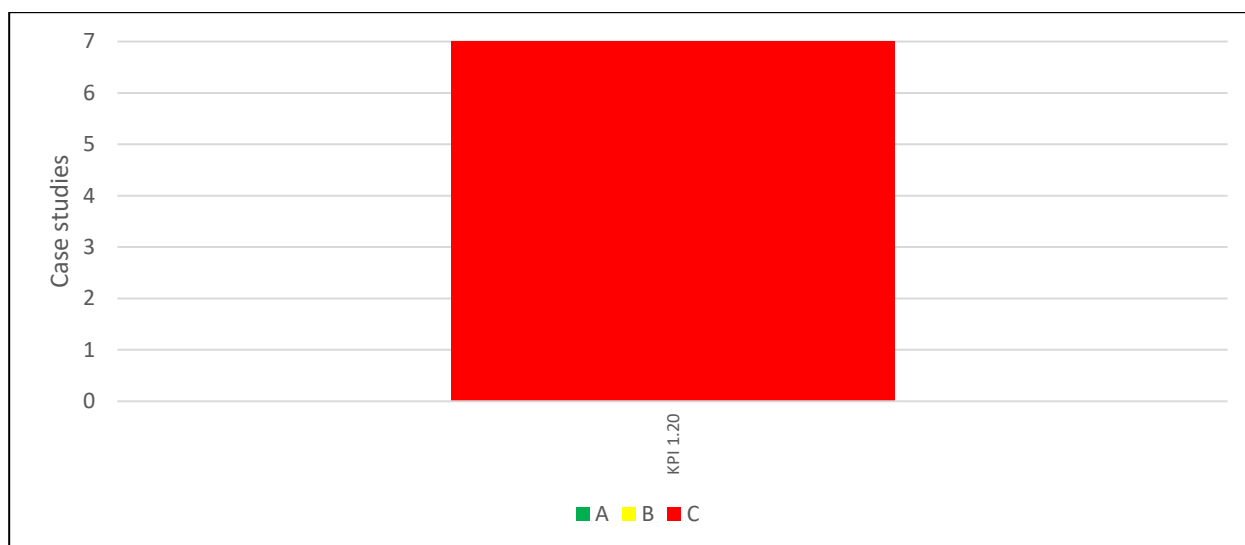


Figure 4-2: Performance of the seven IWWMP case studies as it relates to climate change mitigation measures (KPA 2)

With renewable energy technologies being strongly advocated in South Africa, it is essential to understand the water footprint of renewable energy production (Sparks *et al.*, 2014). Mines are more and more considering renewable energy technologies as a post mining land use. Although wind and solar photo-voltaic require almost no water, concentrated solar plants (CSP) withdraw similar operational water to fossil fuel power plants (Sparks *et al.*, 2014). Importantly, geographical areas suitable for CSP usually have limited or no water resources and, therefore, CSP can compete for scarce water resources (Pocock & Joubert, 2021). Hydropower, while not directly consuming water during generation (as the water is returned to its source), still experiences significant water loss through evaporation. In contrast, biomass is water-intensive; however, in South Africa, biofuel generation primarily uses crop waste; therefore, the water used in crop production can be disregarded (Pocock & Joubert, 2021).

4.4 Chapter summary

The research results confirm that climate change adaptation and mitigation measures are primarily disregarded as part of the IWWMP. Content of the IWWMPs strictly followed the requirements as outlined in the regulations about the procedural requirement for IWULAs and amendments (DWS, 2017a), regulations on water use for mining and related activities aimed at the protection of water resources (DWAF, 1999) and the Operational Guideline: IWWMPs (DWAF,

2010). The documents have not been updated to include climate change requirements stipulated in various policies, guidelines, and strategies applicable to IWWMPs.

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This research investigated whether climate change mitigation and adaptation measures are incorporated in IWWMPs in coal mines in Mpumalanga. This aim was achieved by selecting seven IWWMPs based on selection criteria and evaluated against two KPAs, such as climate change adaptation and mitigation measures. KPIs were developed for each KPA based on relevant policies, guidelines, and legislation. The evaluation results indicate that climate change adaptation and mitigation measures are omitted in the IWWMPs. IWRM is considered one of the ideal approaches to policy-based implementation instruments to address water supply and flood hazards associated with an ever-changing climate (Stuart-Hill & Schulze, 2010). Seeing that DWS use IWWMPs to implement IWRM at source, an IWWMP would be an optimal approach to a policy-based instrument in South Africa to address climate change mitigation and adaptation measures in industries and mines. No mention is made that climate change needs to be incorporated into an IWWMP in the Operational Guideline: Integrated Water and Waste Management Plans Operational Guideline for preparing the water quality management technical document to support the Application for Licences for Mining and Industries in terms of the Requirements of the NWA (DWAf, 2010).

Although South Africa has been slow in ratifying the National Climate Change Bill, various strategy and policy documents have been published incorporating climate change, especially by the DWS. The second edition of the NWRS, published in 2013, already had managing water resources for climate change as one of the strategic themes, with specific strategic actions incorporating climate change adaptation and mitigation measures (DWAf, 2013). The result of the research is, therefore, concerning as it is indicated in all the IWWMP cases that the IWWMPs were compiled incorporating the NWRS, yet none of the IWWMPs address climate change.

5.2 Conclusion

Based on the results from the research, it can be concluded that climate change adaptation and mitigation measures are not incorporated in IWWMPs in coal mines in Mpumalanga. From the document evaluation, the selected cases continue '*business as usual*' and only ensure that the IWWMPs comply with the regulations as a minimum and ignoring climate change adaptation and mitigation measure requirements from strategy and policy documents, despite reference to these

documents. Below are the main conclusions and recommendations based on the evaluation results of the research.

- The DWS policies and strategies have all been published before 2021, the date of the oldest IWWMP case study evaluated. According to the Operational Guideline: Integrated Water and Waste Management Plan (DWAF, 2010), the IWWMP is a living document that needs to be updated and improved continually. Conditions in the IWUL for all mines require the annual update or review of the IWWMP and submission to the DWS (DWAF, 2010). Consequently, the DWS should have reviewed these IWWMPs annually and instructed the mine to include climate change adaptation and mitigation measures. Even though climate change measure is not specifically addressed in legislation, it is a strategic theme in both the NWRS 2 and 3 which is referenced as a source document in all the IWWMPs evaluated. It can, therefore, be concluded that the government is not holding mining companies accountable for ensuring the implementation of climate change adaptation and mitigation measures. The DWS should also look into reviewing operational guidelines and policies to incorporate climate change.
- It is also evident that coal mines are not proactive in addressing climate change adaptation and mitigation measures. Mining activities are resource-intensive and frequently in places susceptible to climate change, especially in South Africa. Mining operations must do future scenario analysis to assess potential impacts and ensure their operations are resilient to climate change. Having a range of options will allow mines to develop effective methods for mitigating the effects of climate change on their operations, which will differ significantly based on aspects, such as commodities, geographical regions, and mining processes.
- The proverbial light at the end of the tunnel is the Water Tribunal's dismissal of a new IWUL application by Thungela Operations v Department of Water and Sanitation & Others WT04/22/GP (2023) owing to omitting climate change information (Rapson *et al.*, 2023). Even though the Water Tribunal's finding is not binding on parties outside those litigating, it does indicate some increase in awareness on climate change.
- Regrettably, South Africa's heavy reliance on coal for power generation persists. If climate change effects continue unaddressed and coal mines neglect adaptation and mitigation measures, we may witness a bleak future. The challenges directed by climate change could significantly affect coal production in South Africa.

5.3 Recommendations and areas of future research

Based on the evaluation results and conclusions of the research, the following recommendations are made:

- Interviewing officials from the DWS in Mpumalanga responsible for the mining sector to determine why mines are not being instructed to review annual updates to IWWMPs that lack information on climate change adaptation and mitigation measures as required by DWS strategies and policies.
- Interviewing consulting companies compiling the IWWMPs on behalf of mining companies to determine why they do not include climate change mitigation and adaptation measures in IWWMPs.
- Interviewing environmental personnel at mining companies to determine why they do not identify the absence of climate change adaptation and mitigation measures when reviewing IWWMPs from consulting companies before submission to DWS.

As this research was only based on document evaluation, the main aim would be to conduct interviews with parties involved in the compilation of the IWWMPs as stipulated above. Detailed recommendations to assist the government and industry can only be formulated once there is a thorough understanding of the evident divergences in knowledge regarding climate change adaptation and mitigation measures within IWWMPs.

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