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Nadunga, Irene

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UNIVERSITY OF THE WITWATERSRAND

FACULTY OF SCIENCE

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

SCHOOL OF GEOGRAPHY, ARCHAEOLOGY AND ENVIRONMENTAL STUDIES

Integration of Sustainable Development Principles and Climate Change Adaptation Measures in Energy Optimization in Gold Mining in South Africa

Ms. Irene Nadunga

Student No. 1484937

Ph.D. Research Thesis

Supervised by:

Prof. Mulala Danny Simatele

School of Geography, Archaeology and Environmental Studies
Faculty of Science
University of the Witwatersrand
Johannesburg, 2014

August, 2023

DECLARATION

I, the undersigned IRENE NADUNGA, student number 1484937 hereby declare that this thesis is my own original work with the exception of quotations and references which are attributed to their sources. This thesis is being submitted for the Degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg, and has not been previously submitted to any other university and will not be presented at any other university for similar or other degree award.



Signature of the candidate

2023/08/14

Date

ABSTRACT

South Africa located in the sub-Saharan African region and being a mining-intense country, is reported to be affected by extreme weather events which are increasing the country's vulnerability to climate change impacts and therefore reducing the chances of achieving sustainable development. In light of this, mining companies are being pressured to make strong commitments towards implementation of sustainable development principles for sustainable mining. This study therefore aimed at investigating how sustainable development principles and climate change adaptation measures are interlinked and structured; and embedded in a gold mining company's policies and strategies, in an effort to build the mining operations' adaptive capacity and resilience against the impacts of climate change and achieve energy optimization. The challenges that can potentially prevent the effective integration of the sustainability principles and adaptation measures were also explored. Using a case study approach, this study was centered on the gold mining operations located within the Witwatersrand Basin of South Africa. Research data was collected from multiple sources, therefore employing a mixed method approach by applying the concurrent triangulation technique. Different analytical tools of policy, content and inductive data analysis, and descriptive statistical data analysis were applied. The empirical evidence shows that the gold mining operations are faced with increasing operating costs associated with the increased energy consumption and implementation of costly mining practices in an effort to combat the impacts of extreme weather events caused by climate change. This affirms that a relationship exists between climate change and energy use in gold mining. In an effort to address climate related risks and energy security, gold mining operations are implementing energy efficiency measures and using renewable energy in their energy mix; which measures are seen to integrate sustainability principles, therefore adopted as sustainability adaptation measures. In addition, some mining company policies and strategies are also seen to integrate sustainability principles and adaptation measures, in an effort to guide the mining operations in effectively developing and implementing sustainability adaptation measures, designed to holistically address climate related risks and energy security. This affirms that a relationship exists between sustainable development principles, climate change adaptation measures and energy optimization. This therefore, implies that sustainability principles and adaptation measures can be integrated to form sustainability adaptation measures, and that gold mining companies have the potential to achieve sustainable mining and contribute to sustainable development, particularly achieving SDG 7 and SDG 13.

DEDICATION

I dedicate this work to my father, Dr. Wanaku Boniface and my mother, Mrs. Zamu Nangoye Kakembo for their endless love and support in all aspects of my life including enduring that I got educated. To my daughter Stacey Faith Nambi, for being so patient and understanding, and allowed that I spent time away from her to pursue this study and fulfil my academic dreams.

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LIST OF ABBREVIATIONS AND ACRONYMS

CDP: Carbon Disclosure Project

CIGI: Centre for International Governance Innovation

ESCAP: Economic and Social Commission for Asia and the Pacific

ESG: Environmental, Social and Governance

EU: European Union

GHG: Green House Gases

GSCM: Green Supply Chain Management

ICMM: International Council on Mining and Metals

IFC: International Finance Corporation

IISD: International Institute for Sustainable Development

MDGs: Millennium Development Goals

NDA: Non-Disclosure Agreement

PAGE: Partnership for Action on Green Economy

SARS-CoV-2: Covid-19

SDGs: Sustainable Development Goals

TCFD: Task Force on Climate-related Financial Disclosures

UN: United Nations

UNEP: United Nations Environment Program

UNESC: United Nations Economic and Social Commission for Africa

CHAPTER ONE
FRAMES OF REFERENCE

1.1 Background to the Study

It has been argued that "sustainable development" is meeting today's development needs without compromising the ability of the future generations to meet their own needs (International Institute for Sustainable Development [IISD], 2018). Sustainable development involves three dimensions of economic growth, social development and environmental sustainability that are interlinked. However, in the World Bank Annual Report (2016) and Bhattacharya (2015b) it has been reported that achieving a balance between these three dimensions of sustainable development and the interrelationships between them, remains a challenge. To address these challenges, efforts were made in April 2015, whereby 125 parties including South Africa, signed the Paris Agreement on climate change to achieve 80% reduction in Greenhouse gases (GHGs) emissions to realize a low-carbon future by 2050 (Wei et al., 2021); and in September 2015 at the United Nations (UN) Sustainable Development Summit, a number of nations, including South Africa, adopted the 2030 Agenda for Sustainable Development, with 17 Sustainable Development Goals (SDGs) at its central (World Bank Annual Report, 2016). The international community thus adopted the SDGs and marked a clear recognition that economic growth, poverty reduction, and environmental sustainability are intricately linked and essential for achieving sustainable development (World Bank Annual Report, 2016).

Since the inception of the SDGs and signing of the Paris Agreement, the European Union (EU) made significant progress in achievement of its SDGs especially with regard to affordable and clean energy (European Union [EU], 2017). Despite the achievement of responsible production and consumption of clean energy, the EU is still faced with the challenge of securing affordable, reliable and sustainable energy supplies. This challenge is attributed to the fact that the EU countries are still heavily dependent on the fossil fuels that release GHG emissions contributing to climate change (EU, 2017). Similarly, generation of GHGs is a challenge in the Latin American and Caribbean countries given that these countries are also dependent on burning of fossils to generate energy and are yet to achieve efficiency in energy transformation and use (United Nations Environment Program [UNEP], 2002). The UN report (2017) also showed that progress in reduction of GHG emissions is lacking in the Asia and the Pacific countries; and according to the

Economic and Social Commission for Asia and the Pacific [ESCAP] (2017), thousands of lives have been lost with almost a billion people affected by storms and floods due to climate change.

The African continent is not any different. The continent is challenged with achieving sustainable development, despite having diverse and rich renewable and non-renewable resources (United Nations Economic and Social Commission for Africa [UNESC], 2015). Africa is the poorest continent and has been left behind in achieving its Millennium Development Goals (MDGs), thus accepted the need to complement the SDGs with the MDGs (UNESC, 2015). Amongst the issues affecting achievement of sustainable development in Africa, is the unsustainable production and consumption of natural resources and climate change. The continent is increasingly vulnerable to climate change given its inability to cope with the physical, human and socioeconomic consequences of climate extremities, which have affected the continent's pace of sustainable development through undermining Africa's ability to grow and develop (UNESC, 2015; Centre for International Governance Innovation- CIGI, 2009).

In the International Finance Corporation (IFC) 2014 annual review, Peschka (2014) argues that sub-Saharan Africa is one of the fastest-growing economies in the world. However, despite this strong performance, economic growth among countries within this region is uneven. Amongst other constraints, the effects of climate change are one of the inhibiting factors to achieving sustainable development in the sub-Saharan African region and it has been projected that the sub-Saharan African region is to be affected by extreme heat events, increasing aridity and changes in rainfall events (Connolly-Boutin & Smit, 2016). South Africa, located within the sub-Saharan African region, is seen to experience the strongest decrease in precipitation with concurrent risks of drought within the region. These climate variabilities within the region is exacerbating the challenges for energy resources that is increasingly exploited due to increased demand for reliable and affordable energy supplies coupled with the lack of infrastructure and facilities to use energy productively and efficiently and yet in turn pollute the environment (Connolly-Boutin & Smit, 2016).

Lebert (2015) argues that, despite Africa being a continent of poverty, it is still the continent of wealth. Africa is the largest mineralized continent in the world and for many African countries, mineral exploration and production constitutes a significant part of their economies and key to

economic growth. For instance, mining in South Africa once drove the history and development of Africa's economy through large scale and profitable mining and provision of extractive activities as an important component of the economy (FTI Consulting, 2017). However, Peschka (2014) argued that, despite the economic benefits derived from mining, this sector is one of the most energy intensive industries significantly contributing to GHG emissions through operation of energy intensive processes through excavation activities, mine operational activities, material transfer, mineral preparation, processing and separation (IFC, 2014; Nelson & Schuchard, 2011).

In the Integrated Planning and Sustainable Development: Challenges and Opportunities report (Partnership for Action on Green Economy [PAGE], 2016), it is noted that mining can make significant contributions to the GDP of the country but may not make meaningful contributions towards sustainable development; especially to benefit poor mining communities and whose livelihoods are reduced by environmental degradation caused by the mining activities (PAGE, 2016). This is similarly noted in the IFC (2014) annual review report where Peschka (2014) argues, that mining increases the vulnerability of the communities in which the mines operate and increased vulnerability to the impacts of climate change such as temperature increases and water shortages. Therefore, mining companies are pressured to mine sustainably given the fact that most mines are located in environmentally sensitive regions where mining activities are impacting on the sensitive environment and natural resources (Kogel et al., 2014).

Furthermore, due to the effects of climate change on mining activities, mining companies are required to apply corporate sensitivity and strong commitments towards implementation of sustainable development principles and best practices for the sustainable mining (International Council on Mining and Metals [ICMM], 2017). However, it was noted in the UNESC (2015) that the effective integration of mining into the African national and regional economies to achieve sustainable development is still a challenge. This is also noted in the Carbon Disclosure Project [CDP] (2017) that South African mining companies are observed to be slowing in the efforts to reduce emissions and address climate change and that the South African mining companies therefore need to further integrate climate change into their risk management.

1.2 Problem Statement

In view of the observations made in the background above, achievement of sustainable development is still a challenge in most countries (World Bank Annual Report, 2016); particularly with the sustainable production and consumption of clean, affordable and reliable energy; and the reduction of GHGs generated from the burning of fossils to mitigate effects of climate change (UN, 2017; UNEP, 2002). In turn, climate variability is exacerbating the challenges for energy resources due to increased demand and the lack of infrastructure and facilities to use energy productively and efficiently (Connolly-Boutin & Smit, 2016). The mining sector being an energy intense industry, is seen to significantly contribute to GHG emissions; and given the locality of mines in environmentally sensitive regions, mines are also seen to cause environmental degradation and increase the vulnerability of the communities to the impacts of climate change (Connolly-Boutin and Smit, 2016; Peschka, 2014; Kogel et al., 2014; Möhr-Swart et al., 2008).

South Africa being a mining-intense country and located within the Sub-Saharan African region, is affected by extreme climate change events which has increased the country's vulnerability to climate change impacts and reducing the chances of achieving sustainable development (Connolly-Boutin & Smit, 2016). Therefore, South Africa needs to address these challenges and find ways of how to integrate climate change adaptation measures and sustainable development principles in energy consumption especially within the mining sector. This is critical for a country whose economy has mining as one of the GDP contributors but still an energy-intensive sector, and given that there is increasing demand for reliable and affordable energy supplies to use energy productively and efficiently (PAGE, 2016).

Therefore, in view of the above observations, this study investigated the ways in which the gold mining industry in South Africa, taking gold mining operations as case study, can integrate sustainable development principles and climate change adaptation measures into their mining processes and systems. The study was particularly interested in investigating how these sustainability principles and adaptation measures are interlinked, structured and embedded in a gold mining company's policies and strategies, in an effort to build the gold mining operations' adaptive capacity and resilience against the impacts of climate change and achieve energy optimization. In this context therefore, the study's interests revolved around identifying ways,

which can effectively and sustainably contribute to increasing the mining operations' adaptive capacity to the impacts of climate change and optimizing energy use as well.

1.2.1 Research Questions

In view of the issues raised in the thematic consideration, the following questions guided the research:

I. In what ways does climate change affect energy use in gold mining?
II. In what ways have gold mining operations incorporated sustainable development principles into their climate change adaptation measures, to adapt to the impacts of climate change and optimize on energy use?
III. What challenges exist in the integration of sustainable development principles and climate change adaptation measures in effort to enhance the gold mining operations' adaptive capacity and achieve energy optimization?
IV. What measures are implemented to address these challenges and the implications of the findings of this study in a wider context?

1.3 Research Aim and Objectives

In answering the four research questions above, this study aims at firstly investigating the different ways in which gold mining operations can integrate sustainability principles into their climate change adaptation measures; and secondly, identify the ways in which the sustainability principles and climate change adaptation measures are structured and imbedded in a gold mining company's policies and strategies in an effort to build the gold mining operations' adaptive capacity and resilience against the impacts of climate change and achieve energy optimization. In view of this aim, the following were the objectives of the study:

I. Identify ways in which the gold mining operations are adapting to the impacts of climate change and achieving sustainable energy consumption.
II. Investigate the feasibility of integrating sustainable development principles into climate change adaptation measures in effort to adapt to the impacts of climate change and achieve sustainable energy consumption, using gold mining operations as case study.

III. Investigate the feasibility of integrating sustainable development principles and climate change adaptation measures into the gold mining company policies and strategies.

IV. Identify, assess and align potential initiatives linking the gold mining companies in achieving Sustainable Development Goal 7 (SDG7)-Affordable and Clean Energy; and Sustainable Development Goal 13 (SDG13)-Climate Action.

Therefore, in an effort to answer the study research questions above, these study objectives are achieved by identifying ways in which gold mining companies can effectively and sustainably contribute to increasing the mining operations' adaptive capacity to the impacts of climate change, optimizing energy use and achieve sustainable development.

1.4 Theoretical Considerations and Literature Review

There is growing awareness and concern that changing climate and its impacts present physical risks to mining operations and installations. This line of thought is complemented by various scholars contributing to the body of knowledge in relation to climate change, sustainable development and energy optimization within the mining industry (PAGE, 2016; Connolly-Boutin & Smit, 2016; Peschka, 2014; Kogel et al., 2014; Nelson and Schuchard, 2011; Möhr-Swart et al., 2008). However, Odell et al. (2018) argues that, there is limited literature and research on mining and climate change; which was also observed by Schaeffer et al. (2012) that, there is limited knowledge relating to climate impact assessments on energy planning and operation in the field of mining.

Despite the limited literature and research, Nelson and Schuchard (2011) gave empirical support to the claim that climate change is already happening, and will continue to be a critical issue challenging mining. Nelson and Schuchard (2011), further argued that the mining sector is a high rate energy consumptive industry with the potential to significantly contribute towards GHG emissions. This was similarly reported by Farrant (2016) in the AusIMM Bulletin, that the Australian mining sector increased its GHG emissions by 22 per cent since 2005, which was in contrast with the Australian Government's target of a 26 to 28 per cent reduction in emissions by 2030. In the same line of thought, Mogodi (2012) argued that, in the effort to reduce on energy consumption, mining companies need to create energy management models for their operations; and minimize energy costs and secure long term electricity supply.

In addition, Müller (2018) notes that energy costs in the mining industry have substantially risen with a 10% increase of mining companies' overall operating costs, which is now pushing to 20%. Furthermore, Müller (2018) notes that this increase will intensify for South African mines, as electricity costs are expected to rise from R0.70/kWh to R1.40/kWh by 2030. This therefore, requires mining companies to apply the principles of sustainable development including implementing fundamental principles of responsible energy use and minimization of emissions that have enhanced sustainable business development (Soler & Marcé, 2018). The concept of linking responsible energy consumption to sustainability was similarly argued by Rábago et al. (2001) that efficient energy use is a driver to sustainability.

In effort to link energy use and climate change, Berbés-Blázquez et al. (2018) and; Rasul and Sharma (2016) have argued that implementation of climate change adaptation measures can enhance efficient use of energy and that climate change adaptation can build climate-resilient development and contribute to achievement of SDGs. However, Wise et al. (2014) argued that, there is less implementation of adaptation actions to climate change, despite the substantial investments in adaptation science. This is further observed by Rasul and Sharma (2016), who claim that there is less effort made in understanding the linkages existing between energy, and adaptation to climate change. Furthermore, Soler and Marcé (2018) are also observed to argue that there is a gap in information and research related to climate change and that the instruments used for mitigating climate change impacts are insufficient and inadequate.

Despite the limitations relating to understanding and linking energy with climate change, identified by some scholars; Nelson and Schuchard (2011) observed that some mining companies have established comprehensive management systems to address climate change adaptation. This was also reported in the 2009 CDP report (Sustainability, 2009) where South Africa is seen to show that some mining companies are adopting adaptive management strategies and implementing a range of adaptive practices to respond to the impacts of climate change. However, Nelson and Schuchard (2011) also did argue that most climate adaptation initiatives within the mining industry were focused on physical risks of climate change and less focus on understanding the site-level social risks and opportunities. In light of this, in 2013, a sustainable development framework was developed by the ICMM, which is used by mining and metal companies to adapt to the challenges and implementation of opportunities of a changing climate (ICMM, 2013). Mining and metals

industries are required to identify and manage risks arising from both sustainable development requirements and general operations; and incorporate climate risks within existing corporate strategic plans, risk management processes and engineering practices (ICMM, 2013).

In an effort to understand the applicability of sustainable development principles within the South Africa mining industry context, studies like Möhr-Swart et al. (2008) noted that the implementation of cleaner technologies could be a solution to addressing challenges associated with changing climate; and that environmental management accounting and sustainability reporting are some of the tools existing to enable the mining industry to successfully achieve sustainable development. This was similarly observed by Bastida (2002) who argued that mining companies will need to integrate sustainability concerns into their legal frameworks for mining, and that this framework will include recognizing environmental and socio-economic impact assessments from the earliest stages of mine development to beyond mine closure. However, Epstein (2018) argues that the integration of corporate social, environmental, and economic impacts into the management decisions is still a challenge, and particularly the development and implementation of sustainability strategies.

1.5 Methodological Considerations

The theoretical framework applied in this study was linked to the research methods; and the research questions are consistent with the research design as described by Alavi Mousa et al. (2018). The methodological consideration here therefore outlines the theoretical ideology informing this study as well as the techniques that were applied throughout the study. This study undertook to investigate the different ways in which gold mining operations have integrated sustainable development principles and climate change adaptation measures in the energy optimization as an adaptive strategy. The philosophical research method was applied to justify why and how the data was collected and analyzed to answer the research questions. The Interpretive and Realism philosophical approaches were considered to be the most appropriate philosophies for this study, given the fact that these approaches involve the collection of scientific data within a business and management research context, also focusing on the interaction of the various structures, processes and procedures existing within a business.

This study was conducted at gold mining operations located within the Witwatersrand basin of South Africa. This study utilized the existing gold mining company documentation for the period of 5 years (2016-2021) which documentation was identified during the interview process and use of questionnaires applied to the research participants. The research participants were identified to be working at the gold mining operations. Additional information was gathered from observations done during the site visits at the gold mining operations. These data collection processes therefore provided the primary data for this study. Given the responses received during the interview questioning and from the responses received from the questionnaire process; a specific list of documentation was identified and a rapid appraisal process was applied to the identified mining company documents in an effort to provide information as secondary data relevant for the study. Both the primary and secondary data obtained from the different data sources was presented in the form of qualitative and quantitative datasets. In doing so, this study therefore adopted the mixed methods approach that promotes interaction of different data sets. The concurrent triangulation technique was applied in order to compare the two datasets (quantitative and qualitative data) so as to determine their convergence, difference or combination thereof.

The qualitative data was reduced to numbers and coded for analysis by using the policy, content and inductive data analytical tools, and the quantitative data was analyzed by using the descriptive statistical data analysis methods. The step by step approach is discussed in detail in chapter three of this thesis including a detailed discussion on the highlights and limitations experienced during the research and how these were enhanced and addressed respectively, in an effort to improve on the quality of the study.

1.6 Scope of the Study

This study is limited to gold mining, with a focus on sustainable development, climate change and energy optimization as the three study themes. Specific to this study is examining how sustainable development principles are integrated with climate change adaptation measures to achieve energy optimization at the gold mining operations. This study is also limited to the gold mining operations located along the Witwatersrand basin of South Africa, used as case study. The Witwatersrand Basin which is located northeastern part of South Africa was chosen as the study site, given that this basin is reported to be one of the world's famous basin to be rich with deposits of gold and thus has got a number of gold mining operations to be working within this gold belt region. The

Witwatersrand Basin stretches across 250 miles, from Johannesburg to Welkom, found to be containing gold-bearing reefs along the margins of the north and west. Gold mining in this basin is reported to have contributed to the socio-economic status of the regions within which this basin is located, causing the creation of cities and mining towns, hence having a major influence in shaping South Africa's economy (Tucker et al., 2016). Therefore, given the above, the boundary of this study is limited to gold mining operations located within the Witwatersrand basin of South Africa; however, this study was done at some of the gold mining operations. These gold mining operations are not disclosed given the desire to remain anonymous. As such, this study has not named these gold mining operations and will just refer to them as "the gold mining operations." Gold mining along the Witwatersrand gold belt identified as case study is qualified as suitable study site to investigate the different ways in which the gold mining operations have integrated sustainable development principles into their climate change adaptation measures in an effort to achieve energy optimization, as an adaptive strategy.

1.7 Ethical Consideration

This study involved working with existing data obtained from the gold mining operations, interviewing some of gold mining company employees, and from observations made during the site visits. In respect to this, prior to commencement of this study, Ethical Clearance was obtained from the Human Research Ethics Committee (Non-Medical) of the University of the Witwatersrand. The importance of this clearance is for the researcher to consider the ethical standards including full disclosure, non-coercion and privacy when gathering data from people (human participants) and to treat them fairly. See Certificate-Appendix 1. Therefore, a number of ethical considerations was considered, such as confidentiality, informed consent, anonymity, access and acceptance. Document analysis of external information does not need ethical considerations except for the proper citation of the authors and publications as detailed in the Reference section of this thesis.

1.8 Structure of the Thesis

This PhD thesis is comprised of six chapters. Chapter one conceptualizes and outlines the limits of the study. Chapter two provides theoretical aspects in review of literature relating to arguments identified in journals. Chapter three provides an engagement with the theoretical study to

determine the approach to collect data and; Chapter four presents the empirical findings related to the collected data. Chapter five provides discussions of the research empirical findings and the existing literature. Chapter six provides the conclusions and recommendations making significant contributions to mining company policy and sustainable mining, and areas for future research.

1.9 Conclusion

The frame of reference presented in this chapter provides a background to the study in subsection (1.1) which presents the context of the important and relevant studies and information pertaining to sustainable development, climate change and energy. In view of the observations made from the different studies, the problem statement is discussed in subsection (1.2) noting that South Africa being a mining-intense country and located within the Sub-Saharan African region, is affected by extreme climate change events which has increased the country's vulnerability to climate change impacts and reducing the chances of achieving sustainable development. Therefore necessitating this study to investigate the ways in which the gold mining industry in South Africa, taking gold mining operations as case study, can integrate sustainable development principles and climate change adaptation measures into their mining processes and systems. Four research questions were identified to guide the research in an effort to achieve the research aim and objectives as described in subsection (1.3), detailing the need to identify the ways in which gold mining companies can effectively and sustainably contribute to increasing the mining operations' adaptive capacity to the impacts of climate change, achieve energy optimization and sustainable development. In subsection (1.4) the theoretical considerations and a framework of the literature review are summarized. The methodological considerations informing this study as well as the techniques that were applied throughout the study is also summarized in subsection (1.5). The scope of study is presented in subsection (1.6) outlining the boundary of this research and its limitations to gold mining including a focus on sustainable development, climate change and energy optimization as the three study themes. Subsection (1.7) provides the ethical considerations in this study which involved working with existing data obtained from the gold mining operations, interviewing some of gold mining company employees, and from observations made during the site visits; this therefore, warranting to gain ethical clearance from the Human Research Ethics Committee (Non-Medical) at the University of the Witwatersrand. Subsection (1.8) presents an outline of the main six chapters that constitute this thesis.

Therefore, this chapter one of the thesis provides basis for the following chapters including chapter two which provides a detailed insight on the literature reviews either supporting or holding theories informed by concepts that are centered on sustainable development, climate change and energy optimization within the mining industry at a global, regional and local South Africa's context.

CHAPTER TWO
THEORETICAL CONSIDERATION AND LITERATURE REVIEW

2.1 Introduction

A large and growing body of literature has shown that climate change exists and continues to impact on mining operations; and that the mining sector is a high rate energy consumptive industry that is significantly contributing to climate change through the emissions of GHGs generated from the increased use of fossil fuels (Farrant, 2016; Nelson & Schuchard, 2011; Epstein, 2008). Studies have also shown that sustainable energy consumption within the mining industry is regarded as an important aspect in leading to the achievement of sustainable development and some mining companies are reported to have implemented climate change adaptation measures to enhance efficient use of energy (Soler & Marcé, 2018; Odell et al., 2018; Rasul and Sharma, 2016; Schaeffer et al., 2012; Mogodi, 2012; Epstein, 2008; Rábago et al., 2001).

Furthermore, previous studies have shown that climate change adaptation measures can also build climate resilient development and contribute towards achieving SDGs (Berbés-Blázquez et al., 2018); and that linkages do exist between energy, adaptation to climate change, and sustainable development (Rasul & Sharma, 2016; Möhr-Swart et al., 2008; Bastida, 2002). In addition, the ICMM (2013, 2003) and Nelson and Schuchard (2011) have shown that these linkages can be enhanced through the integration of sustainable development principles into the mining management strategies, processes and systems to address the impacts of climate change. Therefore, the subsections presented in this chapter, provide an insight on the literature reviews either supporting or holding theories informed by concepts that are centered on sustainable development, climate change and energy optimization within the mining industry at a global, regional and local South Africa's context.

2.2 Climate Change with Sustainable Development of Energy: A Global Context

From existing literature, it is evident that the use of natural resources is a key element of sustainable development; however, Dubiński (2013) argues that the most important fact in sustainable development, is the depletion of the non-renewable resources, particularly the energy resources. This was also noted in the UNEP (2002), that the EU countries are heavily dependent on

unsustainable energy resources due to still being heavily dependent on use of fossil fuels that release GHG emissions contributing to climate change. Therefore challenged with securing affordable, reliable and sustainable energy supplies and subsequently challenged with achieving sustainable development; despite the fact that these EU countries perceive sustainable development as the link to improved life standards whilst providing for economic growth without compromising the future generations' rights to clean and a healthy environment (Zeghici & Polizu, 2013). The mining industry is reported to be one of the industries that are heavily dependent on the use of fossil fuels, consuming energy at a high rate; which is significantly contributing to GHG emissions (Nelson & Schuchard, 2011). For instance, the Australian mining sector is reported to have increased its GHG emissions by 22 per cent since 2005 (Farrant, 2016).

On the contrary, mining companies have also been observed to be contributing towards sustainable development. This view is argued by various scholars noting that through the cost-effective extraction of minerals, this mining practice can be regarded as a key element of sustainable development (Soler & Marcé, 2018; Odell et al., 2018; Dubiński, 2013; Schaeffer et al., 2012; Mogodi, 2012; Rábago et al., 2001). This has been observed in India where mining companies are contributing towards sustainable development by generating employment and wealth (Shen et al., 2015). However, Shen et al. (2015) further argued that despite the contributions made by mining companies towards sustainable development; a challenge still remains in regard to the negative contributions the mines make towards the ecological component of sustainable development. Therefore, necessitating the need for mines to consider the adoption of measures to improve their ecological performance, in an effort to further achieve sustainable development (Shen et al., 2015).

Given the fact that the mining industry is observed to be challenged in achieving sustainable development, a few scholars have presented their views relating to how mining companies have made effort to address the limitations on how to balance the socio-economic and environmental issues in a way that takes full advantage of benefits and reduces or eliminates harm and degradation. Some studies like in the ICMM (2013) and Nelson & Schuchard (2011) have identified different tools and techniques that can be used in the achievement of sustainability in the mining sector. Shen et al. (2015) noted that some mining companies in India have adopted the green supply chain management measures in order to improve on the mine's ecological performance. In addition, Govindan (2015) observed that some mining companies are

implementing the multi-criteria decision making processes and integrating the sustainable practices into their mining practices and systems. However, the integration of sustainable practices can be challenging in how to address all sustainable development related aspects in a quantitative way, while assessing suitable solutions to ensure sustainable development (Chicco, 2010).

Therefore, existing literature on this subject has mostly confirmed that sustainability is the integration of environmental, social and economic aspects, and that these aspects can be integrated into mining operations to achieve sustainable development and lead to a positive impact on mining performance (Berg et al., 2017; Uitto et al., 2017; Nelson & Schuchard, 2011). Berg et al. (2017); and Uitto et al. (2017) furthered this argument by observing that sustainability can also be regarded as an adaptation issue concerning the ways in which the social and economic domains are ready for change in the environmental domain including resulting actions. Their argument confirms that adaptation measures do require actions that transform the interactions existing between the social, economic and environmental domains. Berg et al. (2017) further states that constant adaptation is required in effort to achieve a sustainable balance among civil people, the economy and the environment. This is also affirmed by Uitto et al. (2017) who state that adaptation measures are underpinned by factors including *"effectiveness of institutions and governance, innovation and investments in environmentally sound technologies and infrastructure, sustainable livelihoods and behavioral and lifestyle choices"* (p. 4). Therefore, in as much as it is noted in both studies that adaptation is an important aspect of achieving sustainable development; Uitto et al. (2017) and Berg et al. (2017) are however, observed to give emphasis on evaluation of climate change mitigation and adaptation actions for sustainable development, and not necessarily on how these adaptation measures can be integrated into the mining systems in an effort to achieve sustainable development.

Literature has also shown that SDGs can be achieved through the implementation of climate change adaptation measures seen to build climate-resilient development (Berbés-Blázquez, 2018; Rasul & Sharma, 2016). This theory is supported by Uitto et al. (2017) who refers adaptation to *"the reduction in adverse effects of climate change on human and natural systems"* (p.4). In contrast to this argument, scholars like Leiter (2017) and Wise et al. (2014) have argued that there is less implementation of adaptation actions to climate change, despite the substantial investments made in adaptation science, and the increased development of climate change adaptation policies

and projects as well as continued integration of adaptation initiatives into planning processes. Similarly, Nelson and Schuchard (2011) also argued that most climate adaptation initiatives within the mining industry have placed less focus on understanding the site-level social risks and opportunities, and that most mitigation and adaptation actions that are being undertaken are mostly related to engineering and infrastructure improvements. However, this case may be different in Europe, where according to Aguiar et al. (2018), Europe is observed to be increasingly developing climate change adaptation strategies at a local level but reported to have contradictory patterns of adaptation planning and adaptive capacity observed among the European regions.

Literature has also shown that unreliable energy can inhibit companies from achieving sustainable development (Ley, 2017) and that energy conservation is a driver to sustainability, and noted to have opportunities lying with saving money by saving energy (Rábago et al., 2001). In achieving sustainable development, it is noted that energy savings are regarded to be profitable in strengthening economic vitality and at the same time lead to protection of the climate, and improve living standards; which can be achieved through policy development and implementation (Rábago et al., 2001). However, Ley (2017) argues that the opportunities driven from saving energy have been noted to be blocked by specific obstacles at the level of the firm, locality or society; due to poverty and the lack of community involvement being some of the hindrances to achieving sustainable development. This was similarly observed by Chicco (2010) who argued that social issues, equality and ecology can affect energy systems in the EU countries, therefore these aspects need to be integrated into a comprehensive framework that works towards a solution to achieve sustainable development.

In further linking energy and sustainable development, scholars like Fattahi et al. (2018) argued that, despite large numbers of industries using renewable energy generation systems to reduce their carbon footprint, most mining companies still use electricity generated from diesel generators; which energy source is regarded to be costly and still increases their carbon footprint. The challenges associated with reducing the carbon footprint was similarly argued by Hoffman (2002) that not all companies can benefit from GHG reductions due to the differences lying in strategic factors including capital asset management, market capabilities, and global competitiveness and how to deal with institutional change. Other scholars also noted that there is still need for energy efficiency improvements despite efforts in implementation of mitigation measures like energy

efficient technologies and renewable energy which play a vital role in reduction of energy use and emissions (Chicco, 2010; Uitto et al., 2017). Despite the challenges observed by some scholars, found to be inhibiting companies from achieving sustainable development through the implementation of energy efficiency mitigation measures; Soler and Marcé (2018) did however, observe that, the Barcelona City Council has implemented sustainable development principles responsible for sustainable energy consumption and minimizing GHG emissions, which include concepts like green energy, climate change mitigation and emission reduction measures, in effort to achieve a sustainable business.

More so, on a global level, some countries have been observed to improve on their energy efficiencies as a direct way to deal with the consequences of climate change; which however, has been observed by Zeghici and Polizu (2013) to be a challenge due to lack of clear implementation of the energy efficient measures. Zeghici and Polizu (2013) further note that the EU member states have been reported to have not been able to cut around 30% of their GHG emissions as predicted hence affecting their efforts to combat climate change. It is however, noted that cites in the Nordic countries are implementing more efficient and sustainable energy systems in transitioning to an environmentally sustainable society as part of the strategy to supply the country's energy needs (Hamlehdar & Aslani, 2017). This is similarly observed in Iran, where the Iranian government are reported to be encouraging for the implementation of energy efficiency technologies through the increased use of renewable energy sources in Iran (Mardani, 2013). As we appreciate the contributions made by different scholars towards reduction in GHG emissions by implementing energy efficiency measures and increased use of renewable energy in an effort to achieve sustainable development; most of these arguments are placed on cities and countries not necessarily within the mining sector.

In linking the mining industry to energy efficiency and GHG emissions reduction and climate change; literature has shown that, mining companies in Australia have been reported to respond to challenges of climate change by contributing to emissions reduction and adapting to the impacts of climate change. This is achieved through the implementation of alternative energy sources, climate risk assessment and adaptation planning (Farrant, 2016). Farrant (2016) further noted that if mining companies were to effectively respond to the challenge of climate change, then the mines will need to not only reduce their GHG emissions, but also adapt to the changing weather patterns,

for instance, by conducting regular climate risk assessments of the sites and develop climate adaptation plans for the identified high risks. Similarly, according to Perdeaux (2017), mining companies in Ontario have been observed to be implementing proactive adaptation measures including the adjustment of the mine's operating procedures to accommodate new climate changes. Glencore mine and DeBeers diamond mine are also noted to respond to projected climate change by implementing measures to include construction of all-season roads and airstrips, and optimizing logistics planning to accommodate winter road availability (Perdeaux, 2017). These climate change adaptation measures are however observed to not be associated to energy conservation. Studies like Ma et al. (2019) did however, note that the mining industry in China is required to improve on its sustainable and efficient industrial operations in order to reduce the mine's impacts on energy and CO_2 emissions. This expectation of China's mining industry, comes at a time when China has surpassed United States, in becoming the biggest energy consumer and CO_2 emitter in the world (Ma et al., 2019).

Therefore, as we appreciate the contributions made by various scholars and studies that have engaged with linking energy optimization, climate change mitigation and adaptation measures and sustainable development; most of these studies have mainly focused on discussions relating to energy savings, GHG reductions and climate change mitigation measures and in some cases within the mining sector; it is however observed that, less focus has been made in linking energy optimization, climate change adaptation and sustainable development principles within the mining industry. Furthermore, most of these studies have based their arguments on theoretical reviews of existing related studies and not entirely on mining site investigations; therefore, this has created gaps in information and knowledge relating to linking sustainability principles, energy efficiency and climate change adaptation including instruments being used by the mining companies to adapt to climate change and enhance energy optimization. Some studies have however, been observed to reveal that linkages do exist between climate change adaptation and energy efficiency; and that climate change adaptation can build climate resilient developments including the enhancement of efficient use of energy (Berbés-Blázquez, 2018; Rasul & Sharma, 2016; Epstein, 2008). Whereas other studies have also shown that these linkages are implemented within the mining industry to achieve sustainable development (Soler & Marcé, 2018; Odell et al., 2018; Schaeffer et al., 2012; Mogodi, 2012; Rábago et al., 2001). However, what seems to be lacking from these studies is the

consideration of integrating sustainability principles into climate change adaptation measures in effort to strengthen the achievement of energy optimization by mining companies.

2.3 Climate Change with Sustainable Development of Energy: A Sub-Saharan African Context

Sub-Saharan Africa is reported to be home to some of the fastest-growing economies in the world; however, this part of the African continent is challenged with achieving sustainable development due to the unsustainable consumption of its natural resources and its increased vulnerability to the impacts of climate change (UNESC, 2015; Peschka, 2014; Rahman et al., 2012; CIGI, 2009). The sub-Saharan region of Africa is mostly affected by extreme heat events, increasing aridity and changes in rainfall events. The low adaptive capacity of the developing countries in this region has therefore increased their vulnerability towards climate change impacts (Connolly-Boutin & Smit, 2016; Rahman et al., 2012). Therefore, according to Connolly-Boutin and Smit (2016), information relating to the level of vulnerability towards climate change impacts and its effect to production is increasingly becoming more relevant to understand.

According to Asongu and Odhiambo (2018), the consequences of climate change is projected to be most disruptive in Africa for a number of reasons including the evolving energy crises. In an effort to manage this energy crisis, Asongu and Odhiambo (2018) have argued that Nigeria and other African countries have been observed to be subsidizing the petroleum fuels instead of using alternative sources of energy that are renewable. This was similarly argued by Aliyu et al. (2018) that the African continent can overcome its energy crisis through the utilization of renewable energy sources; citing South Africa, Egypt and Nigeria as some of the countries to be encouraging energy efficiency through the use of renewable energy. Therefore, in effort to achieve sustainable development, some African countries like Nigeria have diversified their energy mix in order to meet the country's energy needs and drive as a strategy to achieve sustainable development (Elum & Momodu, 2017). Similarly, Owusu and Asumadu-Sarkodie (2016) did argue that, in effort to meet the energy demand for the future generations, the implementation of sustainable renewable energies to mitigate against climate change impacts is required. This was also observed by Beg et al. (2011), that energy efficiency is a synergy that exists between climate change and the sustainable development; which will require the need to build cost-effective strategies including

climate strategies and integrated development for energy security in sub-Saharan Africa in order to respond to climate change (Davidson et al., 2003).

Additional literature into the use of energy efficiency as a mitigation and adaptation factor against climate change is noted by Rugină and Badea (2016) who argue that energy efficient utilization can directly contribute towards sustainable development; and that renewable energy projects have the potential to contribute to climate change mitigation, adaptation, and sustainable development objectives. The usage of renewable energy as a tool of sustainable development in mitigating the occurrence and impacts of climate change on the environment and society has notably been implemented in some African countries including Nigeria (Elum & Momodu, 2017). In addition, countries like Guatemala and Nicaragua, have also been observed to implement renewable energy projects in order to meet the triple objectives of sustainable development and climate change mitigation and adaptation (Ley, 2017). This was similarly argued by Gheorghiu et al. (2011) that, modeled and structured energy objectives can reduce resource consumption for the current and future generations, and that sustainable development can be achieved once these energy objectives are achieved.

Therefore, as much as the literature presented above is showing that a linkage exists between energy, climate change and sustainable development; and that some African countries are observed to be implementing the use of renewable energy measures as a strategy to mitigate against and adapt to climate change and achieve sustainable development; these studies however, did not further their discussions within the context of the mining industry seen to be one of the sectors that are energy intensive in the African continent. Furthermore, a number of these studies have also been observed to have placed emphasis in understanding how sub-Saharan Africa is implementing renewable energy, adapting to the impacts of climate change, and identifying the obstacles that are hindering the implementation of renewable energy for sustainable development including how climate change adaptation and ecological resilience can be adopted with policy interventions (England et al., 2018; Connolly-Boutin & Smit, 2016; Spear et al., 2015; Niang et al., 2014; Porter et al., 2014; Cooper et al., 2013); however, less focus has been made in exploring the linkage existing between sustainable development principles and climate change adaptation measures; and how this integration can lead to achievement of energy optimization; and particularly within the mining industry.

In review of literature surrounding the mining industry in relation to energy optimization, climate change adaptation and sustainability. Literature shows that the mining industry in Africa is significantly contributing to the continent's economies (Lebert, 2015); however, it is also observed that the mining industry is one of the most energy intense industries observed to significantly contribute to GHG emissions through operation of energy intensive processes (Peschka, 2014; IFC, 2014; Nelson & Schuchard, 2011). Therefore, in an effort for mining companies to reduce their GHG emissions and address the impacts from climate change; the ICMM (2013; 2003) established an adaptive strategy to address climate change impacts and implementation of sustainable development principles within the mining industry. The need for mining companies to integrate sustainability concerns into the legal frameworks for mining was observed by Bastida (2002), who argued that mining companies needed to identify environmental and socio-economic impact assessments from the initial stages of mine development to beyond mine closure. Scholars like Epstein (2018) did however; observe that a challenge still existed with how companies can integrate corporate social, environmental, and economic impacts and corporate sustainability into the management decisions, particularly the development and implementation of sustainability strategies. Epstein (2018) further argued that it is unlikely for any company to fully integrate or achieve sustainability despite the fact that most companies have taken the initiatives to improve their sustainable performance and reduce their negative social and environmental impacts. Therefore, as we appreciate that some studies have established that there is a linkage existing between climate change and sustainability within the mining industry; and that some studies have further this by establishing adaptive strategies to be used by mining companies in effort to integrate climate change adaptation measures and sustainable development principles; what is however, seen to be lacking in these studies, is the inclusion of energy optimization in this linkage, so as to use these adaptive strategies in an effort to achieve sustainable energy consumption as well.

2.4 Climate Change with Sustainable Development of Energy: A South African Context

From a local perspective, South Africa is the biggest emitter of GHGs in Africa, given its high dependency of coal a fossil fuel (Bond and Erion, 2009) hence being an emission intensive country that has to reduce its GHG emissions and lower its high carbon footprint caused from the excessive dependence on coal-based electricity generation (Nakumuryango & Inglesi-Lotz, 2016; Walwyn & Brent, 2015; Pegels, 2010; Spalding-Fecher, 2003). Mytelka et al. (2016) argues that the

intensive energy consumption and GHG emissions is further exacerbated by the fact that South Africa's mining sector is the most energy intense sector in the country that consumes most of its coal generated electricity from a government state owned company responsible for the generation, transmission and distribution of electricity in the country. This argument is further by Votteler and Brent (2016), who claim that the increased consumption of electricity, coupled with the increased costs of electricity have created the need for the mining companies in South Africa, to investigate alternative sources of electricity in order to lower operational costs and decrease the mine's carbon footprint.

Literature has also shown that energy is a critical factor in achieving sustainable development, and given the fact that South Africa has a long way to achieving sustainable development; it is envisaged that there is need to track the progress on energy consumption due to its role to the economic and social development and its contribution to environmental degradation and climate change (Nakumuryango & Inglesi-Lotz, 2016; Spalding-Fecher, 2009). Therefore, in effort to successfully achieve sustainable development in South Africa; scholars like Möhr-Swart et al. (2008), have argued that the South African mining industry is encouraged to use the available environmental management accounting and sustainability reporting tools, as some of the strategies implemented to achieve sustainable development. Möhr-Swart et al. (2008); however, further argues that this can only be achieved if, the mining companies can first address their environmental issues, which includes resource control, monitoring consumption rate; classified under environmental management techniques to be applied to achieve sustainable development. It is also observed in the CDP (2017) report that, South Africa is likely to take time to diversify its use of resources away from coal and into renewable energy, particularly for the South African mining companies, which are seen to be slowing in their efforts to reduce emissions and address climate change.

Similarly, the Sustainability (2009) reported that, South Africa's mining industry has since been observed to be implementing a range of adaptive practices in response to the impacts of climate change; however, these practices are noted to be implemented mostly with the intention to protect the value of existing or potential assets and create a value through technological innovations, create new market opportunities and collaborate initiatives that addresses the changing needs of the mining company and communities affected by climate change. The need for mining companies to

implement climate change adaptation measures with the focus of addressing the risks associated with climate change is further argued by Aleke and Nhamo (2016) who in their study on information and communication technology and climate change adaptation; state that the adaptive practices that are introduced into the climate change adaptation mix, should be used as an adaptation strategy to reduce the mine's vulnerability and exposure to climate change disaster risks. Similarly, Wise et al. (2014) and Nelson and Schuchard (2011) did argue that for mining companies to address climate change impacts; comprehensive management systems need to be developed and adopt additional adaptation pathways to include changes in facilities management and integration of climate considerations into the mining company strategic planning and work with legislators so as to develop policy changes that support adaptation, and inform robust decision making that is seen to be under uncertainty. In support of this argument, it is also observed that scholars like Chersich and Wright (2019) and in the CDP (2017) report, emphasis is given for the need for a shift to developing plans and systems in an effort to adapt to the impacts of climate change.

Therefore, as we appreciate that a number of studies have observed that the South Africa's mining industry is implementing measures in effort to achieve sustainable energy by diversifying its energy mix, and implementing climate change adaptation measures in effort to address the impacts of climate change; it is however, observed that information relating to how the sustainability principles can be integrated into these energy conservation measures and climate change adaptation measures in effort to achieve sustainable mining, is not discussed.

2.5 Synthesizing Sustainable Development, Climate Change, and Energy Nexus

Studies have revealed that climate change is a complex issue that encompasses physical, technological, institutional, economic, social, environmental and political spheres, which are critical for sustainable development (Connolly-Boutin & Smit, 2016; Hens, 2010). In the context of Africa, various studies have made attempts in connecting climate change within the existing water-energy-food nexus (Asongu & Odhiambo, 2018; Aliyu et al., 2018; Elum & Momodu, 2017; Owusu & Asumadu-Sarkodie, 2016; Beg et al., 2011; Davidson et al., 2003); however, the focus has mainly been on the use of the integrated approach and the cross-sectional coordination of the energy-water-food nexus in order to improve resource use efficiency and achievement of sustainable development including in South Africa (Xiao et al., 2018; Conway et al., 2015).

Similarly, Liu, et al. (2017) argued that the water-energy-food nexus is perceived to be used in developing strategies for sustainable development including the integration of minerals in the water-energy-food nexus; and that this integration is reported to lack a systematic analytical tool that can be applied effectively into the nexus, and seen to not involve the integration of climate change. This was later argued by Mpandeli et al. (2018) that the water-energy-food nexus can be explored as an opportunity in developing cross-sectoral sustainable climate change mitigation and adaptation strategies; however, noting that this nexus was based on the fact that climate change is a cross cutting issue that requires integration into transformative systems approach rather than a sectoral approach like the mining sector.

Clean Development Mechanisms (CDM) adopted as part of the Kyoto Protocol are similarly seem to be some of the initiatives implemented to synergy climate change and sustainable development, in an effort to respond to mitigating global warming. Bond and Erion (2009) argued that CDM projects are used by developing countries to achieve sustainable development, as long as these projects have been approved through the value chain to meet the sustainable development criteria and emission reductions methodologies. However, Olsen (2007) is observed to critique the CDM arguing that there is uncertainty in whether the CDM is achieving its purpose and not to be contributing to sustainable development. More so, Bond and Erion (2009) further argued that carbon trade is a counterproductive climate change strategy where by international community is seen to be using carbon trading as a key response to the climate change crisis through the use and adopting of the Kyoto Protocol's Clean Development Mechanism (CDM). They have further critiqued the carbon trade market claiming that through the CDM, people, companies and states can reduce their carbon emissions through investing in carbon reduction projects implemented in poorer countries. An example of this is the carbon sink projects where trees are grown in poorer countries to absorb the greenhouse gases emitted by other developed countries through the burning of fossils. This trade is seen to be unfair given that scientists have a good indication of how much carbon is emitted from the different industries; however, there is less certainty about how much of this carbon is actually absorbed by the trees planted for this purpose.

The importance of including adaptation measures into the climate change, energy and sustainable development nexus; is argued by Golam and Bikash (2016) that, in effort to effectively adopt the nexus-based approach by adapting to impacts of climate; it is critical to integrate a nexus perspective into climate change adaptation plans. This is similarly argued by Bouhia (2018) that, the integration of the water-energy-food nexus into climate change responses is critical to achieve sustainable economic development which provides an effective approach to build natural resource resilience to climate change. Additional literature into the integration of climate change adaptation measures in a nexus approach is also perceived by Mpandeli et al. (2018) as a risk of mal-adaptation, especially if there is absence of a cross-sectoral approach. This observation is however, based on the use of the water-energy-food nexus in the Agricultural sector and not the Mining sector, with reasons that developing countries are often dependent on Agriculture, which sector is more vulnerable to climate change. On the contrary, the mining sector is also regarded as a vulnerable sector within the South Africa Development Community region and this sector should also be considered in relation with interlinks within the water-energy-food nexus (Kolk & Pinkse, 2011). Kolk and Pinkse (2011) further argue that there is need to integrate climate change and the development agendas, despite there being no guarantee that the synergies existing between climate change and development will materialize in all cases. The above studies have therefore attempted to explore the synergy existing between energy, water, food, and climate change; however, these interactions do not include the sustainability principles nor are these synergies explored within the mining sector.

Furthermore, literature as also shown that climate change and sustainable development principles can be integrated; and that climate change related interventions are a good example for linking environment and sustainable development, which aims to achieve a balance between social, the economic, and the environment (Berg, 2017; Uitto et al., 2017). Berg (2017) and Uitto et al. (2017), have argued that sustainable development can be achieved by addressing climate change impacts through the implementation of climate change adaptation measures. The integration of climate change and sustainable development principles is further argued by Liu et al. (2017), noting that climate change and sustainable development nexus is interdependent and can be strengthened though implementation of integrated models; therefore recommending the need for development and implementation of innovative methodologies and decision support tools that can address the sustainable development and climate change nexus interdependencies. The above studies have

attested to the concept of integration of climate change adaptation measures and sustainable development principles; however, their arguments are limited to the evaluation of climate change action for sustainable development.

Therefore, judging from the arguments presented in these studies, there is progress made towards understanding the nexus existing between climate change, energy, and sustainable development; however, most of these studies have presented their arguments with a different approach by focusing on the water, energy, and food nexus (England et al., 2018; Connolly-Boutin & Smit, 2016; Spear et al., 2015; Niang et al., 2014; Porter et al., 2014; Cooper et al., 2013); whilst a few other scholars have attempted to include climate change into these nexus (Mpandeli et al., 2018; Bouhia, 2018; Golam and Bikash, 2016; Kolk & Pinkse, 2011) and others further including sustainable development into the nexus (Berg, 2017; Uitto et al., 2017; Liu et al., 2017). These discussions have however, not engaged these nexus within the mining sector yet the mining sector is argued to be the most energy intensive and significantly contributes to emissions of GHGs causing climate change (Rasul & Sharma, 2016; Golam & Bikash, 2016). Therefore, there is need for this study to explore the relationship existing between sustainability principles, climate change adaptation measures and energy optimization within the mining industry.

2.6 Integration of Sustainable Development Principles and Climate Change Adaptation Measures: Conceptual Frameworks

A number of studies have supported the notion that climate change cannot be treated in isolation due to its inextricable linkages to sustainable development (Berbés-Blázquez, 2018; Rasul & Sharma, 2016; Möhr-Swart et al., 2008; Bastida, 2002). Therefore, various studies have made effort to identify conceptual frameworks involved in the integration of climate change adaptation and sustainable development (ICMM 2013; Nelson & Schuchard, 2011; ICMM, 2003; Bastida, 2002). However, some of these studies have shown that there is lack of a framework containing a set of principles that has been agreed upon by all stakeholders including the mining sector. This has therefore led to some scholars prioritizing and developing an integrated adaptation option based on a nexus assessment that reduces vulnerability to climate changes (Golam & Bikash, 2016; Kolk & Pinkse, 2012). The importance of engaging different stakeholders in the development of conceptual frameworks designed to address climate change and achieve sustainable development

is argued by Kolk and Pinkse (2012) that, the consideration of multi-stakeholder partnership is one of the approaches to integrate climate change and sustainable development; however their argument focuses on the synergies and trade-offs in the climate change and sustainable development nexus for developing countries.

A sustainable development framework for mining and metal companies to adapt to the challenges and implementation of opportunities of a changing climate was developed by the ICMM, which framework was designed to consider the incorporation of climate risks within the existing corporate strategic plans, risk management processes and engineering practices (ICMM, 2013). The ICMM (2013) noted that, this framework can be used by mining companies to identify and manage risks associated with sustainable development and general mine operations, and implement opportunities caused by climate change. In addition, Shen et al. (2015) observed that the Green Supply Chain Management (GSCM) tool was developed to assist mining companies to positively contribute to the social and economic components of sustainable development by generating employment and wealth and still improve on their ecological performance. This GSCM tool is; however, noted to only be enhanced if the mining industries focused on the appropriate implementation approach and on continuous improvement in an effort to enhance the mining company's GSCM performance (Shen et al., 2015). Therefore, in an effort to further address the weaker areas of the GSCM tool; Govindan (2015) argued that the Analytic Hierarchy Process is a solution methodology associated with the GSCM tool, which could be used by mining companies as a procedural guidance for GSCM in the implementation of a sustainable development framework. Therefore, as we appreciate these frameworks developed to assist mining companies to achieve sustainable development; it is however, observed that these frameworks did not take cognizance of the risks and opportunities existing with the integration of sustainability principles and climate change adaptation measures to enhance the mining company's adaptive capacity to the impacts of climate change and achieve sustainable energy consumption as well.

In an effort to explore the use of the multi-dimensional framework by mining companies; Fuisz-Kehrbach (2015) observed that mining companies considered three perspectives in the implementation of this framework to include the type of the corporate sustainability activity, the issues addressed, and the value chain concerned. Therefore, arguing that through the use of this multi-dimensional framework, mining companies are largely able to implement the systematic

management of environmental aspects at mining operations. Further noting that the implementation of this multi-dimensional framework will require the need for increased exchange across corporate functions as a means to address the challenges and the need to strengthen the systematic management of environmental issues, and improve sustainability of the mining companies (Fuisz-Kehrbach, 2015). The need to address environmental issues in an attempt to achieve sustainable development is also argued by Shen et al. (2015) who states that, for mining companies to effectively make contributions towards sustainable development, the mines will need to consider the adoption of measures to improve their ecological performance; which implementation of the appropriate approaches is; however, noted by Fuisz-Kehrbach (2015) to still be a challenge.

Therefore, as we appreciate the different frameworks developed for mining companies to consider for implementation in an effort to achieve sustainable mining and sustainable development; what is however, observed to be lacking and still needs to be investigated, is the integration of sustainability principles and climate change adaptation measures into these frameworks in effort to achieve sustainable mining by adapting to the impacts of climate change and achieving sustainable energy consumption. At some extend this was similarly recommended by Chicco (2010) that, there is need for integration of energy, environment, economics, risk and asset management, social issues, equity and ecology within a comprehensive framework.

2.7 Identifying the Gaps in Knowledge – New Insights

Having reviewed the arguments presented by a number of scholars at the global, regional and within the South Africa context, particularly information relating to the linkages existing between sustainable development, climate change and energy; it has been observed that at the sub-Saharan Africa level, a lot of information relating to energy, water, food and sustainable development is evident (Sylvester et al., 2018; Xiao et al., 2018; and Liu et al., 2017; Conway et al., 2015; Kolk & Pinkse, 2011). However, this information is noted to be limited in regard to the linkages existing between energy optimization, climate change adaptation and sustainable development, particularly within the mining industry (Bouhia, 2018; Uitto et al., 2017; Berg, 2017; Liu et al., 2017; Elum & Momodu, 2017; Rasul & Sharma, 2016; Golam & Bikash, 2016).

Therefore, as we appreciate the contributions made by various scholars in regard to climate change adaptation measures, sustainable development principles, and energy use optimization within the mining sector; we also acknowledge arguments supporting the notions that climate change adaptation can build climate resilient development and contribute towards achievement of SDGs (Berbés-Blázquez, 2018; Rasil & Sharma, 2016; Mogodi, 2012; Nelson & Schuchard, 2011). It is also observed that some studies have noted that information relating to implementation of climate change adaptation measures is still lacking (Wise et al., 2014), including limited research on mining and climate change impact assessments, and energy planning and implementation of adaptation measures especially within the mining sector (Nelson & Schuchard, 2011; Sustainability, 2009). In addition, a few scholars have confirmed that energy use is a driver to sustainability and energy efficiency measures are implemented as sustainable adaptive measures (Soler & Marcé, 2018; Odell et al., 2018; Schaeffer et al., 2012; Mogodi, 2012; Rábago et al., 2001); however, there is limited knowledge relating to the mining industry.

Furthermore, this study notes the contributions made by Nelson and Schuchard (2011) and in the CDP 2009 report (Sustainability, 2009), discussing the adaptation measures implemented by the mining industry; however, it is noted that the adaptation measures identified in these studies are mainly implemented with a focus to address the physical risks of climate change, rather than placing more focus on the site level social risks and opportunities that drive towards sustainable development. This therefore, affirming that information relating to the linkage and application of sustainability principles and climate change adaptation measures to achieve sustainable development at a more site level like within a mining operation is lacking. In addition, it has been observed that some studies did focus on the engagement with stakeholders as a strategy in addressing the challenges affecting the achievement of sustainable development (Möhr-Swart et al., 2008); however, this was not in relation to climate change nor energy optimization.

More so, it is observed that some scholars undertook studies to understand the relationship existing between climate change management and natural resource management, through the sustainable use of water and energy resources for effective mining but this focused on understanding the cost implications associated with this relationship (Mogodi, 2012; Rábago et al., 2001) rather than the integration of sustainable development principles in the climate change adaptation management measures in an effort to achieve sustainable energy consumption. Other studies did; however,

explore the integration of climate change impacts into the mining existing plans, policies and procedures and internal risk management policies (ICMM, 2013; ICMM, 2003) but uncertainty still exists in understanding the relation existing between climate change adaptation, energy optimization and sustainable development; which according to Epstein (2018) is a challenge specifically with the implementation of climate change adaptation measures.

In regard to information relating to the optimal use of energy as an adaptive strategy; scholars like Bazilian (2018); Mogodi (2012) and Rábago et al. (2001), provided information relating to this, with emphasis as to how mining companies can adopt optimal energy use as an adaptive strategy in an effort to save on their operational costs. Therefore, as we acknowledge that the sustainable consumption of the energy resource can be implemented as an adaptive strategy; it is however, observed that this is done in the context of saving operational cost rather than implemented as a climate change adaptation measure in an effort to enhance the mining companies adaptive capacity to the impacts of climate change. Similarly, as we appreciate the different frameworks developed for mining companies to be considered for implementation in an effort to achieve sustainable mining and sustainable development (ICMM 2017; ICMM, 2013; ICMM, 2003), it is also observed that there is still need to investigate the integration of the sustainability principles and the climate change adaptation measures into these frameworks in an effort to achieve sustainable energy consumption.

This study therefore, takes note that a number of contributions have been made by different scholars into understanding how the mining industry is adapting to the impacts of climate change and optimizing on their energy consumption in effort to reduce on their GHG emissions, including achieving sustainable mining; however, information relating to the integration of sustainability principles in to the climate change adaptation measures is still limited. Furthermore, information relating to how the mining companies have adopted these sustainability adaptation measures including structuring and embedding these sustainability adaptation measures into the company policies and strategies in effort to achieve sustainable mining is also limited. Therefore, this study is attempting to close these knowledge gaps, by providing information relating to how the gold mining operations can integrate the sustainability principles into their climate change adaptation measures in effort to enhance the mining operations' adaptive capacity and achieve sustainable energy consumption.

2.8 Conclusion

In summarizing the content presented in this chapter two; subsection (2.1) provides a brief statement of why literature review is important; noting that it provides insights of previous studies found to be either supporting or holding theories informed by concepts that are centred on sustainable development, climate change and energy optimization within the mining industry at a global level as presented in subsection (2.2), at the regional level presented in subsection (2.3) and at the local South Africa's context as presented in subsection (2.4). Subsection (2.5) presents literature relating to the synthesis of the sustainable development, climate change and energy nexus, which is also reviewed to understand the interlink associated with this nexus. A number of scholars are found to present arguments relating to the linkages existing between sustainable development, climate change and energy; however, a lot of this information relates to energy, water, food and sustainable development. Subsection (2.6) presents the conceptual frameworks found to be integrating sustainable development principles and climate change adaptation measures. However, some of these studies have shown that there is lack of a framework containing a set of principles that has been agreed upon by all stakeholders including the mining sector. Therefore, in review of this literature, this chapter further provides new insights in subsection (2.7) of which some insights can be answered through this study in an effort to address the identified gaps in knowledge. The following chapter 3, methodological considerations, therefore, presents a detailed step by step approach that was followed to link the theoretical framework to the research design and to the data analysis in an effort to answer the study research questions and achieve the research aim and objectives.

CHAPTER THREE
METHODOLOGICAL CONSIDERATIONS

3.1 Introduction

This chapter presents a discussion of the different methodological processes that were followed in the implementation of this study. As part of detailing the methodological consideration, it is important to clearly state the step by step process that was followed to link the theoretical framework to the research design and to the data analysis (Hennink et al., 2020; Alavi et al., 2018). Philosophy, values and assumptions are known to drive the rationale for a study, and the research methods provide the focus and approach the researcher undertakes to conduct a study by pinpointing the methods used to address the research questions (Almalki, 2016). It is also noted that philosophical research methods are applied to justify why and how the data is collected and analyzed to answer the research questions (Meister, 2018).

Therefore, taking cognizance of the philosophical arguments discussed in this chapter, the subsections below provide a strong methodological justification and a coherent argument that defines the methodological position and selection of the research methods applied in this study. The research design described below further promotes an interactive approach through the application of mixed research methods. This chapter is therefore structured around five subsections: The first subsection provides the philosophical approaches adopted in this study, giving emphasis on how the study views the relationship existing between knowledge to be sought and the process in which this knowledge is developed. In the second subsection, the research design is described in order to address the research problem and answer the research questions. In this subsection, the researcher provides insight on the study site, the sample population and sampling procedure, and how the research participants are identified and selected, including details on the sampling size and documentation used in this study. The third subsection in this chapter provides details of the data collection instruments used to obtain different information that can answer the research questions and provide an expanded understanding of the research problem. The data collection tools applied in this study included the use of questionnaires, conducting interviews, document reviews and site observations. Therefore, this study combined the use of all these different data collection tools, which attributed to the mixed methods approach. In addition to the described subsections above for this chapter three, the fourth subsection in this chapter

describes how the qualitative and quantitative data was reduced to numbers and coded for analysis. The fifth subsection provides a reflection on the research journey and describes some of the highlights and limitations experienced during the research and how these were enhanced and addresses respectively in order to improve on the quality of the study.

3.2 Philosophical Approach

Philosophical research is described as how a researcher sees the reality and assumptions about how knowledge is acquired and accepted, and what knowledge is and the assumptions about the reality and the assumptions revealed about the value system (Pathirage et al., 2007). These undertakings and assumptions about the nature of the world formulate a research philosophy that provides guidance to the researcher by influencing the selection of the appropriate research approaches and methods used in an inquiry into a research study (Pathirage et al., 2007).

It is also known that every knowledge is subjective to the researcher's philosophical personality and that researchers are social entities that can be influenced by their philosophical understandings which influences how the knowledge or data is done. However, for this particular study and its adaptability, the philosophy adopted is influenced by the practical considerations of the relationship existing between the knowledge and how this knowledge is developed (Saunders et al., 2015). Therefore, the philosophy assumed in this study is built on the fact that the strategy to collect the data is planned before the study, which according to Pathirage et al. (2007) is very important because the failure to think through the philosophical issues of the research can have serious effects to the quality of the research. As argued by Creswell and Poth (2016), data analysis in this study followed a path of analyzing the data to develop a detailed knowledge of the study. Therefore, a study of this nature took different philosophical research approaches that can be applied to justify why and how the data is collected and analyzed in effort to answer the research questions, identified in chapter one of this Thesis; pertaining to understanding how the gold mining companies are integrating the sustainable development principles and climate change adaptation measures in an effort to address the impacts of climate change and achieve sustainable energy consumption. In doing so, this study adopted two philosophical approaches; the interpretive approach and realism approach, which are discussed below.

(a) Interpretive Approach

For this study, the interpretive approach is adopted, which is characterized by efforts to understand the intricacy of the business world and its products, services and markets, which adds meaning to strategies, actions and events of the business (Flemming, 2010). Flemming (2010), also argues that interpretation exists in all types of scientific studies, be it quantitative or qualitative research. Therefore, the triangulation of research results is one of the key tenets identified in the interpretive quantitative approach, which involves the analysis of data obtained from multiple perspectives, hence requiring the researcher to think reflexively about the manner in which the data came into existence (Babones, 2015). So the research results derived from applying the interpretive quantitative research approach tend to be more meaningful, more understandable and more applicable as compared to results achieved through other conventional philosophical approaches (Babones, 2015).

Similarly, Gephart (2018) argues that the interpretive quantitative approach focuses on the description and understanding of the actual human interactions, meanings and processes that make up the real life organizational settlings. Gephart (2018) further argues that, by applying the interpretive qualitative approach, the researcher seeks to understand the data by making subjective interpretations, but then creates a scientific understanding from the commonsense. This understanding is based on the premise that commonsense knowledge is fundamental to knowing the world, thereby bridging commonsense and scientific concepts (Gephart, 2018). Therefore, following this philosophical understanding and assumptions relating to the nature of this study, this study thus adopted both the qualitative and quantitative interpretive approaches which required interpretation of different data by using the Concurrent Triangulation design in the analysis (Almalki, 2016; Creswell, 2009) and comparison of data results gathered from different sources including data obtained from interviews and from review of documents, so as to interpret it and make sense of it.

(b) Realism Philosophical Approach

In addition to the interpretive approach, it was decided to also adopt the philosophy of realism, because of its value that relates to scientific enquiry compared to what the senses show us as reality being regarded as the truth (Creswell & Poth, 2016; Saunders et al., 2015; Maxwell, 2012). Similarly, Sayer (1992) argued that, the world exists independently of our knowledge of it and of

our knowledge of the world is fallible and theory-laden (Maxwell, 2012). This implies that there is a reality which is quite independent of what the mind perceives as real (Creswell & Poth, 2016; Saunders et al., 2015). Therefore, realism is defined as the view that the world or entities exist independently of what the mind perceives it or as per the theories thought it to be (Maxwell, 2012; Phillips, 1987). The views of critical realist are widely accepted in the philosophy of social sciences (Maxwell, 2012) and characterized by the distinction between Ontology- what actually exists – the nature of reality; and Epistemology- how we acquire knowledge of what exists or how we can know anything (Maxwell, 2012). Maxwell (2012), also argues that critical realists in social sciences perceive the ideas and meanings held by individuals, which is their concepts, beliefs, feelings and intentions, to be equally real to the physical objects and processes. Thereby taking these two aspects of reality to be interacting with each other thus mutually influencing one another.

Therefore, this study being of a social science nature, the critical realism approach is adopted by treating the ideas and meaning provided by individuals during the interview data collection process as being real and integrating this information with the physical and processed data sourced from the secondary sources including published company documents. This approach allows for validating one form of data with the other form of data (Almeida, 2018; Creswall, 2009). More so, given that this study was being undertaken in a business entity, the realism approach was further considered as recommended by Putnam (2016) and Saunders et al. (2015), that the realism approach can be applied as a scientific approach in the development of knowledge particularly relevant for business and management research.

In summary, this study adopted the Interpretive and Realism philosophical approaches by interpreting and making sense of data gathered from different sources including data obtained from interviewing targeted research participants and treating the ideas and meanings provided by the research participants as being equally real to the data obtained from other secondary sources including published company documents, during the study.

3.3 Research Design

Research design is regarded as a significant component in research methodology, therefore, it is imperative that a researcher must weigh many factors when designing a research plan in order to plan logically and address the research problems and answer the research questions (Salkind,

2010). A research design comprises of the study site, sample population and sampling procedure, and the data collection methods used in the study (Vogt et al., 2012). According to Creswell (2003), a researcher is able to understand and achieve the aim and objectives of the study when the right research approach has been selected.

This study was centered on gold mining, carefully selecting gold mining operations as case study based on their location, the physical settling and other institutional and political factors surrounding the mining site areas (Hyett et al., 2014). By applying the case study approach, information was gathered from multiple sources of knowledge including reviewing company documents, using multiple and in-depth data collection techniques and analysis methods (Williams, 2007) in order to investigate the different ways in which the gold mining operations are integrating the sustainable development principles into their climate change adaptation measures; and how these sustainability principles and adaptation measures are structured and embedded in the mining company policies and strategies in effort to build the gold mining operations' adaptive capacity and resilience against climate change impacts and achieve sustainable energy consumption.

3.3.1 Description of the Research Site

This study on which this thesis is based, was conducted at gold mining operations located along the Witwatersrand Basin in South Africa. Over the years, gold mining in South Africa is reported to be done on the Witwatersrand Basin, stretching across 250 miles, from Johannesburg to Welkom, containing gold-bearing reefs along the margins of the northern and western parts (Tucker et al., 2016). Gold mining in this basin is reported to have caused the creation of cities and mining towns, having a major influence in shaping South Africa's economy (Tucker et al., 2016). There are a number of gold mining operations located within the Witwatersrand Basin; however, this study was conducted at a few of these gold mining operations as case study. These gold mining operations are not disclosed given the desire to remain anonymous. As such, this study has not named these gold mining operations and will just refer them to "the gold mining operations;" including reference to individual respondents from all the gold mines is coded to preserve anonymity. Refer to Figure 3.1 below showing the location of the Witwatersrand Basin located northeastern part of South Africa.



Figure 3. 1: Location of the Witwatersrand Basin in South Africa
(Source: Cartographic Unit, 2022. University of the Witwatersrand, Johannesburg. South Africa)

Although, the mining industry can make significant contributions to the GDP of the country; it is however, observed that mining activities increases the vulnerability of the communities in which the mines operate and increase their vulnerability to the impacts of climate change such as temperature increases and water shortages (PAGE, 2016; Peschka, 2014). According to Connolly-Boutin and Smit (2016), South Africa is seen to experience the strongest decrease in precipitation with concurrent risks of drought within the region. These climate variabilities within the region is exacerbating the challenges for energy resources that is increasingly exploited due to increased demand for reliable and affordable energy supplies coupled with the lack of infrastructure and facilities to use energy productively and efficiently and yet in turn pollute the environment (Connolly-Boutin & Smit, 2016).

The Witwatersrand region experiences a subtropical highland climate, characterized by hot summer days with regular afternoon showers, dry and sunny winter days with cold nights; refer to Figure 3.2 below showing the climate zones of South Africa with the subtropical highland climate (Cwb) identified for the Witwatersrand region. The natural vegetation occurring within the basin falls within the Savanna Biome and the grassland Biome (Dye & Weiersbye, 2010). The grassland vegetation has got animal species to include the Straw-colored fruit bats, rodents, and the Botha's lark and the Blue crane birds, including snakes and other reptiles (Dye & Weiersbye, 2010).

However, literature has shown that the years of mining in Witwatersrand have affected its ecosystems, particularly affecting the environment and community in which the mine operates (PAGE, 2016; Peschka, 2014; Kogel et al., 2014; Dye & Weiersbye, 2010). The pressures from mining operations on the natural environment have increased significantly over the years, due to abandonment of mines amidst the global economic crisis, and due to implementation of environmentally irresponsible business practices (IFC, 2014; Nelson & Schuchard, 2011), which has therefore required mining companies to consider mining sustainably especially for the mining activities located in environmentally sensitive regions (Kogel et al., 2014).

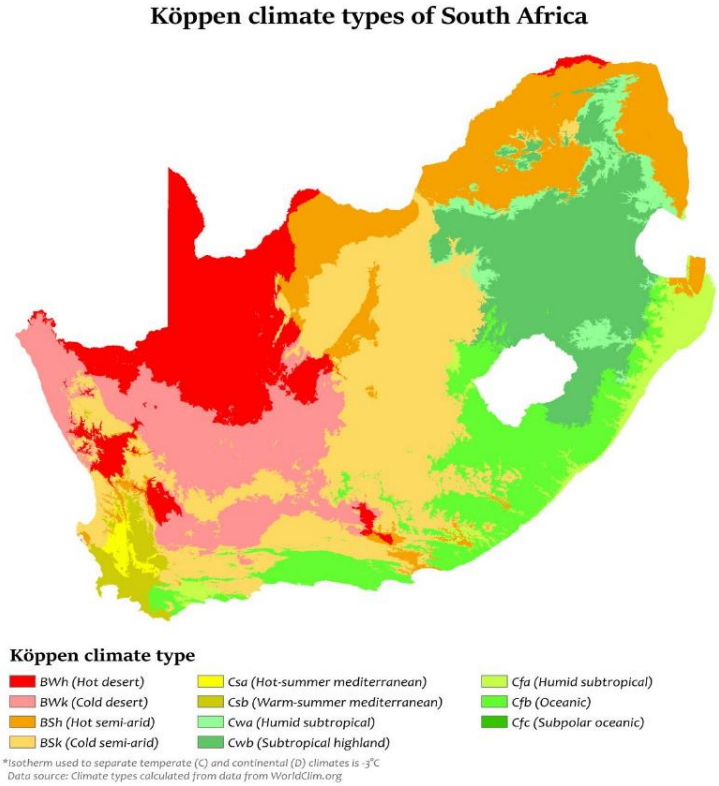


Figure 3. 2: Subtropical highland climate (Cwb) for the Witwatersrand region in South Africa

((Source: Climate types calculated data from WorldClim.org; as cited from SouthAfricaMap360[0] (https://southafricamap360.com/south-africa-geography-map))

Given the above literature, that South Africa is a mining-intense country and is affected by extreme climate change events which has increased the country's vulnerability to climate change impacts and reducing the chances of achieving sustainable development, this study therefore found that the gold mining operations located along the Witwatersrand gold belt region is a suitable study area

to investigate how sustainable development principles are integrated into the climate change adaptation measures in an effort to enhance the gold mining operations' adaptive capacity to the impacts of climate change and achieve sustainable energy consumption. This study site is also considered most appropriate given that, the outcomes from this study, can portray how the gold mining companies can make significant contributions towards the progress in achieving sustainable development, and in particular achieving SDG7 and SDG13, in the mining sector of South Africa.

3.3.2 Study Population and Sampling Procedure

Prior to collection of data, this study adopted the sampling process steps as presented in Figure 3.3 below. Research participants working in the fields of climate change, energy and sustainable development departments at the gold mining operations were identified as the target study population by applying different sampling techniques. According to Taherdoost (2016) sampling is taking a subset from an entire population and use this sample population to make inference about the entire population or make a generation relating to an existing theory. This study therefore, gathered research information from the identified sampled research participants through administering research questionnaires and from conducting research interviews. The subsections below provide the different methods used in the identification and selection of the sample population and existing company documentation.

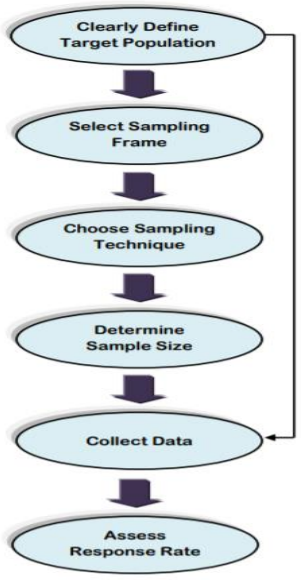


Figure 3. 3: Sampling Process Steps
(Source: Taherdoost, 2016)

3.3.3 Identifying and Selection of Research Participants

This study only targeted employees working in the fields relating to climate change, sustainable development and energy at some of the gold mining operations located within the Witwatersrand Basin of South Africa. Therefore, in order to single out the targeted employees working in the fields of climate change, sustainable development and energy; the researcher started by applying the Non-Probability Sampling strategy. This is associated with case study research designs and qualitative research as done with this study. Case studies focus on small samples which are not designed to make statistical inferences in relation to the wider population (Taherdoost, 2016). The rational to only include participants selected from the identified mining disciplines that is climate change, sustainable development and energy, is because these participants were in position to provide information relevant for this study as per the study themes. This sampling technique is used to provide important information that is likely not to be obtained from applying other choices (Taherdoost, 2016; Creswell, 2009).

By applying this sampling technique, the researcher believed that the participants selected would be relevant for inclusion. Therefore, as per the Non-Probability sampling strategy, the Purposive or judgmental sampling technique was then adopted in this study to deliberately select the relevant mining company departments within which the targeted disciplines fall under. These mining departments included the Environmental department, Sustainable development department and Energy and Engineering departments. Taherdoost (2016) argued that this sampling technique is advantaged because of its cost effectiveness, convenience, less time consuming and quite ideal for an exploratory research design; however, this technique does not allow for generation and can be subjective.

The Quota Sampling technique was then applied to identify and select employees working within these identified mining departments; so as to participate in the study. Taherdoost (2016) defines Quota sampling as a non-random sampling technique where participants are identified by their predetermined characteristics. Therefore, the targeted employees were identified from the selected mining departments to participate in this study, given their roles and responsibilities in relation to the study themes that is climate change, sustainable development and energy. Taherdoost (2016) argued that this sampling technique is advantageous because the samples can be controlled for certain characteristics; however, it does create biases with no assurance.

The Snow ball (Chain) sampling technique was also applied based on the principle that people know people within the same interest group (Creswell, 2009). This approach is applicable for small sample populations, and is defined as a non-random sampling method that uses a few cases to assist in encouraging other cases to participate in the study, thereby increasing the sample size (Taherdoost, 2016). Therefore, by using the snow ball-chain sampling technique, additional research participants were further identified by the targeted specialized research participants who during the interview and in response to the interview questions were requested to recommend other participants given that their roles and responsibilities were involved in the study theme, of either climate change, energy, or sustainable development; and were known to be working at the gold mining operations. It is argued that this sampling technique is advantaged because it can be used to estimate rare characteristics; however it is noted to be time consuming (Taherdoost, 2016).

3.3.4 Sample Size Determination

According to Taherdoost (2016) and Singh and Masuku (2014), the sample size of a population is an essential factor of any scientific research which reflects the number of obtained responses. Similarly, Singh and Masuku (2014) argued that, it is important to carefully fix the sample size so that it can adequately draw valid and indiscriminate conclusions. They further argued that a very small sample size can lead to failure in detecting important effects or associates, and similarly a very large sample size can be quite complex and is likely to lead to inaccuracy in the research results (Singh & Masuku, 2014). Based on this literature and the fact that this study focused on targeted specialized research participants who were identified through the non-probability sampling technique as discussed in the above subsection 3.3.3; the targeted specialized sampling size was thus limited to a small population. The targeted research participants were thus identified with the assumption that based on their job titles and associated mining departments, they were knowledgeable and had experience in the areas of either climate change, energy management, or sustainable development. Their titles and roles and responsibilities at the gold mining operations was also confirmed during the interview process and in response to the interview questions.

Furthermore, Singh and Masuku (2014) also argue that, if the sample population is limited to a small size i.e. 200 or less, then the Census for small populations approach should be adopted to determine the sample size for the study. Therefore, taking this into consideration, this study

adopted the Census for Small Populations approach and sampled the entire targeted specialized research participants. The advantage of using a Census approach is that the sampling error is eliminated (Singh & Masuku, 2014). However, in reality not all the sampled targeted research participants were able to participate in the research for different reasons to include but not limited to the refusal to respond, not in the position to respond, incapacity to respond, or in some cases where the research participants and the researcher were not in the position to meet (Taherdoost, 2016). Given these inevitable limitations, this study therefore aimed at obtaining responses from at least 30 participants, which number is regarded as an ideal number of research participants to be involved in order to develop a well saturated theory (Creswell et al., 2007). In effort to reach the sampled number of at least 30 participants, this study further applied the Snow ball (Chain) sampling technique were the research participant were given the opportunity to further recommend other relevant participants known to be involved within the same targeted mining discipline of interest (Creswell et al., 2007).

3.3.5 Existing Documents and Data

Relevant documentation for this study was identified from the interview process, and responses provided in the questionnaire and from observations done during the site visits. A rapid appraisal process was applied to the identified documents and a specific list of documents was selected to provide information and data relevant for the study. Below is the list of documents identified during the interview and questionnaire process:

a) Environmental policy, which contained information relating to how the gold mining company is to address its environmental impacts and enhance its environmental performance; which information was relevant for answering research question two pertaining to understanding how the gold mining operations are incorporating the sustainable development principles.

b) Energy efficiency and climate change policy and strategy, which contained information relating to how the gold mining company will take action to reduce its carbon footprint by improving its energy efficiency. This information was relevant for answering research question two pertaining to understanding how the gold mining company is implementing its climate change adaptation measures to address the impacts of climate change and achieve energy optimization.

c) Mining operation's strategic business plans and reports, provided information relating to the mining operational performance on key aspects of operational excellence, to include environmental and social management. Performances are reported for energy consumption and GHG emissions, which information is relevant for answering research questions one, two and three, pertaining to effects of climate change on energy use at the mining operations, and how the mining operations have addressed the impacts of climate change and in particular optimizing on their energy consumption in effort to reduce their carbon footprint.

d) Global Reporting Index (GRI) scorecard reports, these scorecards provided information pertaining to the sustainable consumption of resources including energy. This information was relevant for answering research question one and two, pertaining to energy consumption at the gold mining operations.

e) Integrated Annual and Sustainability (Environmental, Social and Governance) reports. These documents provided information relating to identified risks and opportunities and management measures implemented to manage these risks and reduce environmental exposure. This information was relevant for answering research questions one, two and three; in order to understand risks presented by a changing climate especially towards energy consumption and the opportunities identified in addressing these risks.

3.3.6 Mixed Methods Approach

A mixed methods research approach is the use of different procedures or processes to collect and analyze both quantitative data and qualitative data in the framework of a study (Driscoll et al., 2007). Driscoll et al. (2007) argue that by using this mixed methods approach, the weakness of one approach is offset by the other approach and that the concurrent mixing of data collection methods allows for validating one form of data with the other form of data so as to transform that data for comparison or to address different types of questions (Almeida, 2018; Creswell, 2009). Almalki (2016) argues that different types of mixed methodologies can be used to evaluate the data such as using different methods of data collection, conducting different forms of interviews, and sourcing data at different times, locations, and contexts (Almeida, 2018). This study therefore, employed the concurrent mixed method approach to collect and integrate the two databases (qualitative and quantitative data) by merging the quantitative data with the qualitative data. By

use of the Quasi-structured questionnaires, the research participants provided both qualitative and quantitative data.

The Quasi-structured questionnaire allowed for the concurrent collection of both structured and unstructured data, where by each study theme was set into specific structured questions in the questionnaires and some questions formatted as open-ended and with an unlimited comment field as "other"- "please specify", which was clearly linked to the question asked immediately above it. The advantage of using this approach is that the data was easily compared and the researcher was able to get more information or clarity from the respondents especially if some responses were quite confusing (Driscoll et al., 2007). The qualitative data was the primary data in this study, therefore provided supportive information to the quantitative data sourced as secondary data (Almeida, 2018; Creswell, 2009).

3.4 Data Collection Instrumentations

Relevant data were collected using the identified philosophical research methods which provided the information needed to answer the research questions in this study. Given that this study is of an interdisciplinary nature and is a case study, a mixed methods approach was employed to include both the qualitative and quantitative data, obtained to provide an expanded understanding of the research problem (Creswell & Poth, 2016; Almalki, 2016; Creswell, 2009). Data were collected through a combination of processes to include examining documents, interviewing participants and from site observations during the field visits. Data from the interview process was organized based on the research questions (Patterson & Williams, 2002), and the company documentation identified during the interview process and site observations was subjected through a document appraisal process in terms of the study theme content, so as to provide a theoretical platform used to complement the data obtained from the responses obtained during the interview process (Cardno, 2018). The subsections below provide a detailed description of the tools used to collect data in this study.

3.4.1 Questionnaires

i. Designing Research Questionnaires

The use of questionnaires was the primary methods of data collection in this study. Questionnaires are a form of data collection tool used to gather information from people, usually by posing direct

or indirect questions (Gillham, 2008). The advantage of using questionnaires, is that the primary qualitative data reduces biasness by validating the quantitative data obtained from other sources of data collection. However, Gillham (2008) argues that, the disadvantage of questionnaires is that they are used to get answers by just asking questions. This is noted in administering Structured Questionnaires where the researcher determines the questions that are asked and the range of answers that can be given. The disadvantage with this is that the researcher has already decided on the possible answers thus reducing on the element of discovery. To minimize on this risk in this study, the researcher constructed both comprehensive well-structured and non-structured questionnaires that allowed for the respondents to provide additional information that was not necessarily listed in the structured questions.

The mixing of both structured and non-structured questions formed the Quasi-Structured questionnaire which is a recommended tool for data collection mostly used in Social Science research (Acharya, 2010). The Structured questionnaires provided quantitative data with the advantage of having less discrepancies, consistent, easy to administer, and easy to manage the data. On the other hand, the Unstructured (open ended) questionnaires do require the researcher to elaborate the sense of the question (Acharya, 2010). Questions in the questionnaire were divided into two categories; the "Background view" and the "Technical information". The technical information was further subdivided into sections under the different research themes. The researcher constructed the questions to be clear, simple, specific and relevant to the study themes (Lietz, 2010). The qualitative data collected from the open-ended interview questions was then quantified to create a single comprehensive dataset. This involved the counting of the number of times a qualitative code occurred (Driscoll et al., 2007). The questionnaires designed by the researcher are presented in Annexure 2.

ii. Questionnaire Administration

Structured and non-structured (open ended) questionnaires were self-administered by the researcher to the participants. The Quasi-Structured questionnaires (combined structured and non-structured questions) were presented to participants in order to gather additional information by providing the participants with an alternative of options "others" (please specify) (Acharya, 2010). It was however, noted that not all the questionnaires were returned despite that Phillip et al., (2002)

recommends a questionnaire return rate of 98%, which is noted to be time consuming and costly. To offset the reduced questionnaire, return rate, the questionnaire constructed in this study added an additional question that asked the respondent that *"Who should I talk to in order to learn more?"* (Creswell, 2009). Responses to this question, provided lists of additional research participants that were then also presented with the same questionnaires. This increased the number of sampled respondents that participated in this study to 30 participants and with the questionnaire return rate to 100%.

3.4.2 Interviews

Creswell et al. (2007) argues that interviews play a central role in the data collection especially for a grounded theory study. Interviews also offer a more controlled environment for researchers looking for specific information; and can be used to gather factual information (Wei & Moyer, 2008). This study therefore applied the Interview process to gather additional information; however, prior to conducting the interviews, ethical clearance was obtained from the ethics committee at the University, only after presenting the drafted structured and unstructured questionnaires proposed to be completed by the research participants (Clifford et al., 2016). On receipt of the ethical clearance, the research sought for a quiet and convenient place opted for interviewing the participants and consent was obtained from the interviewee to participate in the study (Creswell, 2009).

This study also employed the unstructured interview format where by the researcher conducted interview sessions with the respondents through telephonic interviews, face to face interviews, and through email correspondences. However, the drawback associated with the one-on-one interview process is that some participants were less articulate and provided less data, which was offset by the use of written questionnaires as part of the structured interview process. The telephone interviews were used only when the researcher had no direct access to the research participant. The limitation associated with the telephonic interviews is that the researcher didn't see the informal communication expressed by the participant. The research participants involved in the interview process where employees working at the gold mining operations, and were purposefully identified and systematically selected and others also identified through a chain (snow ball) process; all participants predetermined according to their roles and responsibilities in relation to the study themes. The list of participants was obtained from the gold mining company contacts

list. This was done in order to verify their roles and responsibilities relating to the research themes of the study; however, the level of qualifications, knowledge and experience in the respective disciplines was not basis for the participant selection process. The nature of information obtained from the interview process was dependent on the format of the interview questions whether the questions were open-ended (qualitative) or closed-ended (quantitative).

3.4.3 Documentary Review/ Rapid Appraisal

A Rapid Appraisal is a qualitative research method of a document review used for developing a preliminary qualitative understanding of a situation (Beebe, 1995). Therefore, this study employed a rapid appraisal approach subjected to existing documentation, which documents were identified during the questionnaire and interview processes, and from the insights observed during the site visits. This study only focused on documentation received from the gold mining company identified to be published and available to the public via different platforms and compiled within the period of the last 5 years (2016-2021). A document review of the documentation was done in three steps to systematically eliminate and select information relevant to the study context. The first step was the inception of the report; followed by conducting a situational analysis and establishment of the status quo; and then literature review (Cardno, 2018). A list of specific questions was developed, formulated from the document review so as to provide a theoretical platform used as a guide in terms of the content (Cardno, 2018). This study was advantaged in that the requested documents were easily available.

The information obtained from the document review process was used to complement the information obtained from the responses gathered during the questionnaire and interview processes and from the field observations (Cardno, 2018). Permission was sought from the relevant document controllers; however, authentication of the currency and accuracy of the information in the documents was not done, as this study assumed that, given the publication of these company documents deems it to be accurate. In further eliminating the uncertainty relating to currency of the document, and to verify whether the documents being reviewed were the up-to-date versions; the researcher engaged with the relevant company employees working with these documents, to gather confirmation. More so, this study opted to work with only company published information especially found on the company website.

3.4.4 Site Observations

Observational protocols were designed and adopted in this study. The researcher developed field checklists that were compiled using the information obtained from the questionnaire and interview processes and from the document reviews. The field checklist simply provided a ground truthing, so as to manually capture data relevant to the themes identified from the interview process. Field notes were taken using the checklist as a method for recording the field observations. By using this method, descriptive and reflective information was observed in relation to the themes of the study. This was however, based on the knowledge and experience of the researcher about the study themes and what to expect or look for in the field. Prior to conducting the field observations, the researcher was introduced to the sites, and permission to access the sites was granted. The researcher visited the different gold mining operations and information from these site visits was manually recorded onsite on to the field observation checklists. The researcher then used this information gathered from the field observations and compared it with the information obtained from the questionnaire and interview processes and from the document review.

3.5 Data Management

In an effort to integrate, process and validate the different types of data collected through the mixed methods approach; a concurrent triangulation technique was adopted.

3.5.1 Concurrent Triangulation Technique

Due to the fact that this study drew on multiple sources of data and employed different methods-mixed method approach, the concurrent triangulation technique was therefore applied in this study in order to compare the two datasets (quantitative and qualitative data) so as to determine their convergence, difference or combination thereof. The advantage of using the Triangulation design is that; different but complementary data can be collected on the same topic (Almalki, 2016). The other advantage of using this approach is that, if there is an inherent weakness in one method, the strength of the other method is used to offset the other method's weakness, and the strength of one adds to the strength of the other method (Almeida, 2018; Creswell, 2009). This has however, been argued by Almalki (2016) to be time consuming, especially when a researcher collects both quantitative and qualitative data. This study did offset the time consuming constraint by adopting the concurrent approach where both qualitative and quantitative data were collected at the same

time during the same interviews, conducting the Quasi-structured questionnaires and from the field site visits. The other constraint observed by Creswell (2009) is that the researcher may prioritize one method over the other. This was also offset in this study where the researcher merged both sets of the databases by using the Concurrent Triangulation design in the analysis, comparison of data results and interpretation as shown in figure 3.4 below (Almalki, 2016; Creswell, 2009).

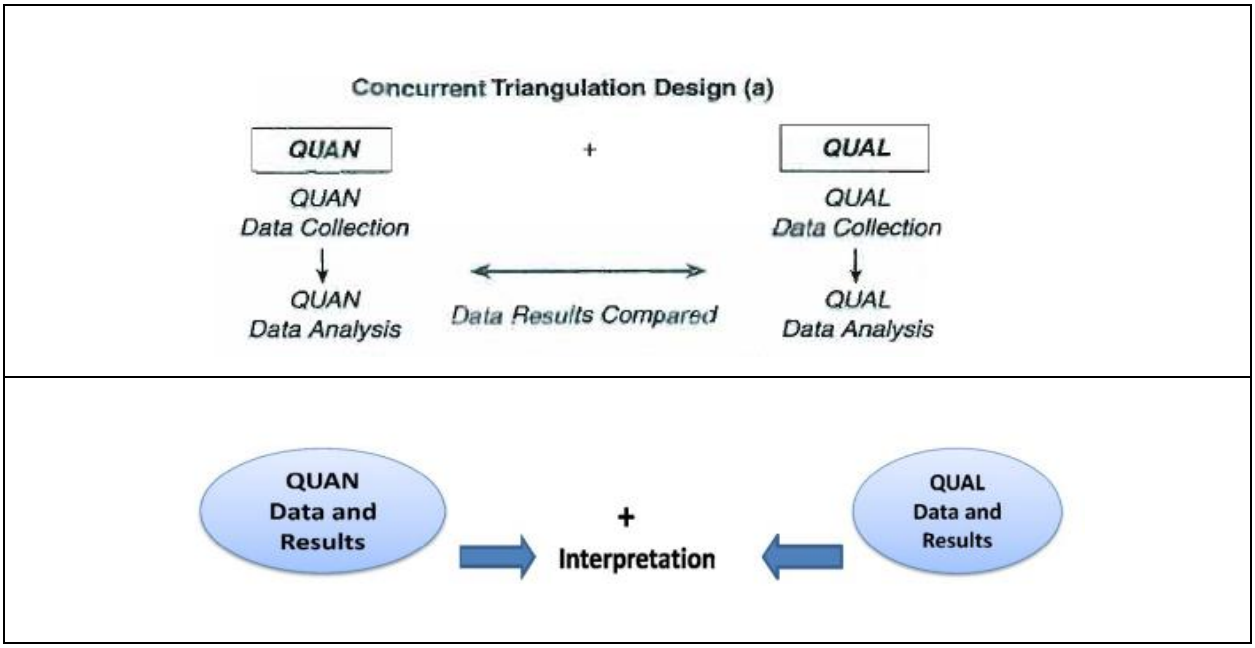


Figure 3. 5: **Concurrent Triangulation Design**
(Source: Almalki, 2016; Creswell, 2009)

3.6 Data Analysis

Primary and secondary data were obtained from different data sources as described above, and was presented in the form of qualitative and quantitative datasets. Both the qualitative and quantitative information was then reduced to numbers and codes for analysis. The qualitative data as described above were enumerated for the frequency of themes, and percentage or numbers of the respondents who selected specific themes. The quantified data was used to support the quantitative data collected separately. The data was then presented on excel spread sheets to be assessed and evaluated (Driscoll et al., 2007). It is however, noted to be a complex and time consuming exercise when analyzing, coding and integrating unstructured data with structured data, which may result into reducing the sample size or even reduce the time spent on conducting interviews (Driscoll et al., 2007). This study therefore, reduced this risk by keeping to the planned sampling protocols of the study. The subsections below therefore provides the data analytical tools applied in this study.

3.6.1 Qualitative Data Analysis

i. Policy Content and Inductive Data Analysis

Using the Policy Content Analysis, the company's policies were gathered and examined against the three Perspectives-Policy purpose analysis; Policy Construction analysis; Practice implementation and impact (Cardno, 2018). According to Cardno (2018), it is important to analyze the content of organizational policy documents to establish not only what is said but also what is not said. The Inductive data analysis was applied to review all the data including information provided during the interview process, by organizing the data into categories and themes associated with the study and arranged the data in a bottom up format according to the increasing level of abstractness in the policy information (Creswell, 2009). According to Thomas (2006) Inductive analysis is defined as the approach that uses detailed readings of raw data to derive concepts and themes. Raw text data were condensed into summarized format and coded to extract categories and themes in relation to the study themes (Hsieh & Shannon, 2005). The summarized findings derived from the raw data were linked with the research objectives in an effort to develop a theory about the fundamental structure of experiences and processes that are evident in the data found in the text of the documents.

ii. Content and Document Analysis

Content and document analysis is a widely used as a qualitative research technique, to analyze information obtained from the document review and content of the verbal material noted during the interview processes (Bowen, 2009; Hsieh & Shannon, 2005). A document content analysis was applied to analyze the words, language, and text in the company documents (Bowen, 2009) this allowed the researcher to uncover meaning from the content and develop an understanding and discover insights that were relevant to the study themes (Bowen, 2009). According to Cardno (2018) a researcher needs to consider what may be lying in, beneath and around the text in terms of the themes that can be conveyed by or inferred from the words in the text. Cardno (2018) further argues that a content analyst is able to clearly distinguish between what is described in the content and what is being inferred from the content. This study therefore, adopted the guiding framework of questions recommended by Cardno (2018), to be used in the document analysis. This is due to the fact that there is no simple guideline for data analysis (Cardno, 2018). By using this approach, this study drew inferences from the content by recognizing and recording the "presence" or

"absence" of certain words or phrases in relation to the themes of study; and to examine trends and patterns in the documents (Stemler & Bebell, 1999). The qualitative data collected from the document review was thus quantified by recording the frequency and presenting it in percentages of the number of times the "presence" or "absence" of each code, which was then further presented into dichotomous variables of 1 and 0, respectively. The advantage of coding is that the codes can be revisited during analysis to allow for the acknowledgement of developing themes and insights (Driscoll et al., 2007).

3.6.2 Quantitative Data Analysis

Data obtained from the content and inductive analysis were organized and grouped into themes and categories and quantified to support the quantitative data collected separately, which was then further analyzed by using the descriptive statistical data analysis to determine the frequency distribution of the themes presented in either numbers or percentages (Manikandan, 2011). This data was analyzed by use of Microsoft excel spreadsheet. In using this software to analyze the quantitative data; statistical summaries of the data were presented in different formats for example in tables and graphs so as to get a true feel of the research findings (Williams, 2007; Thomas & Brubaker, 2007).

3.7 Methodological Reflections

This study reflects on the research journey that was followed due to the application of the methodologies outlined above. A number of special events occurred which had both a positive and negative influence on the study. At the time when the research data was being collected which was between 2020 and 2021, the world was being affected by the coronavirus, SARS-CoV-2 (Covid-19) pandemic which was reported to have emerged in December 2019 and the first positive case reported in South Africa on the 5 March 2020 (Giandhari et al., 2020). Given the increase in the Covid-19 positive cases and the number of deaths at the time, the South African government then declared a national state of disaster on the 15 March 2020, and subsequently enforced a national lockdown on the 27 March 2020 (Giandhari et al., 2020). This was around the same period when the research questionnaires were being distributed to the first few identified research participants. The immediate lockdown of the country nationwide was effected on the midnight of the 26 March 2020, placing the country at the Alert level 5 which is the highest level of lockdown. This meant

that only essential services sector of the country were permitted to operate. Transport and movement restrictions were imposed, which meant that there was no longer physical approach to the research participants or the study sites as initially planned in the data collection technique. The mining sector in South Africa was amongst the business sectors that were restricted and had to effect the hard lock down rules. This meant that the majority of the mining employees had to stay away from work with others working from home.

Given that the research participants were mining employees, I therefore had to reinitiate contacting the identified research participants through phone calls and request for their permission to either have telephonic interviews with them and later email to them the participant consent form for their approval or rather email to them the research questionnaire and consent form formatted in a word editable version for them to complete electronically and email back completed copies. These changes to the initial planned data collection process had both negative and positive effects on the study. There was an opportunity of saving costs and time which would have been spent on travelling to physically meet some research participants. However, on the downside, this caused further delays in the time allocated for collecting research data because some respondents didn't have sustained access to their emails, and other participants did not see the urgency in responding to the research questionnaires. This required me to exercise patience with the research participants and rather took the approach to politely remind them on a regular basis, for them to find time and complete the research questionnaires or spend time for a telephonic interview session.

In addition, I being a full time employee, also had its own limitations towards balancing work and study time. Most of the time, the amount of workload was quite high which meant that limited time would be availed for study purposes. At the time of undertaking this research work, I was at the level of middle management position, which even exacerbated this limitation given the fact that a lot of man-time is required from individuals at middle management level. Persons at middle management positions are found to be at the center points of the organizations' organogram, which means that this person is required to support both the ground frontline teams and the senior managers. This challenge was however, addressed by taking some time off from work for study purposes and sacrificing some of the weekends and public holidays for study purposes.

Further reflecting into how this study was undertaken, I found that it was quite an interesting experience being a female researcher conducting research in a male dominated mining industry as

described by some scholars (Botha & Cronjé, 2015; Martin & Barnard, 2013; Zungu, 2012; Ranchod, 2001). A number of times, some research participants posed challenging and yet interesting questions during the interview sessions, that seemed to undermine the research study or even proposing different study themes that were thought to be perhaps easier and less challenging compared to the study themes presented at the time in the research interview questions. I took these interesting questions as an opportunity to think broadly and prepare myself better for the next research interviews. This positively encouraged me to further cultivate confidence in myself and in some instances take an assertive approach and keep the interview discussions focused around the identified study themes as stipulated in the research questionnaire. This was done in a diplomatic way in effort to not discourage the participant from conveying their thoughts and not lose their very interesting responses and suggestions received around the study themes.

Additional emphasis is also given to the techniques, problems and potentialities experienced during the data collection process. Whilst collecting primary data through interviewing of the research participants, it was found that the process was quite informative given the knowledge and expertise that was displayed by some of the research participants. This was not expected and it enriched the study information. However, despite some research participants being flexible and had the desire to participate in the study, there were some participants that did not have the time nor the desire to contribute in the research study. This, therefore, required the need to modify and change the research interview questions so as to reflect the responses received from the other research participants and thus create options of responses, thereby reducing and shortening the questions being asked. The advantage of modifying the research tools, allowed more participants to take part in the research; however, the shortfall to this approach created a limit to the scope of responses to be received, which was offset by asking the research participant of " any other comments" in addition to the list of options provided in the interview questions. The data collection process during the field observations was not challenging, given the fact that the field sites were quite accessible, which sites were visited once the Covid-19 alert levels were lowered with adjusted restrictions allowing people to be phased back to work. However, there was need to make prior arrangements with the site research participants and agree to be subjected to Covid-19 screening protocols and to adhere to the health and safety precautions of the areas visited, which was done with ease.

Further to this research journey, it was also found that the company data gathered as secondary research data was protected due to confidentiality of company information. This company data regarded as secondary data in this study, was very useful to complement the primary data obtained from the responses received during the interview process and from administration of the research questionnaires including data obtained from the field observations. Given the fact that this company data was confidential, this required to sign a Non-Disclosure Agreement (NDA). Therefore, this study only utilized company documents made available to the public and are published on the company website. In addition, as part of the University research ethics, I honored the commitments stipulated in the NDA and only used the company information for the intended research study and kept the company documents confidential.

3.8 Conclusion

The methodological approach followed in this study aimed at linking the theoretical framework to the study research design and to the data analysis; and with a focus to address the problem being studied and answering the research questions posed in an effort to address the research problem. Subsection (3.2) presented the different philosophical approaches to include the interpretive and realism approaches that were adopted in this study. This was influenced by the practical considerations of the relationship existing between the knowledge and the process in which the knowledge was being developed. The research design is presented in subsection (3.3) detailing a case study approach that was also adopted given the fact that this study was centered on the gold mining. Therefore, some gold mining operations located within the Witwatersrand Basin were used as case study. Subsection (3.4) further describes the non-probability sampling approach that was adopted to include the use of purposive, quota and snow ball sampling techniques, in which specialized research participants were identified. The identified research participants were interviewed by use of structured and non- structured questionnaires and the combination of these (Quasi-structure questionnaires) research tools. Additional research data was sourced from existing company documentation which was identified from the site observations and through the interview processes. A rapid appraisal was subjected to these identified documents so as to select the documentation relevant to the study themes. This study therefore adopted an interactive approach through the application of mixed research methods in order to integrate the quantitative data and qualitative data. Subsection (3.5) further detailed how the two data sets were managed by

organizing and processing the data through the use of the concurrent triangulation technique. Both the qualitative and quantitative data were reduced into numbers and analyzed using different analytical tools to include policy, content and inductive data analysis and descriptive statistical data analysis as detailed in subsection (3.6). A reflection of the research journey experienced by the researcher whilst undertaking this study has also been presented in subsection (3.7) noting that despite the limitations encountered during this study especially during the Covid-19 pandemic, the research was successfully completed. Therefore, the following chapter four will then present the empirical evidence as findings deduced from the data analysis process; used to either prove or disprove the research theories and gather better understanding of the theories being studied.

CHAPTER FOUR
EMPIRICAL EVIDENCE

4.1 Introduction

Empirical evidence is information that comes from the research data, which data was collected and analyzed from designed research methods to ensure accuracy, quality and integrity of this data. For any research process it is imperative that we present the empirical evidence where certain assumptions of the study are drawn from. Presenting empirical evidence is regarded as an important step in research because the information presented as empirical evidence leads to either proving or disproving the research theories and better the understanding of the theories being studied. This chapter is therefore, dedicated to presenting the research findings from the data collection process described in the preceding chapter. This chapter is based on the four research questions articulated in chapter one, and the critical points are drawn out.

Therefore, the findings from the data collection are structured around the four research questions. The first subsection (4.1) is this Introduction, followed by the second subsection (4.2) which explores how climate change is affecting energy consumption in gold mining. The third subsection (4.3), explores the ways in which the gold mining operations have incorporated sustainable development principles to their climate change adaptation measures, in an effort to address the impacts of climate change and achieve energy optimization; the fourth subsection (4.4) presents some of the challenges that have the potential to prevent the gold mining operations from integrating sustainable development principles and climate change adaptation measures, and their implementation thereof; and the fifth subsection (4.5) presents the proposed actions identified as measures to address the potential challenges, in an effort to enhance the gold mining operations' adaptive capacity to the impacts of climate change and achieve energy optimization. The last subsection (4.6) in this chapter is the conclusions drawn from the empirical findings.

4.2 Effects of Climate change on Energy use in Gold Mining

One of the thematic focus of this study was to investigate and establish the effects of climate change on energy use in gold mining. It is important that such a link is established so that we understand the link between energy use and climate change. In view of this, a number of important discussions were conducted with gold mining experts in an effort to further understand what is

presented in the different literature and what is experienced by the gold mining operations. It was then necessary to firstly understand whether the gold mining operations were affected by climate change. In doing so, the research participants were requested to answer questions relating to how climate change has affected the gold mining activities; and what the gold mining operations are doing to address the impacts of climate change.

In view of the responses received, these are illustrated in Figure 4.1 below. After a close scrutiny of Figure 4.1, this study seems to indicate that climate change is impacting on the gold mining operations. According to the research participants, mining production (19%) is most affected by climate change in the sense that climate change affects the availability of resources required to boost the gold mine's productivity. The participants did claim that the impacts of climate change have caused a reduction in mine productivity due to operational stoppages or down time caused by flooding or heat waves, which leads to reduced mine revenue due to no production. The effect of climate change on mining productivity was further explained by one of the key participants working very closely with the engineering department pointing out that *"Ineffective operation of cooling equipment can also affect production if suitable conditions are not maintained underground – the resulting financial loss of such an occurrence can be devastating owing to the expensive nature of underground mining in South Africa"* (Pers. com, 2020a). Similar to this argument, 12% of the participants also thought that climate change can affect the gold mine's operational costs which similarly affects mine productivity. The views that climate change has affected the gold mining operations was; however, disputed by a few of the participants (12%), who were grouped as "Others[1]". Some of these participants stated that climate change has not had an impact on the gold mining activities, with a few participants indicating "not applicable", as to not sure whether climate change had impacted on the gold mining activities.

[1] *"Others" is the grouped responses received from less than 5 research participants.*

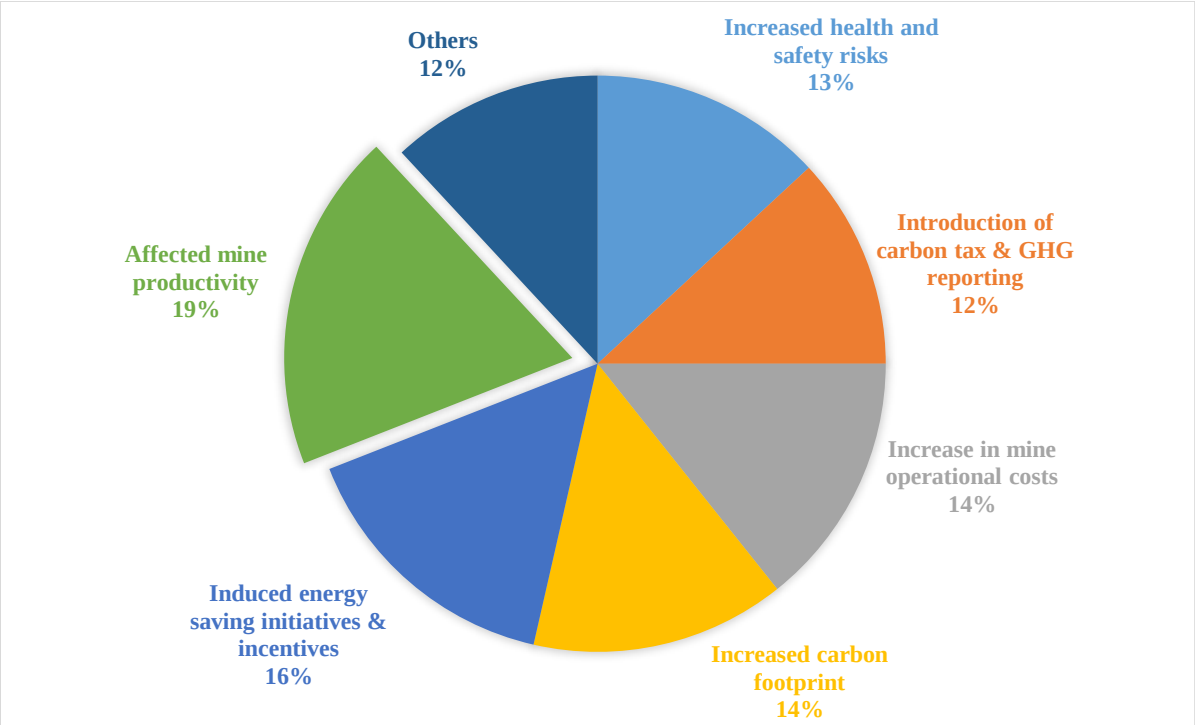


Figure 4. 1: Perspectives of the mining experts on the effects of climate change on gold mining activities (N^2=84)

(Source: Field based data, 2020 and 2021)

**The singled out slice of the pie chart represents "Response" received from the majority of participants*

In scrutinizing the findings presented in Figure 4.2 below, this study further seems to indicate that the gold mining operations are seen to be addressing the impacts of climate change by implementing energy efficiency measures (22%) to include the implementation of energy saving projects and implementation of processes and equipment to optimize on energy consumption. 16% of the participants indicated that the gold mining operations are sustainably utilizing their energy and water resources; and monitoring and reporting on efficiency performance in an effort to address the impacts of climate change. Some of the key participants in the engineering and energy management department did elaborate this view by noting that the gold mining operations are seen to be engaging with engineering and energy experts to assist the operations with energy and

[2] *N=Refers to the total frequency of the responses received*

environmental management so as to improve the efficiency of the mining operations. In addition, a few of the participants (7%) grouped as "Others" also claimed that the gold mining operations are using renewable energy as means to address the impacts of climate change and that the gold mining operations do identify risks associated with climate change impacts and determines management measures to address these risks. The views from these participants was found to concur with the information documented in the gold mining company's Task Force on Climate related Financial Disclosures (TCFD) reports, where it is reported that the gold mining company conducts climate change impact scenario analysis to identify the most likely scenarios that might have an impact on its mining operations and activities. However, what was found to be interesting is that a few participants also grouped under "others" claimed that the gold mining operations did not implement any measures to address the impacts of climate change.

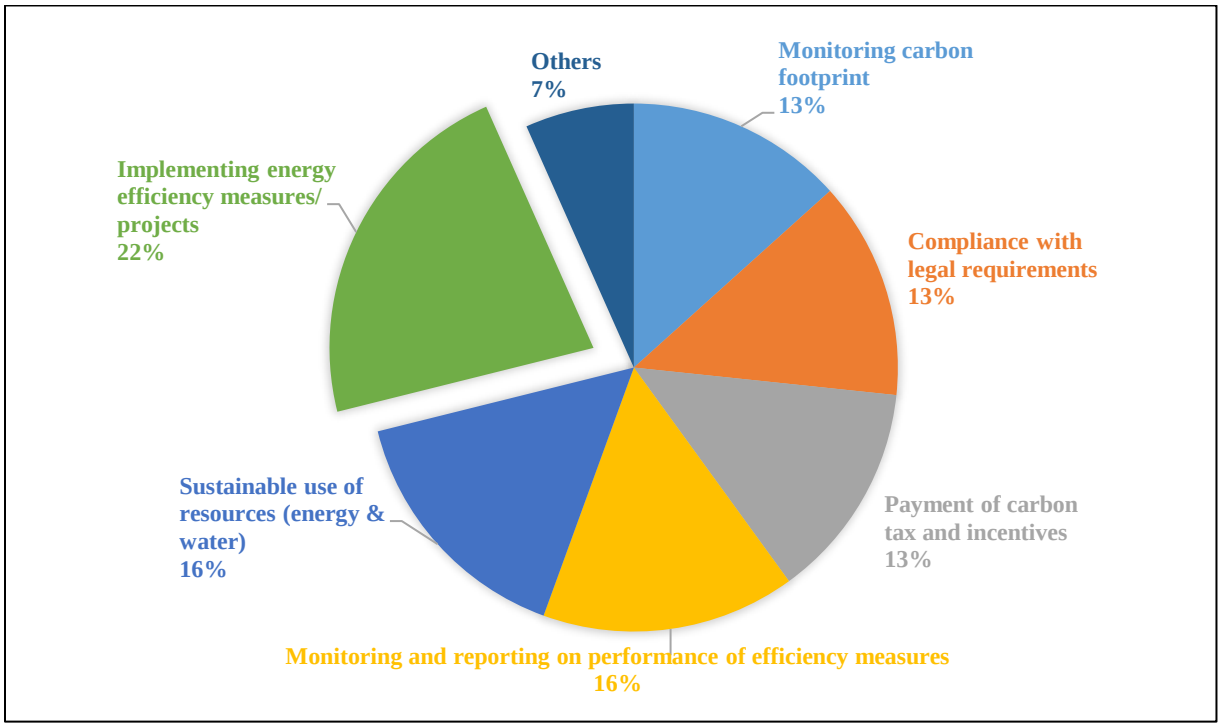


Figure 4. 2: Perspectives of the mining experts on the measures implemented to address the impacts of climate change on gold mining activities (N=90)

(Source: Field based data, 2020 and 2021)

**The singled out slice of the pie chart represents "Response" received from the majority of participants*

To further unpack the research question relating to climate change impacts and energy consumption in gold mining; questions were posed to the research participants pertaining to how climate change has affected the gold mining operation in its energy consumption. In view of the responses received as presented in Figure 4.3 below, this study seems to indicate that a changing climate is known to have its impacts on energy consumption in gold mining, with the majority of the gold mining experts (52%) seeming to agree that changing climate has led to an increase in energy consumption by the gold mining operations. However, a few of these respondents (6%) did claim that, due to climate change and given the nature of the gold mining processes, the gold mining company being a business that emits GHGs is now faced with obligations to pay carbon tax.

Given the responses received relating to the impacts of climate change on energy consumption at the gold mining operations, follow up questions were further posed to the research participants questioning as to what measures were being implemented in an effort to conserve energy. Responses received are presented in Figure 4.4 below, with and majority of the respondents (25%) claiming that the gold mining operations are conserving energy through the implementation of energy saving initiatives. In further discussing with these research participants, it was revealed that the gold mining operations are seen to implement energy saving and energy efficiency initiatives to include optimizing of refrigeration units, optimizing ventilation supply by installing a variable speed drive and installing inlet guide vanes on the main fans, including optimizing seasonal control of cooling and the general reduction of electricity consumption during peak times.

Interestingly, some participants did; however, further elaborate that the gold mining operations are implementing some of these energy saving initiatives not to deliberately address the impacts of climate change on its energy consumption but rather, implementing these energy saving initiatives as a strategy to save operational costs. This was captured by one of the key participants stating that *"…energy savings are primarily motivated by reducing operational costs due to electricity prices."* (Pers. com, 2020b). Similarly, another key participants noted that through the "*using of renewable energy – e.g Bio Gas Project"* (Pers. com, 2020c) the gold mining operation is making an effort to conserve its energy resource and save on energy costs. A few respondents (5%) grouped as "other" did; however, claim that the gold mining operations are able to optimize on their energy consumption through inter-mine departmental coordination in implementing and

monitoring on energy efficient measures, and by undertaking researching and implementing technological opportunities aimed at conserving energy at the gold mining operations. The views of these participants were found to concur with what was documented in the gold mining company's TCFD report, where it is reported that the gold mining company is moving towards using mining methods with lower energy requirements and that the gold mining company is recognizing opportunities related to operational efficiencies in effort to reduce its GHG emissions.

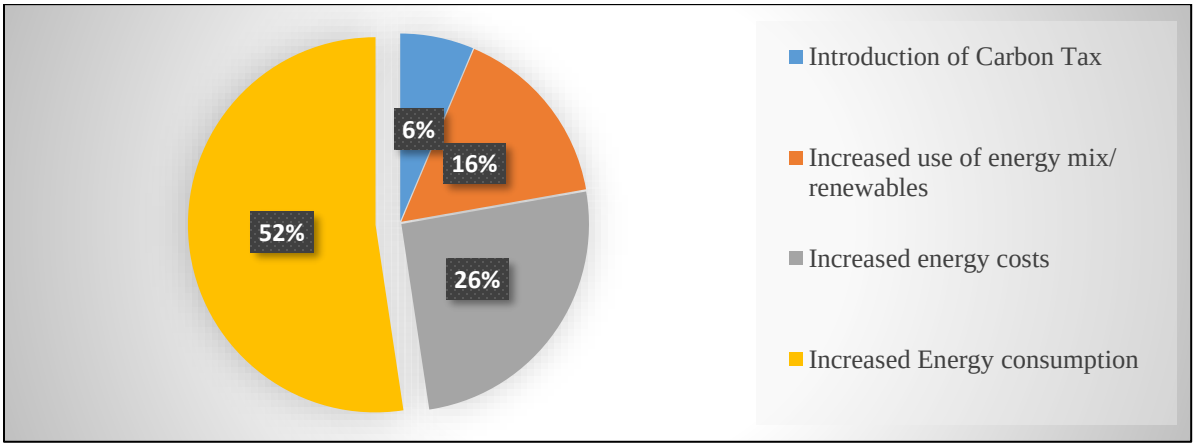


Figure 4. 3: **Perspectives of mining experts on the impacts of climate change on energy consumption at the gold mining operations (N=63)**
(Source: Field based data, 2020 and 2021)
**The singled out slice of the pie chart represents "Response" received from the majority of participants*

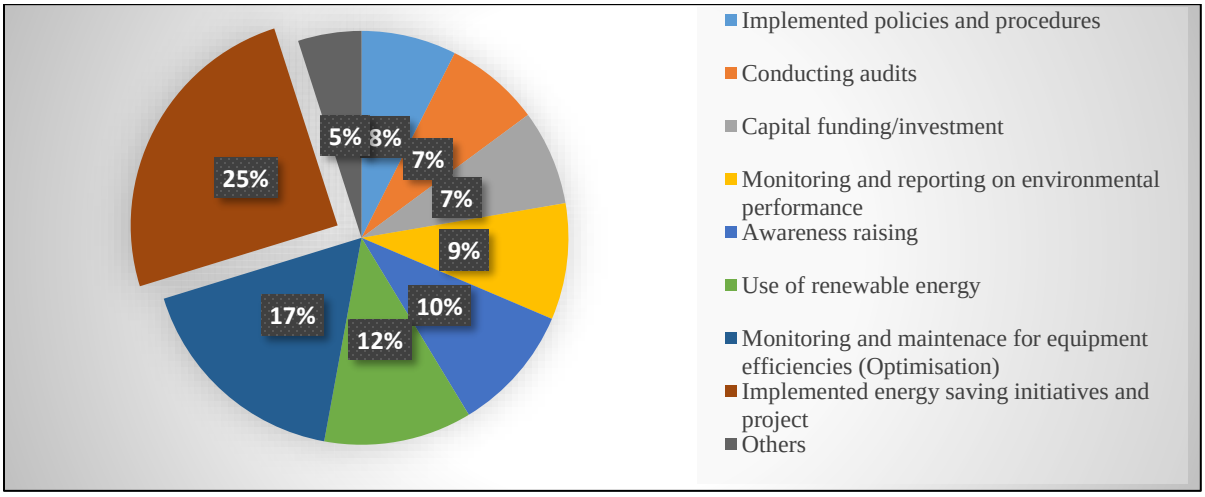


Figure 4. 4: **Perspectives of the mining experts on the measures implemented to conserve energy at the gold mining operations (N=121)**
(Source: Field based data, 2020 and 2021)
**The singled out slice of the pie chart represents "Response" received from majority of participants*

In further understanding the relationship existing between climate change and energy use in gold mining, this study found it important to gain information as to whether the initiatives implemented by the gold mining operations to conserve its energy resource were effective. Therefore, in view of the responses received, as expressed in Figure 4.5 below, majority of the research participants (85%) agreed that the energy conservation measures being implemented by the gold mining operations are effective in reducing energy consumption. 12% of the respondents indicated as not applicable or not sure as to whether the measures implemented were effective or not, or the effectiveness of these measures was yet to be determined. However, a few (3%) of the respondents claimed that the energy saving measures being implemented by the gold mining operations were not effective.

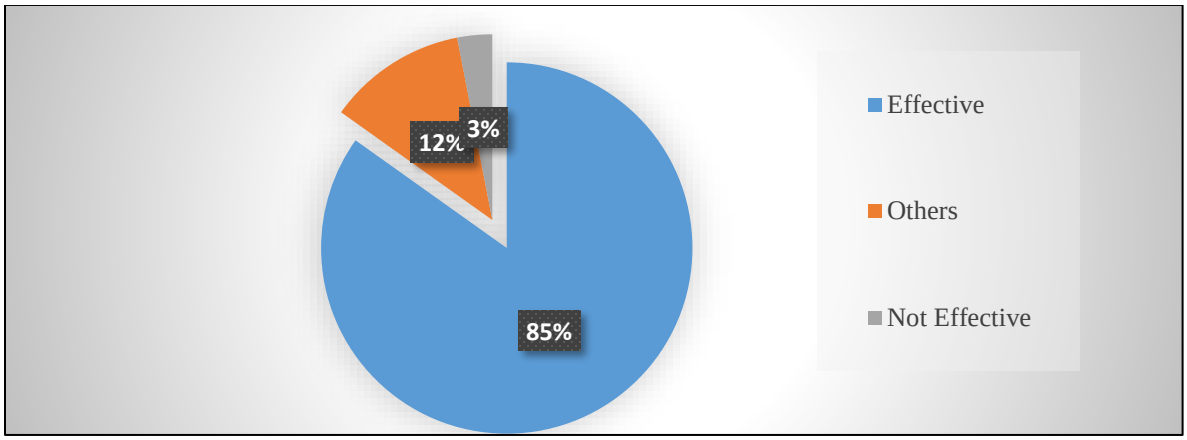


Figure 4. 5: Perspectives of the mining experts on the effectiveness of the energy conservation measures implemented by the gold mining operations (N=33)
(Source: Field based data, 2020 and 2021)
**The singled out slice of the pie chart represents "Response" received from majority of participants*

4.3 Integration of Sustainable Development Principles into Climate Change Adaptation Measures in Gold Mining

Literature has shown that the mining industry cannot make meaningful contributions towards sustainable development given the environmental degradation caused by mining activities (PAGE, 2016) and that mining increases the mining communities' vulnerability towards the impacts of climate change (Peschka, 2014). Therefore, mining companies have thus been required to apply corporate sensitivity and strong commitments towards implementation of sustainable development principles and apply best practices for the sustainable management (ICMM, 2017). Given these views presented in the existing literature; this study therefore, found it important to understand

how the gold mining operations are incorporating the principles of sustainable development into their mining practices in an effort to adapt to the impacts of climate change and optimize on their energy consumption. In effort to answer this research question; during the interview processes, questions were posed to the research participants, relating to the relationship existing between sustainable development principles and climate change adaptation measures; and linkage existing between sustainable development principles and energy optimization; and further the linkage existing between climate change adaptation measures and energy optimization.

In view of the responses received, Table 4.1 below, presents the views received from the participants, pertaining to some of the sustainable development principles being implemented by the gold mining operations. Majority of the participants (17%) claimed that the gold mining operations are seen to be implementing sustainable development principles through the sustainable use of their resources including energy and water resources, and through waste reclamation. In further unpacking this response, one of the key participants working closely with the engineering department, noted that the gold mining operations are *"reducing water usage for primary mining activities by recycling water. Reducing energy usage (electricity, diesel and petrol)"* (Pers. com, 2020d). In further scrutinizing the responses presented in Table 4.1 below, it is observed that a similar response was presented by 16% of the participants, indicating that the gold mining operations are implementing the principles of sustainable development through the implementation of energy efficiency initiatives in an effort to conserve the energy source.

A few respondents (scored 1% and 2%) in the Table 4.1 below; did also make interesting views that the gold mining operations do implement sustainable development principles through implementing awareness programs on efficient energy use, and through the development of holistic business plans that involve all the three dimensions of sustainable development which include economic growth, social development and environmental sustainability. An example of these views was captured from one of the key participants who stated that through *"using of Bio Gas to reduce electrical usage at the kiln at the elution plant"* (Pers. com, 2020e), the gold mining operation is seen to be incorporating the sustainable development principles into its mining activities. Photo 1 below shows the bioenergy project being implemented at one of the mining operations where giant king grass is propagated to be explored for a number of opportunities including phytoremediation and use as biofuel at one of its operations. The participants did also

claim that, through registration and accreditation with relevant government regulators, and by disclosing information to different stakeholders, the gold mining operations are seen to be implementing the principles of sustainable development that requires transparent engagement with different stakeholders.

Table 4. 1: Perspectives of mining experts on some of the sustainable development principles implemented at the gold mining operations (N=121)

Participant Responses	No. of Responses	Percent	Cumulative Percent
Disclosure of information	1	1%	1%
Registration and accreditation with regulatory bodies	1	1%	2%
Develop holistic business plans	1	1%	2%
Awareness programs on efficient resource use (energy & water)	2	2%	4%
Mine productivity	5	4%	8%
Socio-economic projects	6	5%	13%
Not Applicable	6	5%	18%
Conducting feasibility studies/ SEIA	8	7%	25%
Safety, Health and Environmental policies	9	7%	32%
Biodiversity protection to prevent pollution	10	8%	40%
Maintenance and reuse of equipment	10	8%	49%
Use of renewable energy	10	8%	57%
Implementing rehabilitations processes	12	10%	67%
Implement energy efficiency measures/ projects	19	16%	83%
Sustainable use of resources (energy, water, waste)	21	17%	100%
Total	121	100%	

Source: Field based data (2020 and 2021)



Photo 4.1: Bioenergy project taken during the site visit in 2021

In effort to further understand the linkage existing between sustainable development and climate change adaptation measures, this study sought to gain information from the participants to answer questions relating to how the gold mining operations are implementing the sustainable development principles in effort to address the impacts of climate change. In view of the responses received, these are presented in Figure 4.6 below. In scrutinizing Figure 4.6**,** majority of the participants (12) seem to agree that, the gold mining operations are implementing energy efficiency measures, regarded as a sustainable development principle pertaining to the sustainable use of the energy resources, which was similarly identified by some participant (2), that through the sustainable use of resources, the gold mining operations are applying the sustainability principles required to address the impacts of climate change.

Some participants (11) argued that, through the implementation of measures pertaining to reducing the mine's carbon footprint, the gold mining operations are also seen to be implementing sustainable development principles as measures geared towards addressing the impacts of climate change. One of the participants working closely with the engineering and energy department, expounded this view by stating that *"Emission reduction or elimination as a result of a proper maintenance plan/schedule"* (Pers. com, 2020f).

It is also observed that through, making resources available (1) and providing capital funding (8); the gold mining operations are applying the principles of sustainable development, in an effort to

make provision of the necessary resources and financing the relevant measures implemented to address the impacts of climate change.

A few respondents (2) did make interesting views that, through initiatives like partaking in disclosing of the gold mining company's initiatives relating to environmental impacts and reduction of GHG emissions including sustainable water use reported in the CDP, the gold mining company is seen to be implementing the principle of sustainable development by disclosing information to its stakeholders in regards to how the gold mining company is addressing the impacts of climate change seen to be affecting the gold mining business.

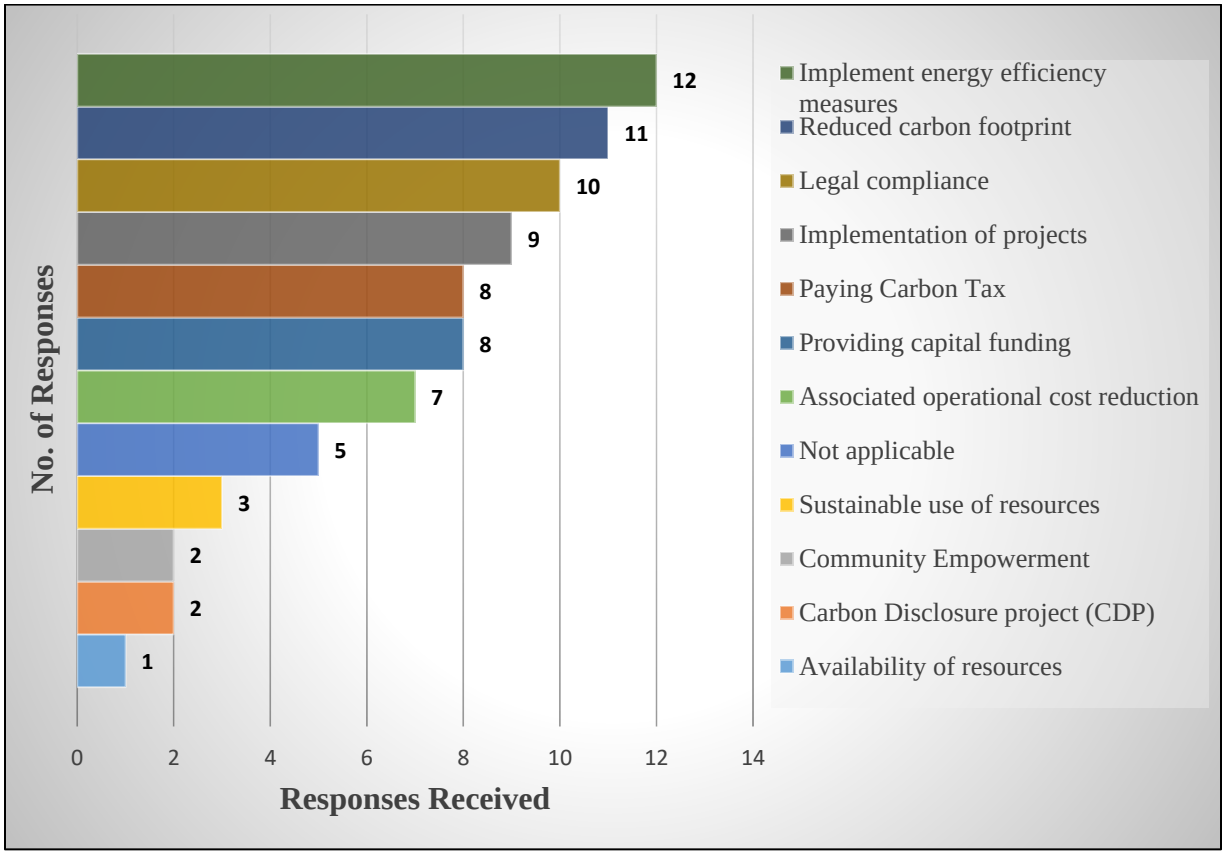


Figure 4. 6: Perspectives of the mining experts on sustainable development principles implemented to address the impacts of climate change (N=78)
(Source: Field based data, 2020 and 2021)

To further unpack the linkage existing between sustainable development principles and climate change adaptation, questions were posed to the participants pertaining to how the gold mining operations are integrating the sustainable development principles in the implementation of their climate change adaptation measures. In view of this, responses received are expressed in Figure 4.7 below.

A close scrutiny of the Figure 4.7, the empirical evidence seems to indicate that majority of the respondents (13) were not sure as to how the gold mining operations was integrating the sustainable development principles into their climate change adaptation measures. However, a few of the participants seem to indicate that the gold mining operations were seen to be integrating the principles of sustainable development into the implementation of their climate change adaptation measures. These included some participants (11) stating that through the use of renewable energy, and through the sustainable use of resources in an effort to adapt to the impacts of climate change; the gold mining operations are therefore integrating the sustainable development principles of sustainable energy consumption into their climate change adaptation measures.

On an interesting note, some participants (5); did however, claim that, through community engagement in the development of the climate change adaptation measures, the gold mining company is seen to be implementing the sustainability principles relating to stakeholder engagement and involvement when developing and implementing its adaptation measures.

Similar to this view, some respondents (5) did indicate that through community empowerment during the implementation of the climate change adaptation measures; the gold mining operations are implementing the sustainability principles into their climate change adaptation measures. This view was elaborated by one of these participants and quoted to state that, through *"Empowering communities to reduce risk of interference in mining activities"* (Pers. com, 2020g); which implied that, through community empowerment which relates to the socioeconomic aspects of sustainable development, the gold mining operations are integrating the sustainability principles into the implementation of their climate change adaptation measures.

A few participants (2) made interesting views, noting that, through the transparent disclosure of information relating to climate change adaptation measures planned and implemented by the gold mining company in the TCFD company report, which report is directed to the stakeholders; the gold mining company is therefore seen to be applying the sustainability principles of transparent disclosure of information to its stakeholders. The information disclosed to the stakeholders pertains to the development and implementation of the climate change adaptation measures, by the gold mining operations. However, only one participant did state that the gold mining operations are

integrating the sustainable development measures in there climate change adaptation measures, through participating in stakeholder engagements.

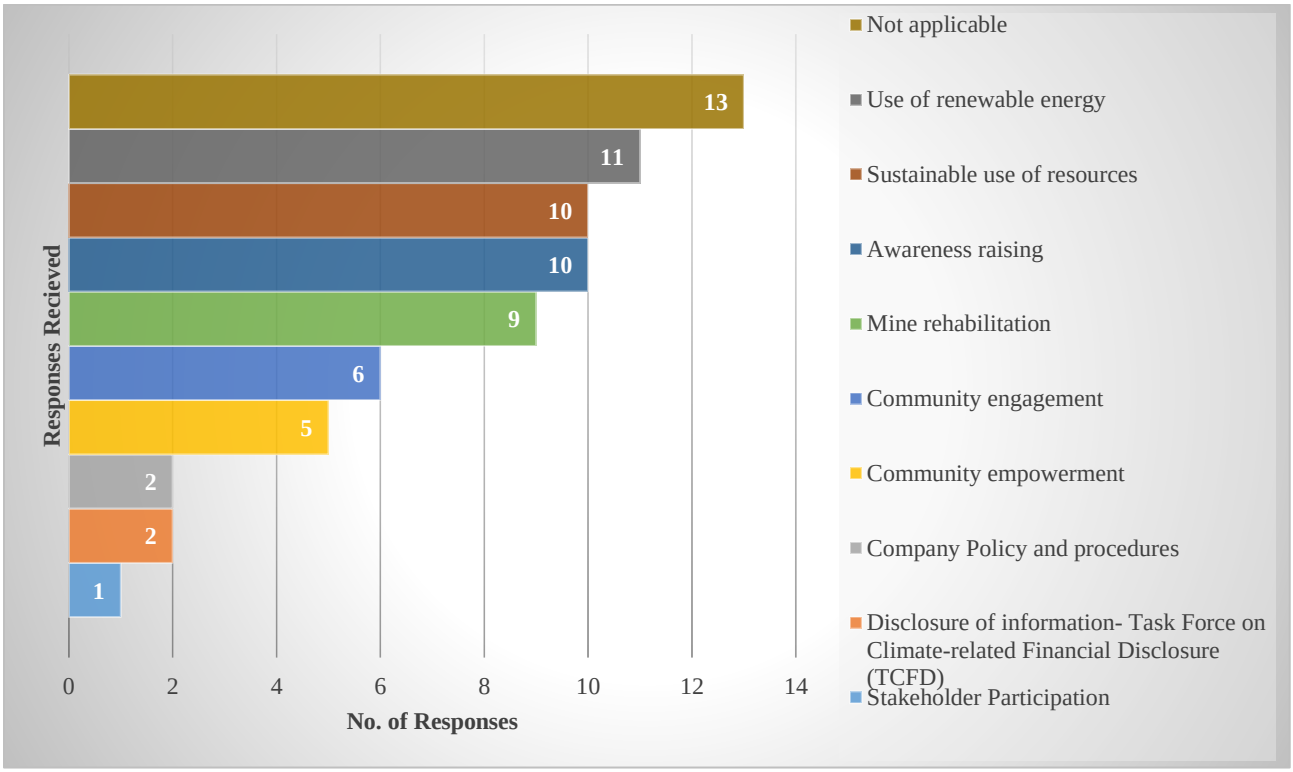


Figure 4. 7: Perspectives of the mining experts on sustainable development principles integrated in the climate change adaptation measures (N=69)
(Source: Field based data, 2020 and 2021)

After unpacking the linkage existing between sustainable development principles and climate change adaptation measures, it was equally important to also understand the linkage existing between sustainable development principles and energy optimization. In view of this, question relating to how the gold mining operations are applying the principles of sustainable development in effort to optimize on its energy consumption were posed to the research participants. Figure 4.8 below, presents the responses received, which seems to indicate that the gold mining operations are applying the principles of sustainable development in the measures implemented in an effort to optimize on its energy consumption. This is captured by majority of the participants (25) who claimed that, the gold mining operations are applying the principle of sustainable use of resources through the implementation of energy efficiency measures in an effort to optimize on its energy consumption. In light of this view, a participant stated that: *"The gold mining company is managing its energy efficiencies and reducing carbon intensities through the life cycle of our*

operation" (Pers. com, 2020h). The reduction in carbon intensities is similarly captured by some participants (11) who claimed that the gold mining operation is implementing sustainable development principles in an effort to effectively consume its energy resources through the implementation of initiatives that reduce the mine's carbon footprint. Similarly, a few participants (4) also claimed that, the gold mining operations are applying the principles of sustainable development through the implementation of alternative energy resources in an effort to reduce the gold mining operations' dependence on fossil generated energy and optimize of its energy consumption. This view was captured by one of the participants, who stated that the gold mining operations are *"moving towards the increased use of renewable energy where appropriate"* (Pers. com, 2020i). However, only one participant each did state that the gold mining operations are conducting trainings and undertaking stakeholder consultations as some of the sustainable development measures implemented in an effort to achieve energy conservation at the operations.

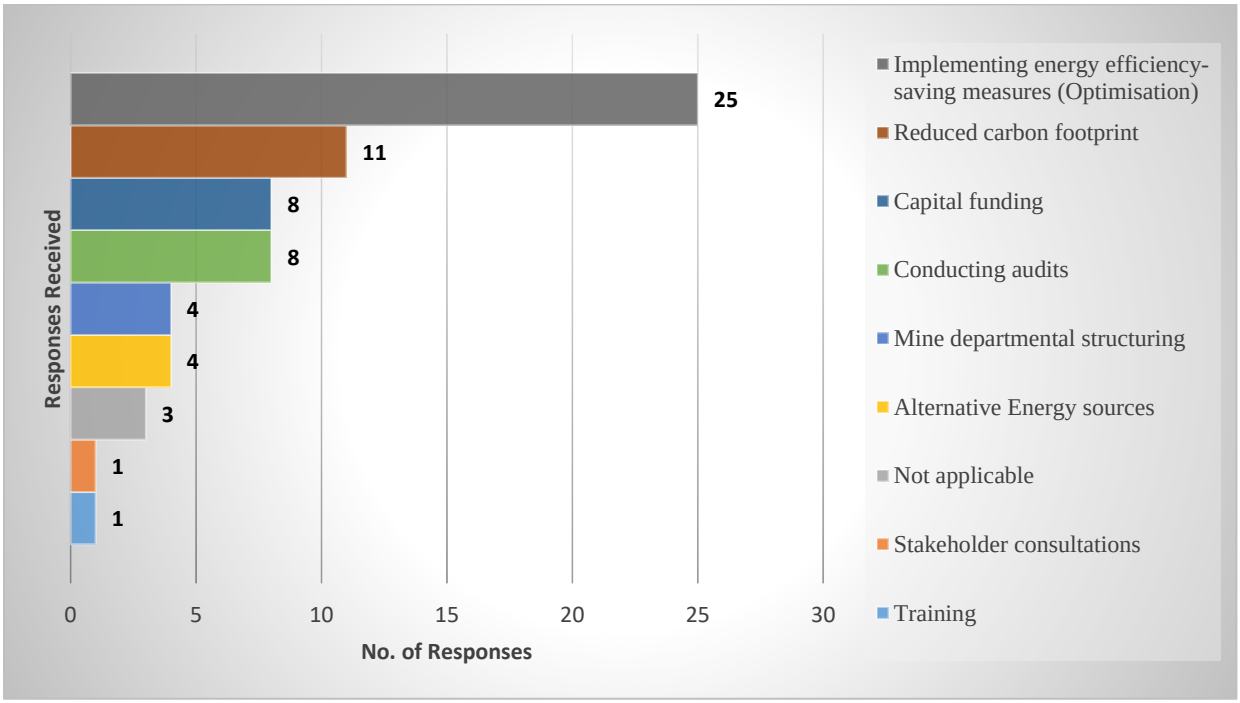


Figure 4. 8: Perspectives of the mining experts on sustainable development principles implemented in an effort to optimize on energy consumption (N=65)
(Source: Field based data, 2020 and 2021)

Given the need to further understand the linkage existing between climate change adaptation measures and energy optimization; this study found it important to gain information from the participants relating to how the gold mining operations are implementing their climate change adaptation measures in an effort to achieve energy optimization. Responses received are presented

in Figure 4.9 below. A close scrutiny of Figure 4.9, seems to indicate that majority of the participants (23) claimed that, the gold mining operations are implementing energy efficiency measures are implemented as climate change adaptation measure in effort to optimize its energy consumption. Some participants (16) claimed that, through the monitoring of the mining company's carbon footprint in effort to reduce its GHG emissions and through the use of renewable energy, the gold mining company is implementing this as part of its climate change adaptation measures in effort to optimize on its energy consumption. Similarly, two (2) other participants identified the use of renewable energy adopted the energy mix, is some of the climate change adaptation measures implemented by the gold mining company in effort to optimize on its energy consumption. However, only one participant each did state that the gold mining operation is implementing its company policies and procedures relevant to climate change and energy efficiency and conducting climate change scenario analysis, as some of its climate change adaptation initiatives implemented in an effort to conserve its energy.

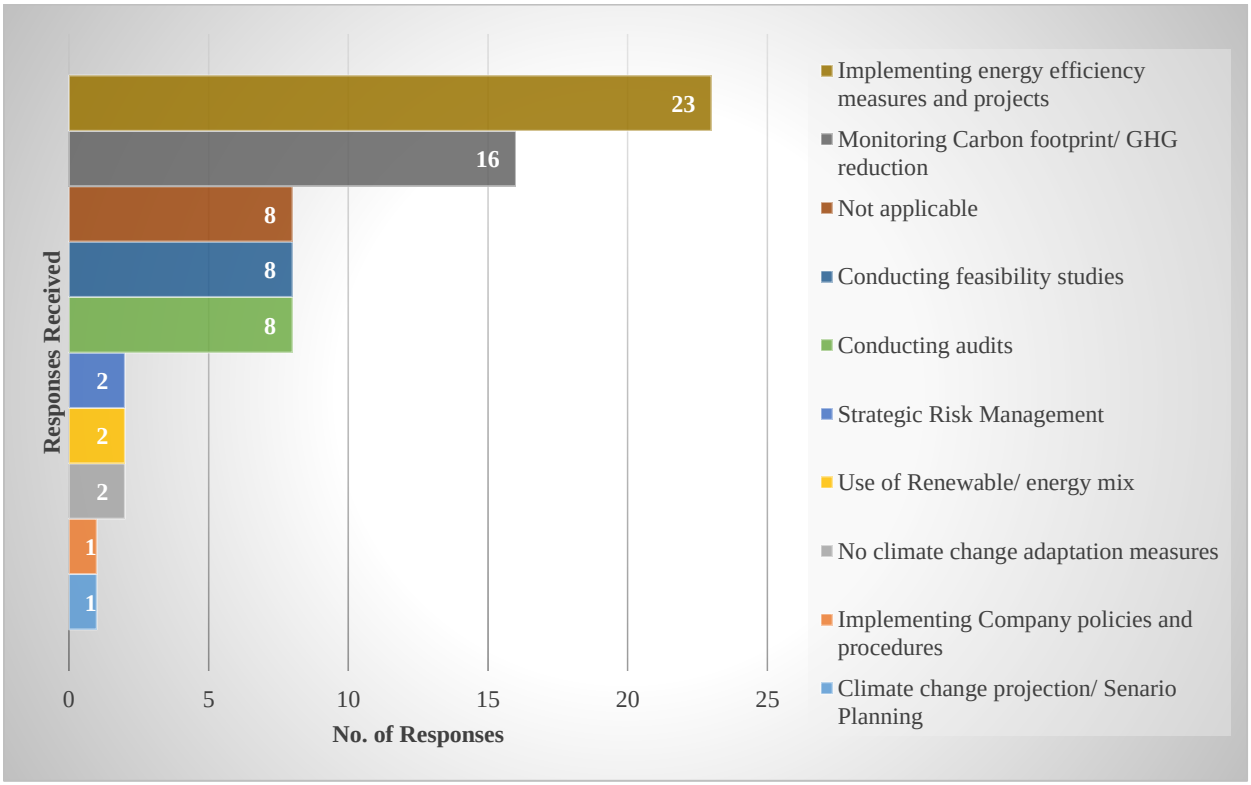


Figure 4. 9: Perspectives of the mining experts on climate change adaptation measures implemented in an effort to conserve energy (N=71)
(Source: Field based data, 2020 and 2021)

In effort to further understand how the gold mining operations have incorporating sustainable development principles and climate change adaptation measures into the company policies and strategies, in an effort to combat the impacts of climate change and optimize on its energy consumption; this study found it important to establish which company documents contained information relating to the three study themes; sustainable development, climate change and energy management. This was to also further supplement on the information provided by the research participants during the questionnaire and interview process. In doing so, the research participants were asked to list some of the mining company documents that are relevant to support their responses provided during the interview and questionnaire processes. This was quite an important step in the data collection process because this documented information is used to complement the information obtained from the mining experts interviewed during the data collection. In view of the responses received, as illustrated in Figure 4.10 below, this study seems to indicate that there are company documents containing information relating to the three study themes which are; sustainable development, climate change and energy management.

In scrutinizing Figure 4.10, this study found that the Integrated Annual and Sustainability report was identified by majority of the respondents (28%); with the rest of the company documents identified by 9% of the participants to be relevant to find information relating to the three study themes; sustainable development, climate change and energy management. The company documents identified during the interview and through the questionnaire process included; Policy documents, Energy reports and newsletters, Integrated Annual report, Environmental, Social and Governance (ESG) reports, Mining Operational Strategic business plans and reports, Energy saving feasibility reports, Stakeholder reports and the Global Reporting Index (GRI) score cards.

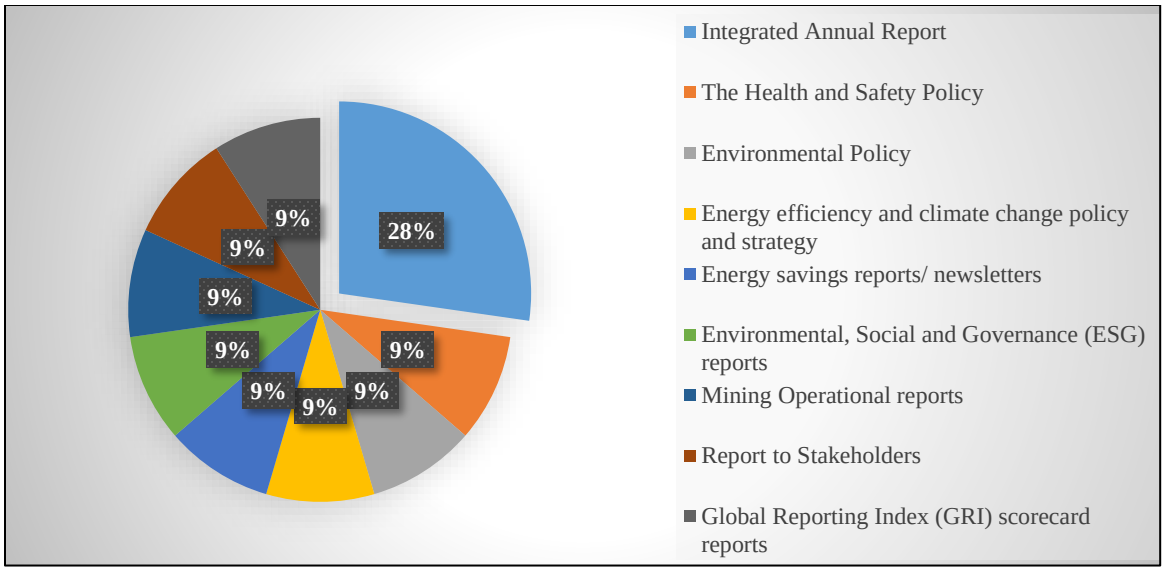


Figure 4. 10: Existing mining company documentation relating to the study themes
(Source: Field based data, 2020 and 2021)
**The singled out slice of the pie chart represents "Response" received from majority of participants*

In further examining the eleven (11) company documents identified during the interview and questionnaire process; a rapid appraisal was applied to these documents in an effort to identify company documentation that meant the criterion of being published and was available to the public. In doing so, out of the 11 company documents proposed by the respondents, seven (7) of these company documents were found to meet the criterion of being public published company documents. In an effort to further have a comprehensive understanding of the relationship existing between the three themes of the study, this study therefore, conducted a policy and content analysis of these published company documentation so as to attain evidence relating to the three study themes. A "Presence" or "Absence" of certain phrases, trends and patterns, including information lying in beneath and around the text was done in relation to the three themes of study; sustainable development, climate change and energy management. Table 4.2 below, therefore presents findings from this process.

In scrutinizing this Table 4.2, this study seems to indicate that out of the 7 published company documents, four (4) of these documents scored an cumulative presence value of three (3), to be containing a "presence" of content relating to all the three study themes; climate change, energy, and sustainable development. These four (4) company documents included; the Climate Change and Energy Policy and Strategy, the Integrated ESG reports, the Integrated Annual reports and the

Mining Operational reports. However, in further scrutinizing the seven (7) company documents, this study found that only one (1) company document, which is the Environmental Policy scored the lowest accumulative presence value of (1), which implies that this company document contained content relating to only one (1) theme of the study which relates to sustainable development. Some of the commits relating to sustainable development identified in the company's environmental policy, included: promoting active partnership with different stakeholders at international, national, regional and local levels; implement and maintain environmental management systems at the mining operations; setting and achieving targets that promote efficient use of resources and reduce environmental exposure; including transparent engagement with the mining communities affected by the gold mining operations and consider their views and concerns in the decision-making process; and to close the mines in a manner that promotes ecological and socio-economic sustainability.

In addition to these findings; a total "presence" score and "% presence" score was recorded for all the three study themes, and it was found that the study theme "sustainable development principles" was more evident, scoring a "total presence" score of seven (7) which is a total percentage score of (100%), meaning that this study theme "sustainable development" was found to be documented content contained in all the seven (7) identified company documents. In further scrutinizing Table 4.2 below, this study also found that, the study theme of "climate change" was found to have the least scoring of a "total presence" score of four (4) which is a total percentage score of (57%), meaning that this study theme was not documented in three (3) of the identified company documents to include; the Environmental Policy, Report to stakeholders and in the Energy efficiency feedback newsletters.

Table 4. 2: Presence or Absence of documented content in relation to the study themes

Document Type	Presence (1) and Absence (0) of phrases, trends and patterns of the Study Themes			Cumulative Presence Score
	Climate Change	Energy	Sustainable Development Principles	
Energy Efficiency and Climate Change Policy & Strategy	1	1	1	**3**
Environmental, Social and Governance (ESG) report	1	1	1	**3**
Company Integrated Annual Report	1	1	1	**3**
Company Operational Performance	1	1	1	**3**
Energy Efficiency Feedback newsletters	0	1	1	**2**
Report to Shareholders	0	1	1	**2**
Environmental Policy	0	0	1	**1**
Total Presence Score	**4**	**6**	**7**	**17**
Percentage % Presence Score	**57%**	**86%**	**100%**	

Source: Field based data (2020 and 2021)

4.4 Challenges in Integrating Sustainable Development Principles and Implementation of Climate Change Adaptation Measures in Gold Mining

Literature has shown that sustainable development involves three dimensions of economic growth, social development and environmental sustainability, which are interlinked. Yet on the other hand, some studies have shown that achieving a balance between these three dimensions of sustainable development and the interrelationships between them, remains a challenge (World Bank Annual Report, 2016; Bhattacharya, 2015). In view of this, this study therefore found it important to investigate the challenges that could be constraining the gold mining operations from effectively integrating the principles of sustainable development into their climate change adaptation

measures and the subsequent implementation of these integrated climate change adaptation measures in an effort to enhance the mine's adaptive capacity and achieve sustainable energy consumption.

In an effort to answer this research question; questions were posed to the research participants, inquiring as to what are some of the challenges preventing the gold mining operations from effectively integrating the sustainable development principles and its climate change adaptation measures. Responses received are presented in Figure 4.11 below. A close scrutiny of Figure 4.11, seems to indicate that due to delays in implementing projects related to addressing the impacts of climate change, delays caused by the high costs associated with the implementation of such projects (28%), this is seen to limit the gold mining operations from effectively integrating the sustainability principles with the climate change adaptation measures, as desired.

A few respondents (2%) did however, claim that because of lack of information and understanding of the benefits associated with the integration of sustainable development principles and climate change adaptation, the gold mining operations are seen to not effectively integrate the sustainable development principles and climate change adaptation measures. However, in reviewing the company ESG and Annual Integrated reports, there is documented information as evidence, showing some of the sustainability practices adopted by the mining company when developing and implementing some of its climate change adaptation measures and projects. Therefore, despite these challenges identified during the interview process, this study also seems to indicate that the gold mining operations are seen to be integrating the sustainability principles into their climate change adaptation measures.

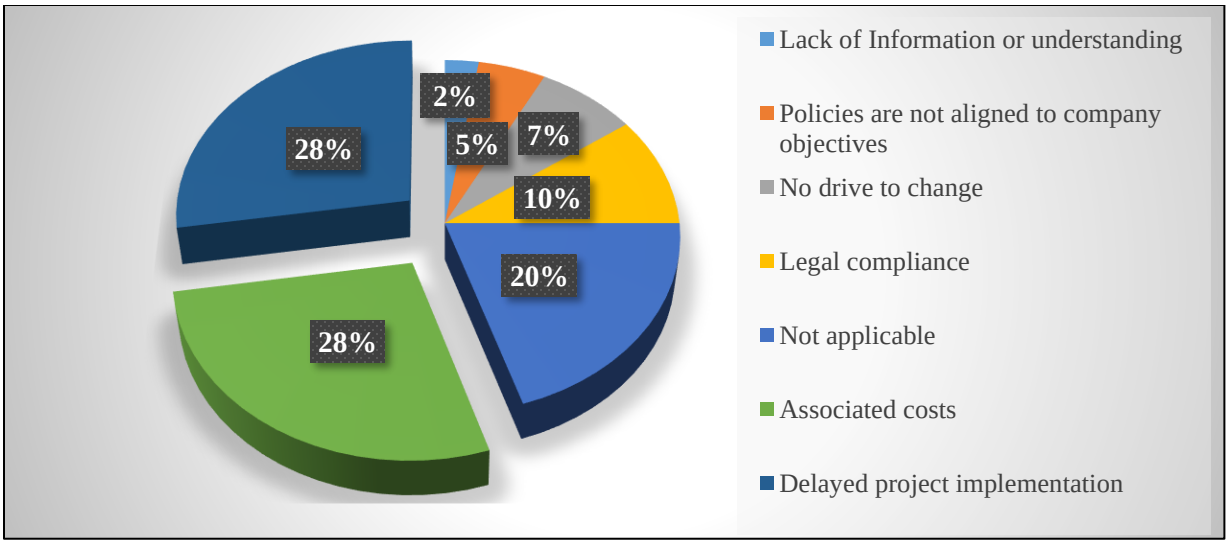


Figure 4. 11: Perspectives of the mining experts on challenges affecting the integration of sustainable development principles with climate change adaptation measures (N=40)
(Source: Field based data, 2020 and 2021)
**The singled out slice of the pie chart represents "Response" received from majority of participants*

In further exploring the challenges faced by the gold mining company in relation to integration of sustainable development and climate change adaptation measures; a follow up question was posed to the research participants, inquiring as to what are some of the challenges seen to be preventing the gold mining operations from implementing their climate change adaptation measures. Responses received are presented in Figure 4.12 below.

In scrutinizing Figure 4.12, this study seems to indicate that due to limited capital funding (24%), the gold mining operations do not implement their climate change adaptation measures as desired. In addition to this view, some participants (13%) argued that due to the stringent legal obligations surrounding the implementation of some of the climate change adaptation measures; and due to limited process efficiency and technology relating to adaptation of climate change; and due to the mining operation prioritizing mining productivity over addressing the impacts of climate change; the gold mining operations are not able to effectively implement their climate change adaptation measures as desired. However, upon reviewing the company ESG and Annual Integrated reports, there is evidence of information pertaining to climate change adaptation measures and projects both planned and being implemented at the different mining operations. Therefore, despite the challenges identified during the interview process, this study also indicates that there is evidence

that the gold mining operations are seen to be implementing their climate change adaptation measures as desired.

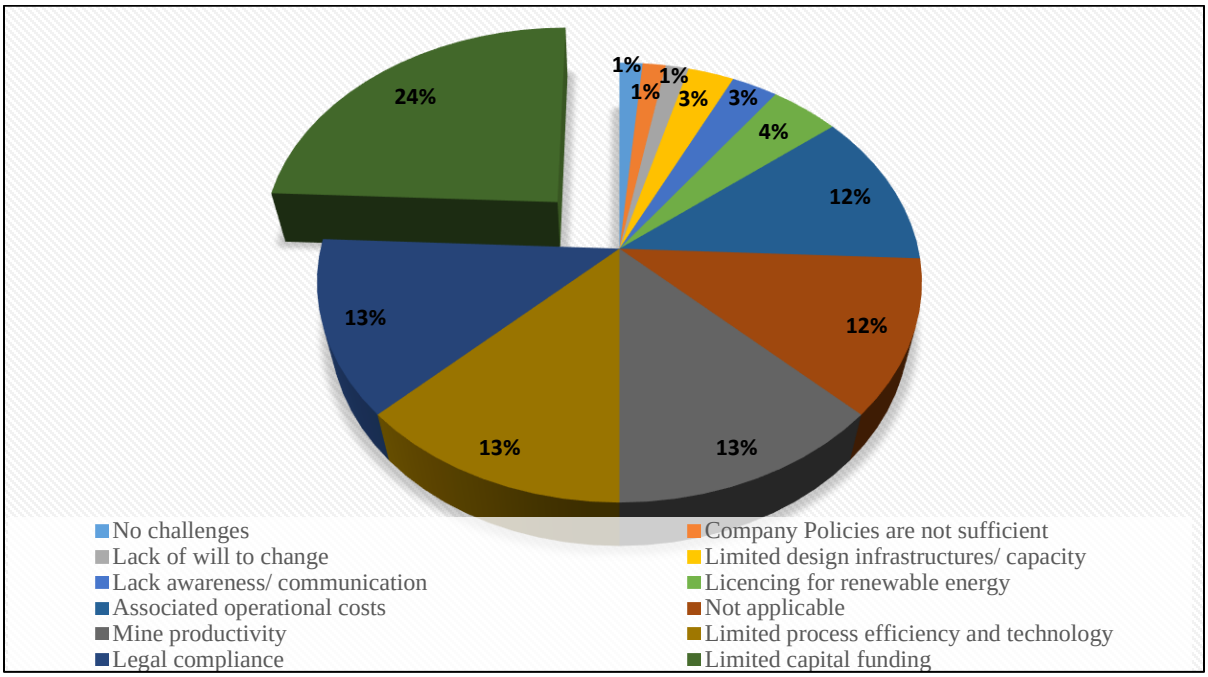


Figure 4. 12: Perspectives of the mining experts on the challenges affecting the implementation of climate change adaptation measures by gold mining operations (N=70)
(Source: Field based data, 2020 and 2021)
**The singled out slice of the pie chart represents "Response" received from majority of participants*

4.5 Actions addressing challenges affecting the Integration and Implementation of the Sustainable Development Principles and Climate Changes Adaptation Measures

This section presents the measures implemented by the gold mining operations in an effort to address some of the challenges identified by the participants as presented in the subsection 4.4 above. This relates to the existing literature, where it is reported that mining companies should consider mining sustainably, given the fact that mining companies are not only located in environmentally sensitive regions where mining activities are impacting on the sensitive environment and natural resources (Kogel et al., 2014), or because mining activities are seen to increase the vulnerability of the mining communities to the impacts of climate change (Peschka, 2014), but also because mining companies are being faced with the effects of climate change on their mining activities (ICMM, 2017). Literature has also shown that South African mining companies have been observed to be slowing in the efforts to reduce emissions and addressing

climate change and that the South African mining companies therefore need to further integrate climate change into their risk management (CDP, 2017). Therefore, in view of this, this study found it important to identify some of the measures being explored by the gold mining operations in effort to address some of the challenges that have the potential of preventing the effective integration of the principles of sustainable development into the climate change adaptation measures, and their implementation thereof.

In an effort to answer this research question; questions were then posed to the research participants, relating to how the gold mining operations are attempting to address the challenges preventing it from fully integrating the principles of sustainable development into its climate change adaptation measures. In doing so, a follow up question in this regard was therefore posed to the participants, and responses received thereof are presented in Figure 4.13 below. In scrutinizing Figure 4.13, it is found that majority of the participants (32%) were not sure as to how the gold mining operations can address the challenges associated with the effective integration of the principles of sustainable development into its climate change adaptation measures. On the other hand, some participants (22%) suggested that, by conducting feasibility studies in effort to further understand aspects relating to interrelationships existing between sustainable development and climate change adaptation, implying that the gold mining operations will be in a better position to gain understanding and information relating to the integration of the sustainability principles and adaptation measures. Also of interest is that some participants (21%) claimed that, through the provision of capital funding, the gold mining operations will be able to implement the sustainability principles required when developing and implementing the identified climate change adaptation related projects that have integrated the sustainability principles.

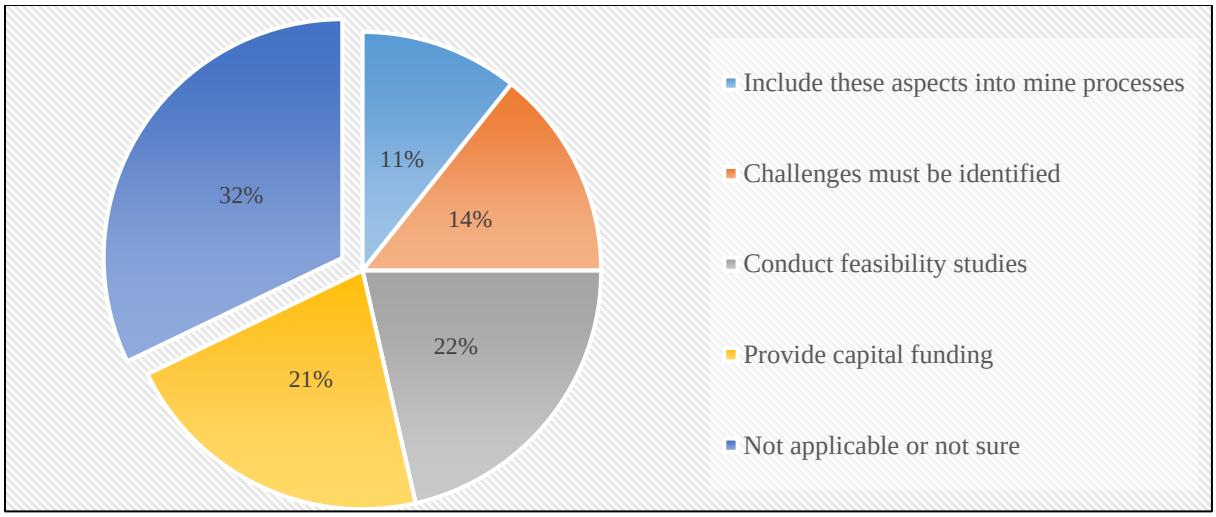


Figure 4. 13: Perspectives of mining experts on measures to address challenges preventing the effective integration of sustainability principles into climate change adaptation measures (N=28)

(Source: Field based data, 2020 and 2021)

**The singled out slice of the pie chart represents "Response" received from majority of participants*

Having established the ways in which the gold mining operations are able to address some of the challenges in effort to enhance the effective integration of the sustainable development principles into its climate change adaptation measures; this study found it also important to further establish ways in which the gold mining operations are attempting to address the challenges preventing it from fully implementing their climate change adaptation measures. Responses received are presented in Figure 4.14 below, with majority of the participants (22%) seen to agree that the gold mining company should conduct more feasibility studies and research so as to attain additional information relating to climate change and its impacts and better analyze and understand and consider the different initiatives that will consider the factors relating to socioeconomic, environmental, technical, financial and legal aspects relating to addressing the impacts of climate change. These participants claim that this will better inform the mining operations of the most favored effective climate change adaptation related projects to be implemented.

Other participants (14%) indicated that the gold mining operations needs to make financial provisions for additional capital funding models in an effort to finance some of the most critical climate change adaptation projects. A few respondents (12%) interesting claimed that the gold

mining company should design aligned and integrated policies which should guide the gold mining operations on how to effectively implement its climate change adaptation measures.

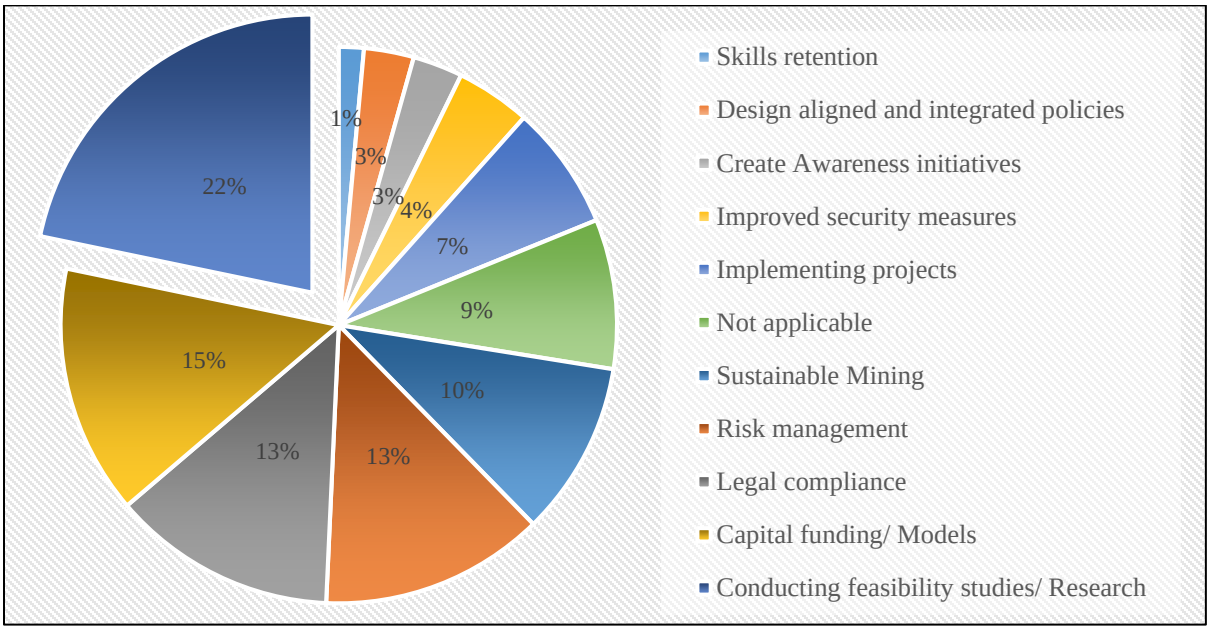


Figure 4. 14: Perspectives of the mining experts on measures to address challenges affecting the implementation of climate change adaptation measures (N=69)

(Source: Field based data, 2020 and 2021)

**The singled out slice of the pie chart represents "Response" received from majority of participants*

4.6 Conclusion

In summary, this chapter has presented details of the results deduced from the data gathered during the interview and questionnaire processes and from reviewing of the identified company documents; aimed at answering the research questions of this study. Therefore, findings presented in subsection (4.2), seem to indicate that the gold mining operations are affected by climate change including impact on how the gold mining operations are consuming their energy resource. Majority of the participants indicated that climate change has mostly affected mining productivity through the reduction in the availability of resources which in turn is affecting the gold mining overall operational costs. The empirical evidence further indicates that changing climate has led to an increase in energy consumption by the gold mining operations; therefore in an effort to address these impacts of climate change on the mining activities; the gold mining operations are seen to be implementing a number of measures to address the impacts of climate change and achieve sustainable energy consumption. These include implementation of energy saving initiatives and

implementation of energy efficiency measures that allow for efficient mining processes and equipment to optimize on energy consumption. However, some participants did further elaborate that, these energy saving and efficiency initiatives are not deliberately implemented to address the impacts of climate change but rather implemented as a strategy to save operational costs associated with high energy consumption.

In subsection (4.3), from the empirical evidence, this study seems to indicate that the gold mining operations are implementing sustainability principles through the implementation of energy efficiency measures, regarded as sustainability principles pertaining to the sustainable use of the energy resources. In addition to this, the findings in this study seem to indicate that the gold mining operations are integrating the principles of sustainable development into their climate change adaptation measures through the sustainable consumption of the energy resource and by implementing renewable energy.

In further establishing the linkage existing between sustainable development principles and energy consumption in gold mining, the empirical evidence in this study also did indicate that, the gold mining operations are applying the sustainability principles of sustainable use of resources by implementing energy efficiency measures and use of alternative energy resources in an effort to reduce the gold mining company's dependence on fossil generated energy, and achieve sustainable energy consumption.

Furthermore, in establishing the relationship between energy optimization and climate change adaptation, the empirical evidence in this study does indicate that the gold mining operations are also implementing energy efficiency measures regarded as climate change adaptation measures in an effort to address the impacts of climate change and achieve energy optimization. In addition, this study also found that all the three themes of this study; sustainable development, climate change and energy, were documented in most of the company documents which seems to indicate that the gold mining company has structured and embedded the sustainable development principles, climate change adaptation measures and energy management measures into its policies and strategies, including in its Annual Integrated and ESG reporting.

Furthermore, findings presented in subsection (4.4), seems to indicate that limited capital funding and stringent legal obligations; are some of the challenges that are seen to potentially prevent the

gold mining operations from effectively implementing their climate change adaptation measures as desired. In addition to this, this study further indicates that delays in implementing climate change related projects caused by high costs associated with the implementation of such projects; these challenges have got the potential to prevent the gold mining operations from fully integrating the sustainable development principles into their climate change adaptation measures. However, this study also found from review of the company ESG and Annual Integrated reports; that there is evidence of implementation of sustainability principles and adaptation measures by the gold mining operations. Implying that the gold mining operations are seen to be integrating the sustainability principles into their climate change adaptation measures; and implementing these climate change adaptation measures as desired.

Subsection (4.5), does provide findings relating to the possible measures that can be implemented by the gold mining operations to address the challenges highlighted in subsection (4.4). The evidence therefore indicates that the gold mining operations should conduct more feasibility studies and research so as to attain additional information, in an effort to better understand and consider the different project factors relating to socio-economic and environmental aspects. This measure is considered to put the company in a better position to identify most favored effective climate change adaptation related projects that can be considered for implementation. In addition, findings in this study seem to indicate that through adequate capital funding models, the gold mining operations will be able to finance some of the most critical climate change adaptation projects.

A broader conclusion within in this chapter, therefore reveals that the empirical evidence presented in this study indicates that climate change is impacting on gold mining activities including having an impact on how the gold mining operations are consuming their energy resource. Therefore, in an effort to address the impacts of climate change and achieve sustainable energy consumption, the gold mining operations are seen to be applying the sustainability principles of sustainable energy use by implementing energy efficiency measures, energy saving projects, and using of alternative energy sources including using renewable energy; which principles and practices are integrated into the climate change adaptation measures, and structured and embedded in some of the company policies and strategies; implemented in an effort to build the gold mine's adaptive capacity towards climate change impacts, and achieve sustainable energy consumption. The

evidence in this study further indicates that, despite the challenges identified to have the potential to prevent the gold mining operations from fully integrating the sustainability principles into the climate change adaptation measures and the effective implementation of these adaptation measures; the gold mining operations have subsequently identified some of the interventions that can be considered in addressing these challenges. In view of this, we therefore move to chapter 5.

CHAPTER FIVE
ANALYSIS AND DISCUSSION

5.1 Introduction

Data analysis and discussion in research is generally to interpret data and provide insight into the strength of the relationship in which the study is interested in (Bailey & Gatrell, 1995). This chapter therefore, is to critically examine and interpret the empirical findings presented in chapter four of this thesis. Interpretations relating to the empirical evidence obtained in this study will be discussed in light of this study's research objectives, and insights will be made with inferences made in relation to the relevant existing literature. This study is aimed at exploring the ways in which the gold mining operations in South Africa are integrating sustainable development principles into their climate change adaptation measures in an effort to build the gold mining operations' adaptive capacity to the impacts of climate change and effectively and sustainably contribute to optimizing their energy use.

In view of this aim, the objectives of this study were: to identify ways in which the gold mining operations are adapting to the impacts of climate change and achieving sustainable energy consumption; to investigate the feasibility of integrating the sustainability principles into the gold mining operations' climate change adaptation measures; to further investigate how the gold mining operations are integrating the sustainability principles and the climate change adaptation measures into the mining company's policies and strategies; and to identify, assess and align potential initiatives identified in this study that can be used as sustainability tools in linking the gold mining companies in achieving their associated SDGs, particularly SDG7- affordable and clean energy and SDG13- climate action.

In light of the above, this chapter will address the research gaps highlighted in chapter two of this study- theoretical and literature review; and provide useful contributions to the existing body of knowledge in the field of climate change adaptation, sustainable development and energy optimization in the gold mining industry. Therefore, this chapter is structured and broadly divided into five subsections. The first subsection (5.1) is this Introduction. The second subsection (5.2), presents discussions on the ways in which the gold mining operations are affected by climate change and how these impacts are being addressed and particularly in an effort to optimize on its

energy consumption. The third subsection (5.3), delvers to understand the feasibility of integrating sustainability principles into the climate change adaptation measures; and the fourth subsection (5.4), provides discussion on the feasibility of integrating the sustainability principles and climate change adaptation measures into the gold mining company's policies and strategies, in an effort to enhance the mine's adaptive capacity and achieve sustainable energy consumption. The fifth subsection (5.5), identifies and discusses potential initiatives linking the gold mining companies in achieving SDG7-affordable and clean energy and SDG13-climate action.

5.2 Climate change and Energy optimization in Gold Mining

Based on the empirical evidence presented in the previous chapter four of this Thesis, this study seems to suggest that there is a connection between climate change, energy consumption and gold mining. The relationship between climate change and energy consumption is highlighted in this study, in the sense that climate change can have a significant impact on gold mining in South Africa, which view is seen to be argued by Pearce et al. (2011) that climate change can pose a risk to the mining business. In light of this, this study suggests that mining productivity is most affected by the impacts of climate change, which is seen to have a financial consequences causing an increase in the mining operational costs when the gold mining operations make efforts to address the impacts of climate change. More so, mining productivity is affected by a reduction in productivity due to operational stoppages or down time caused by impacts of climate change like flooding or heat waves, which leads to reduced mine revenue due to no production.

In addition to financial losses caused by reduction in mining productivity, this study also seems to suggest that, the financial implications associated with the payment of carbon tax is another consequence of climate change on the gold mining company; which is identified by the company in its TCFD report, as a transitional climate change risk to the mining business. The payment of carbon tax is similarly identified by Cox et al. (2022) to be one of the effects of climate change on the gold mining companies; however, this is argued differently, in that carbon taxation on the mining industry is regarded as a financial benefit for the mining industry in the sense of implementation of the carbon tax. Cox et al. (2022) argues that the benefits of paying carbon tax is derived from mining having got a very high economic value per tonne of CO_2 emitted compared to the other industries, which therefore results in the tax benefitting the mining business, and that

the mining industry should therefore be seen to be supporting the implementation of the carbon tax. Similarly, Haites (2018); supports the adoption of carbon tax as an instrument used to cost effectively reduce greenhouse gas emissions; however, he further argues that it is difficult to assess the performance of carbon taxing because emissions can also be affected by other external factors like policies and economic conditions. Further noting that the effectiveness of the carbon taxing is also dependent on the effects of inflation, increases in real income and technology changes including changes in fossil fuel prices.

Furthermore, this study seems to suggest that climate change has got an impact on the availability of natural resources to include the water and energy resources required by the gold mining operations. This is discussed in the sense that water and energy resources are some of the natural resources seen to be affected by climate change and as argued by Gilsbach and Schütte (2019), these natural resources are the most crucial resources required by the mining operations given the fact that the nature of mining activities are highly dependent on these natural resources. The gold mining company has therefore identified "water security" and "energy security" as critical climate related risks that can have the potential to cause serious impact on the mining business. This view is supported by Bouhia (2018) who argued that, it is quite critical to integrated water into climate change responses in an effort to build natural resource resilience to climate change.

More to this, this study suggests that climate change is affecting the mining physical infrastructure due to the extreme variability in the weather events, for example increased temperatures and changes in the precipitation patterns causing either drier conditions or heavy rains leading to flash floods. This view is supported by Nelson and Schuchard (2011) who argued that sudden changes in weather conditions can pose physical risks including damage to mining physical infrastructure and its installations and mine processes for example the cooling requirements change according to the extreme weather conditions. Nelson and Schuchard (2011) further argue that mining companies should therefore put more emphasis in identifying climate change adaptation initiatives that focus on addressing the physical risks caused by climate change. This view is supported in this study, where the gold mining company is noted to have identified the physical and transitional risks associated with climate change, reported in the company's TCFD report.

Therefore, upon understanding that climate change is affecting the gold mining business, this study found it important to further establish the relationship existing between climate change and energy

optimization in gold mining; and in doing so, this study seems to suggest that indeed climate change is having an impact on how the gold mining operations are consuming the energy resource. This view is discussed in the sense that, the gold mining operations are increasingly consuming the energy resource due to the increase in temperatures caused by climate change. The gold mining operations are seen to be increasing their running hours of the ventilation cooling fans for the underground gold mining operations in an effort to increase the cooling process because of the increased high temperatures caused from the changing weather patterns, normally described as heat waves. Therefore, implying that due to the increased operation of the cooling equipment, this results in the increased consumption of the energy resource in an effort to combat the increased temperatures caused by climate change.

It is further noted that the increased consumption of the energy resource has got financial implications on the gold mining business; thus identified as one of the key risks seen to be affecting the gold mining business. This study finding is seen to support the views by Fattahi et al. (2018) who argued that most mining companies are still faced with increasing costs associated with their increased energy consumption and implementation of costly mining practices. Also seen to concur with the views by Müller (2018) who argues that energy costs in the mining industry have significantly increased the mining companies' overall operating costs. This view is however, found to contradict the views by Rábago et al. (2001) who claim that, despite the increased energy costs associated with the increased energy consumption due to climate variabilities; there are opportunities driven from the relationship between climate change and energy consumption, which is saving money by consequently saving energy and that energy savings are regarded to be profitable in strengthening economic vitality and at the same time lead to protection of the climate, and also improve living standards. Therefore, in view of the study findings and the views of different scholars; this study affirms that the gold mining operations are being impacted upon by climate change, which is affecting how the gold mining companies are consuming their energy resource, seen to have a financial impact on the mining business.

In taking cognizance that the gold mining operations are being faced with climate risks associated with the energy security, seen to be affecting the gold mining business; this study found that the gold mining operations are therefore, implementing energy efficiency measures in an effort to sustainably consume the energy resource and adapt to the changing climate by increasing the

mine's resilience towards the impacts of climate change. As argued by Votteler and Brent (2016), due to the increased consumption of electricity, coupled with the increased costs of electricity; mining companies in South Africa are seen to be investigating alternative sources of electricity in an effort to lower the mining operating costs and decrease their carbon footprint. In concurring with Votteler and Brent (2016), this study found that the gold mining operations are implementing energy efficiency measures in effort to address the impacts of climate change affecting its energy consumption that allow for optimizing on energy intense equipment and processes. In addition, the gold mining operations are reported to be implementing energy saving initiatives that generally cause reduction in energy consumption during mining operating peak times.

In addition to these, the gold mining operations are also reported to be implementing a number of energy saving projects to include: the upgrading of existing water jets to an automatic shut-off system when not in use; installation of inlet guide vanes and installation of variable speed drives on the main fans in order to optimize on ventilation supply particularly during the very cold winter seasons; and optimizing compressor air control based on demand requirements; including optimizing control of refrigeration units. Therefore, in controlling the operation of these energy intense equipment and processes, the gold mining operations are seen to be efficiently and sustainably utilizing their energy resource and consequently combating the impacts of climate change. These study findings are also seen to support the views of some scholars including Beg et al. (2011), who argued that energy efficiency measures are implemented to address the impacts of climate change; and as reported by Farrant (2016) in the AusIMM Bulletin; and from the views by Mardani (2013) that, the mining companies are seen to be implementing energy efficiency technologies in an effort to address the impacts of climate change.

Therefore, in further exploring the link between climate change and energy consumption in gold mining, this study also suggests that the gold mining operations are implementing a mix of its energy portfolio as alternative energy sources in effort to reduce the mine's dependency on fossil fuel generated electricity that contributes to GHG emissions causing climate change. Interestingly, this study also found that the gold mining operations are considering to use renewable energy as an alternative source of energy not only to reduce on the GHG emissions in an effort to reduce its carbon footprint, but also implemented in an effort to combat and adapt to the impacts of climate change and conserve the energy resource. The use of renewable energy in an effort to reduce the

GHG emissions is regarded as a mitigation measure as argued by Owusu and Asumadu-Sarkodie (2016), who noted that the implementation of sustainable renewable energies are efforts done to mitigate against climate change. However, as indicated in this study, that the mining operations are also considering to utilize renewable energy as an adaptation strategy to combat to the impacts of climate change on how the gold mining company is consuming its energy resource. Therefore, this study is seen to support the views by Chicco (2010) and Uitto et al. (2017) that the use of renewable energy is implemented as a measure to reduce on consumption of the costly fossil fuel generated electricity. In doing so, the gold mining operations are therefore, observed to be opting to advance projects related with improving on the energy supply and substantially reducing on the associated costs, as argued by Votteler and Brent (2016) that, mining companies are seen to be investigating alternative sources of electricity in effort to lower the costs of electricity and decrease their carbon footprints in terms of reduction in their GHG emissions.

More so, this study suggests that, the gold mining operations are considering the use of an energy mix portfolio which will include sourcing energy from independent power producers, to include; solar energy, wind energy and energy generated from natural gas. These findings are seen to agree with the views by Aliyu et al. (2018) that, South Africa is one of the African countries seen to overcome its energy crisis through the utilization of renewable energy sources and by encouraging energy efficiency. These study findings therefore affirm that gold mining operations in South Africa are aggressively pursuing the use of renewable energy; which view is seen to disagree with what was reported in the CDP (2017) report that the South African mining companies will take time to move away from utilizing fossil generated energy and into the use of renewable energy; similarly in contradiction to Bond and Erion (2009) argument that the South African government was seen to be less supportive of the use of renewable resources like solar and wind energy as the only logical ways of addressing the climate change crisis.

Furthermore, this study suggests that the energy efficiency measures, energy saving initiatives and the use of renewable energy in its energy mix by the gold mining operations, are regarded to be effective in combating the impacts of climate change on the energy resource. Therefore, this study findings are seen to disagree with the views by Uitto et al. (2017); Zeghici and Polizu (2013); and Chicco (2010) that, there is still lack of clear implementation of energy efficiency measures hence the need for improvement. Given the above study findings and supporting discussions from various

literature, this study can safely indicate that a relationship exists between climate change and energy consumption in gold mining, and that the gold mining operations have taken cognizance of this relationship by identifying the climate change related risks associated with energy consumption, and therefore are seen to proactively position themselves to address climate change and adapt to its impacts.

5.3 Sustainability Principles, Adaptation Measures and Energy Optimization in Sustainable Mining

This study sought to explore the feasibility of integrating sustainable development principles into climate change adaptation measures, in an effort to enhance the gold mining operations' adaptive capacity and achieve energy optimization. In light of this, this study first explored some of the sustainable development principles being implemented by the gold mining operations. In doing so, findings in this study therefore, suggest that the gold mining operations are implementing sustainability principles in their mining processes to include the principles of sustainable consumption of natural resources and in particular the sustainable consumption of the energy resource. This therefore, implies that the gold mining company is committed to efficiently consume its energy resources so as to achieve long-term sustainability. This study finding is seen to concurs with the views by Dubiński (2013); Mytelka et al. (2016); Votteler and Brent (2016) who argued that, the conservation of the energy resource is crucial especially at the time when South Africa's mining industry is taking cognizance of the depleting fossil generated fuel seen to be supplying most of its electricity, and also because of the high costs associated with the use of this fossil generated energy. The implementation of the sustainability principle of sustainable energy consumption is; however, contradicting the views by Zeghici and Polizu (2013) and Nelson and Schuchard (2011) that, it is difficult to achieve sustainable energy consumption within the mining industry, given the fact that mining companies are heavily dependent on the fossil fuel generated energy.

Furthermore, this study seems to suggest that, the gold mining operations are developing and implementing holistic business plans found to involve all the three elements of sustainable development. Some of these business plans are embedded in to projects like the sustainable energy projects designed to address the socio-economic issues and also have the potential to deliver on sustainable energy consumption for the mining operations and provide sustainable benefits to the

mining communities as well. This study finding is seen to support the views by Berg et al. (2017); Uitto et al. (2017) and Nelson and Schuchard (2011) who argue that sustainability is the integration of environmental, social and economic principles of sustainable development and that, these three elements of sustainable development can be integrated into mining operations to achieve sustainable development and lead to a positive impact on mining performance. This is similarly in agreement with the views by Soler and Marcé (2018) that, in an effort to achieve a sustainable business, the mining companies are seen to be implementing socio-economic mine business plans that contribute towards economic growth and social development of the mining communities and achieve environmental sustainability of the areas within which the mines operate. These observations are also noted to be supporting the views by Shen et al. (2015), who argued that the mining companies are contributing towards sustainable development by implementing community development initiatives that allow the mining company to generate employment and wealth within the communities they operate.

Therefore, in establishing that the gold mining operations are implementing sustainability principles through the sustainable consumption of the energy resource and by implementing holistic business plans that involves all the elements of sustainable development; this study further explored the feasibility of integrating the sustainability principles into the climate change adaptation measures. Given the empirical evidence provided in this study, this study seems to suggest that the gold mining operations are integrating the sustainability principles of efficient energy resource use, by implementing energy efficient measures designed to reduce the mines energy consumption and reduce its carbon footprint through emitting less GHGs reported to cause climate change. This implies that by implementing energy efficiency measures, the gold mining operations are essentially applying the sustainability principles of sustainable energy resource use and implementing these energy efficiency measures to adapt to the impacts of climate change. Therefore, this study finding implies that the energy efficiency measures are implemented as sustainability principles found to create a link between sustainable energy consumption and adaptation to climate change. These study findings are noted to collaborate with the views by Davidson et al. (2003) who argued that, the use of energy efficiency measures can be implemented as climate change adaptation measures and that these efficiency measures are a cost-effective strategy that includes climate strategies integrated in the development of energy security in effort to respond to climate change. More so, these views are similarly seen to concur with the views by

Beg et al. (2011) that, energy efficiency measures are implemented as both an adaptation factors against climate change, and as a measure to optimally consume the energy resource. The use of energy efficiency measures as climate change adaptation measures is also reported by Farrant (2016) in the AusIMM Bulletin, that mining companies are observed to be implementing emission reduction measures as climate change adaptive strategies in an effort to respond to the challenges of climate change.

Furthermore, this study suggests that the gold mining operations are adopting the use of renewable energy in their energy mix in an effort to adapt to the impacts of climate change and implemented as a strategy to optimize on the mine's energy consumption. This study finding is therefore seen to concur with the views by Rugină and Badea (2016) who argue that, renewable energy projects are implemented as a climate change adaptation measures. Therefore, energy efficient measures and renewable energy projects are identified in this study to be some of the climate change adaptation measures seen to be implemented by the gold mining operations in an effort to address issues around energy security, which is also identified as one of the climate related risks affecting the gold mining business.

In establishing that through the implementation energy efficiency measures, and by using renewable energy in the energy mix, the gold mining operations are integrating sustainability principles into their climate change adaptation measures, which measures are also regarded as sustainability tools that can be implemented by the gold mining companies to address the impacts of climate change and achieve sustainable development. These study findings are therefore seen to agree with the views by Rugină and Badea (2016) who have argued that, energy efficiency is a synergy existing between climate change and sustainable development; and the views by Elum and Momodu (2017) and Ley (2017) that, renewable energy projects are implemented in an effort to meet the triple objectives of sustainable development and climate change adaptation.

In addition, this study seems to give emphasis on the need and importance of engaging with different stakeholders during the development and implementation of climate change adaptation measures and projects that are designed to combat the impacts of climate change and achieve energy optimization. This view is argued that the gold mining operations are engaging with their stakeholders; which practice is regarded as a sustainability principle that requires the inclusion of

different stakeholders, in the development and implementation of the mining projects to include climate change adaptation and sustainable energy related projects. It is known that stakeholder engagement is normally done during the impact and risk assessment processes where the views and concerns of the stakeholders are obtained in an effort to implement a sustainable project. This, therefore, implies that different stakeholders are involved through an inclusive approach during the identification of potential risks and opportunities including identification of climate related risks. The inclusion of stakeholders means that these mining adaptation measures and projects will have considered the interests of the stakeholders including the mining communities. Therefore, the importance of engaging with different stakeholders as a sustainability principle seen to be integrated in the development and implementation of climate change adaptation measures as suggested in this study, is seen to support the views by Möhr-Swart et al. (2008) who emphasize the importance of engaging with stakeholders, as a key strategy in addressing the challenges affecting the achievement of sustainable development; and as argued by Ley (2017) that sustainable development cannot be achieved due to the lack of community involvement. This study finding is also seen to agree with the views by Kolk and Jonatan (2012) who argued that, a multi-stakeholder partnership should be considered as one of the approaches in integrating climate change and sustainable development.

Therefore, these study findings and the discussions presented herewith, affirm that a relationship exists between sustainable development principles, climate change adaptation and sustainable energy consumption in gold mining. This relationship is established through the implementation of energy efficiency measures and use of renewable energy regarded as sustainable adaptation measures, used in the integration of sustainability principles into the climate change adaptation measures, so as to enhance the mine's adaptive capacity towards climate change and achieve sustainable energy consumption. Figure 5.1 below, is drawn to demonstrate the adoption of these sustainability adaptation measures, implemented as sustainable tools, used to integrate sustainability principles and climate change adaptation measures, in an effort to achieve sustainable mining by adapting to the impacts of climate change and achieving sustainable energy consumption.

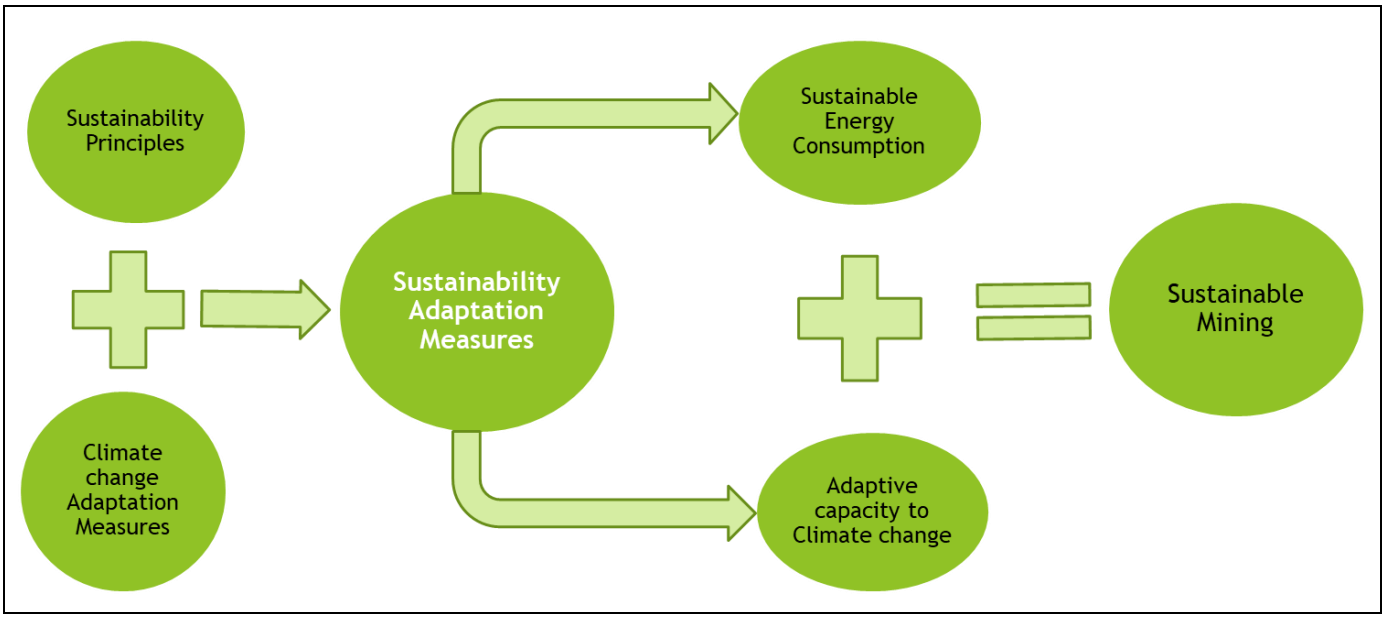


Figure 5. 1: Framework to Integrate Sustainability Principles and Climate Change Adaptation Measures to achieve Sustainable Mining

As we appreciate that the gold mining operations are seen to be integrating sustainability principles in to their climate change adaptation measures in an effort to enhance the mine's adaptive capacity and achieve sustainable energy consumption; this study therefore, found it equally important to further understand whether the gold mining operations are faced with challenges that are potentially causing limitations in fully integrating the sustainable development principles into their climate change adaptation measures; and the effective implementation of these adaptation measures as desired.

This study found it important to understand whether the gold mining operations were challenged in integrating the sustainability principles into their climate change adaptation measures. In gathering findings from the empirical evidence, this study therefore seems to suggest that due to delays in the implementation of the climate change related projects, the gold mining operations are not fully integrating the sustainability principles into their climate change adaptation measures. However, from reviewing the company ESG and Annual Integrated reports, there is evidence of sustainability adaptation measures and projects seen to have integrated the sustainability principles and being implemented as adaptation measures. Therefore, in discussing the limitations associated with delayed implementation of these sustainability adaptation measures; it is noted that because of the bureaucracies surrounding the implementation of some climate change adaptation projects, the issues surrounding sustainability are normally ignored and thus not integrated into these

climate change adaptation projects. This also implies that because of the lack of clear implementation processes required to provide guidance in the inclusion of sustainability issues into these climate change related projects, the sustainability principles are not incorporated into the development and implementation of the climate change adaptation measures. This study finding seems to not be discussed in the literature and this is new based on this research, therefore there is need to pay more attention to this issue. However, close to this finding, is the views by Zeghici and Polizu (2013) who also argued that, because of the lack of clear implementation of the energy efficient measures; it is difficult to deal with the consequences of climate change.

In addition, this study seems to suggest that, due to the high costs associated with the integration of sustainability principles into the climate change adaptation measures, the gold mining operations are seen to be challenged with integrating the sustainable development principles into their climate change adaptation related projects. This implies that due to the high costs associated with the implementation of climate change related projects found to have included the issues surrounding sustainability, the gold mining operations are seen to shy away from going an extra length to include the sustainability issues. It is known that, the inclusion of the sustainability issues will require additional costs to address these issues. However, upon reviewing the company documents, is was observed that the gold mining company has identified sustainable energy projects, to be implemented as climate change adaptation measures and found to have the potential of contributing towards sustainable mining and make contributions towards the socio-economic development of the mining communities. Therefore, this study finding concurs with the views by Mardani (2013), who argues that due to high costs associated with the implementation of the energy efficiency initiatives in effort to reduce emissions causing climate change, this is seen to be blocking the opportunities of integrating sustainable development principles and climate change. Furthermore, close to this study finding is the discussion presented by Epstein (2018) who argues that companies are challenged with how to integrate their corporate social, environmental, and economic impacts and corporate sustainability into the management decisions.

In taking cognizance of the challenges that have the potential to prevent the gold mining operations from effectively integrating the sustainability principles into their climate change adaptation measures, this study seems to suggest that the gold mining operations are therefore, implementing a number of interventions in effort to address these challenges. Findings from the empirical

evidence in this study seem to suggest that the gold mining operations are overcoming the challenge of limited capital funding by making financial provisions by creating funding opportunities in support of initiatives that allow for the integration of the sustainable development principles into climate change adaptation measures. An example of this, the gold mining company is noted to be aiming at increasing its total cost savings obtained from implementing some of its energy saving initiatives, and therefore use these cost savings to fund the implementation of additional energy efficiency capital projects; also regarded as adaptation measures to address the impacts of climate change. This implies that, by making sufficient financial funding for initiatives that include integrating sustainability principles into climate change adaptation measures, the gold mining company will effectively implement its desired sustainability adaptation measures that are deemed to be highly costly, and achieve sustainable mining and address the mining community socio-economic issues seen to be affected by climate change. It is observed that this study finding is not discussed in the literature and this is new based on this research, which needs further understanding; however, close to this study findings is the views by Davidson et al. (2003) who argued that companies are able to respond to the impacts of climate change when found to be implementing cost-effective climate related strategies.

More so, this study seems to further suggest that the gold mining operations need to conduct more feasibility studies in effort to address issues pertaining to limited understanding on how to integrate sustainability principles into climate change adaptation measures. This therefore, implies that the intervention to conduct research through undertaking feasibility studies to identify the opportunities and risks associated with integrating sustainability principles into the mining adaptation measures; this can provide avenues in which more knowledge is obtained and an understanding of how sustainability issues can be integrated into climate change adaptation related initiatives. The need to conduct additional feasibility studies as suggested in this study, concurs with the ICMM (2003) report, and the views by Bastida (2002), who argue that, research has played an important role in the facilitation of information required in the development of an adaptation strategy. The investment into adaptation science through research is; however, argued differently by Leiter (2017) and Wise et al. (2014), who claim that investments in adaptation science is not be enough, given the fact that mining companies are seen to be implementing less of their adaptation actions to address climate change; despite making substantial investments into adaptation science. Furthermore, this study finding is seen to not agree with the views by Epstein

(2018) who argues that, it is unlikely for any company to fully integrate or achieve sustainability, despite the fact that most companies have taken the initiatives to improve their sustainable performance and reduce their negative social and environmental impacts.

Besides the challenges faced by the gold mining operations in fully integrating the sustainability principles into its climate change adaptation measures, as discussed above; empirical evidence presented in this study, as observed from the interview process; seems to suggest that the gold mining operations are subsequently faced with challenges that have got the potential of limiting the mining operations from implementing their climate change adaptation measures as desired. Therefore, findings in this study seems to suggest that because of the reluctance by the gold mining operations in accepting and transitioning in the use of different mining methods or practices reported to contribute towards addressing the impacts of climate change; the gold mining operations will not be able to effectively implement their climate change adaptation measures as desired. These findings seem to be similar to what is reported in the CDP 2009 report (Sustainability, 2009), where the South African mining companies are reported to be slowing in the efforts to reducing their GHG emissions and address climate change. However, despite the identification of the issue of reluctance by the gold mining operations during the interview process; upon reviewing the company documents, this study further suggests that the gold mining company are seen to be implementing their climate change adaptation measures in effort to address issues around climate related risks and energy security, which risks are identified to have an effect on the gold mining business. Therefore, given all the evidence provided in the company documentation, of climate change adaptation measures and projects being planned and implemented; it is unlikely that the gold mining operations are reluctant to not implement these measures as desired.

In addition, empirical evidence gathered during the interview processes, seems to suggest that, due to limited capital funding, the gold mining operations are not able to implement some of their climate change adaptation measures as desired. However, on reviewing the company documents, it was again found that, the gold mining company is investigating a number of climate change adaptation projects to include carbon sinks, agriculture and water beneficiation projects, including implementation of biodiversity management action plans and land rehabilitation projects to be implemented in an effort to increase the mine's adaptive capacity to the impacts of climate change. More so, this study also suggests that the gold mining company is noted to be using some of the

cost savings made from implementing energy saving initiatives, to facilitate the implementation of additional projects. Therefore, it is quite unlikely that limited capital funding can be a reason for the gold mining operations to not implement their climate change adaptation measures as desired.

Therefore, in an effort to address some of these challenges, this study seems to suggest that by conducting more feasibility studies and research, the gold mining operations are able to gather more information relating to the effective implementation of their climate change adaptation measures. This study finding implies that there is limited information relating to the identification of effective climate change adaptation measures, which is similarly argued by Wise et al. (2014); Nelson and Schuchard (2011); and in the CDP 2009 report (Sustainability, 2009), that information relating to identification of climate change impacts and implementation of climate change adaptation measures within the mining industry is still lacking. Similarly as discussed above, the gold mining company is reported to already be investigating a number of climate change adaptation projects planned to be implemented by the gold mining operations.

In addition to conducting research, this study also seems to suggest that, through developing and effectively implementing the gold mining company integrated policies that relate to issues around climate change and sustainability, the gold mining operations will be able to effectively implement their climate change adaptation measures. More so, this study observed that the gold mining company has developed a climate change and energy policy that has integrated sustainability principles and energy optimization measures and climate change related issues into this policy. Some of these policy commitments state that, the gold mining company will; integrate the risks and opportunities associated with climate change and energy management into the gold mining company business strategy and; pro-actively integrate climate change adaptation measures into the gold mining company's business in effort to ensure the increased resilience of the gold mining business and communities to the impacts of climate change. Therefore, this study finding supports the views by Leiter (2017) and Wise et al. (2014), who argue that, mining companies are increasingly developing climate change adaptation policies and projects that continue to integrate adaptation into the mining planning processes. The views about policy being used as a tool to inform climate change adaptation is similarly supported by various scholars, including England et al. (2018); Connolly-Boutin and Smit (2016); Spear et al. (2015); Porter et al. (2014) and Cooper

et al. (2013), who note that climate change adaptation measures can be adopted through policy interventions.

5.4 Mining Company Policies and Strategies in Sustainable Mining

In establishing that a linkage exists between sustainable development principles, climate change adaptation measures and sustainable energy consumption in gold mining; this study further finds it equally important to explore the feasibility of integrating the sustainable development principles and climate change adaptation measures into the gold mining company policies and strategies. In doing so, from the empirical evidence gathered in this study from reviewing the identified company policies and strategies; this study found that the gold mining company has made developed policies and strategies found to integrate the sustainability principles and adaptation measures, in effort to mine sustainably. The gold mining company is noted to have developed a number of documents found to contain information pertaining to sustainable development, climate change and energy optimization. Amongst these documents, is the company climate change and energy policy statement found to contain information relating to how the gold mining company will take action to reduce its carbon footprint by improving its energy efficiency.

This implies that the gold mining company has taken cognizance of the importance of integrating the sustainability principles, adaptation measures and energy optimization measures into its relevant policies and strategies in an effort to respond to the transitional and physical risks posed by climate change to the mining business. Therefore, in an effort to integrate the sustainability principles and the adaptation measures in into the company's business process, it is observed that the gold company has made commitments in its climate change and energy policy statement regarding to how the gold mining company will integrate its risks and opportunities associated with climate change and energy management; and pro-actively integrate climate change adaptation measures into the company's business in an effort to increase the resilience of the mining business and the mining communities to the impacts of climate change.

The importance of policies to be used as medium in integrating sustainability principles and adaptation measures is therefore emphasized in this study, which is also seen to support existing literature and concur with the views by Rábago et al. (2001), who argues that through policy development and implementation, sustainable development can be achieved. In effort to

demonstrate the path in integrating sustainability principles and adaptation measures into the mining company policies and strategies in an effort to enhance the mine's adaptive capacity to the impacts of climate change and achieve sustainable energy consumption; this is drawn in Figure 5.2 below.

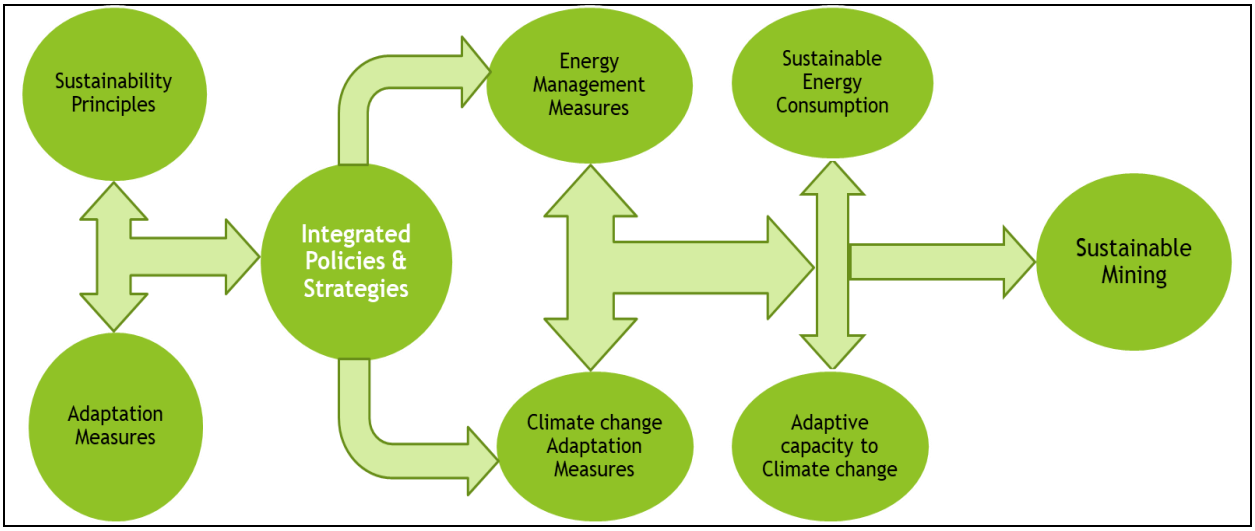


Figure 5. 2: **Integration of Sustainability Principles and Adaptation Measures in Mining Policies and Strategies to achieve Sustainable Mining**

More so, this study finding also agrees with the views of scholars like Wise et al. (2014); and Nelson and Schuchard (2011), who argue that, for mining companies to address climate change impacts, comprehensive management systems need to be developed including integration of climate considerations into the mining company strategic planning, and engaging with regulators so as to develop policy that support adaptation, and inform robust decision making that is under uncertainty.

Furthermore, this study seems to suggest that, through policy interventions, integrated policy commitments have the potential to influence and provide guidance in the engagement of stakeholders, which is a practice regarded as a sustainability principle that requires the inclusion and involvement of different stakeholders in the development, implementation and monitoring and reporting of the actions implemented to manage climate change risks. This implies that the gold mining company is seen to ensure that an inclusive approach is done to involve its stakeholders through frequent engagement during the identification and management of climate change related risks and opportunities. This study finding therefore is seen to support the views by Kolk and

Pinkse (2012) who argued that, multi-stakeholder partnership should be considered when developing sustainability adaptive measures.

5.5 Sustainable Mining to achieve Sustainable Development

Another emerging theme from this study evolved around how the gold mining companies can make contributions towards the achievement of the SDGs. This theory is founded from information reported in the previous studies and from existing literature, that the African continent is increasingly vulnerable to climate change given its inability to cope with the physical, human and socioeconomic consequences of climate extremities, which have affected the continent's pace of achieving sustainable development (UNESCO, 2015; CIGI, 2009). Similarly, it is reported that climate variabilities is affecting the sub-Saharan African region, where South Africa is seen to experience the strongest decrease in precipitation with concurrent risks of drought within the region. These climate variabilities within the region is reported to be exacerbating the challenges for energy resources that is increasingly exploited due to increased demand for reliable and affordable energy supplies coupled with the lack of infrastructure and facilities to use energy productively and efficiently and yet in turn pollute the environment (Connolly-Boutin & Smit, 2016).

Further still, literature has also shown that the mining industry increases the vulnerability of the communities in which the mines operate, to the impacts of climate change like temperature increases and water shortages (Peschka, 2014). It is however, argued that the mining industry is also seen to be making significant contributions to the GDP of the country, despite the fact that this may not make meaningful contributions towards sustainable development especially for the poor mining communities and whose livelihoods are affected by environmental degradation caused by mining activities (PAGE, 2016). It is therefore, reported that, in an effort to address these climate related challenges and achieve sustainable development, mining companies are required to apply corporate sensitivity and strong commitments towards implementation of sustainable development principles and best practices for the sustainable mining (ICMM, 2017). However, the UNESCO (2015) reported that the effective integration of mining into the African national and regional economies to achieve sustainable development is still a challenge; which was similarly, argued by Bhattacharya (2015b) that, achieving a balance between the elements of sustainable

development and the interrelationships between them, remains a challenge. More so, the CDP (2017) report, also notes that South African mining companies are observed to be slowing in the efforts to reduce emissions and address climate change and that the South African mining companies therefore, need to further integrate climate change into their risk management.

In taking cognizance of this existing literature as presented above, this study therefore found it important to further explore whether the gold mining companies have the potential to achieve their associated SDGs through the implementation of the initiatives discussed in this Thesis. The evidence presented and discussed in the preceding subsections 5.2, 5.3 and 5.4, seems to suggest that the gold mining company has got the potential to make significant contributions towards the achievement of the associated SDGs. In unpacking this, findings and discussions presented in subsections 5.2 and 5.3 above, are suggesting that through the implementation of energy efficiency measures the gold mining company is able to achieve sustainable energy consumption. This implies that by implementing its energy efficiency measures to improve energy efficiencies and achieve sustainable energy consumption, the gold mining company is able to achieve one of the key facets of SDG7 which is SDG7.3 that requires improvement in energy efficiency. More so, this study further suggests that the gold mining operations are implementing the use of renewable energy in their energy mix, which is regarded as a sustainable adaptation measures implemented in an effort to achieve sustainable energy consumption. This therefore, implies that by using renewable energy, the gold mining company is able to achieve the key facet of SDG7 which is SDG7.2 that requires increase share in renewable energy. Therefore, these study findings show that through the implementation of the energy efficiency measures and use of renewable energy in the energy mix, the gold mining company is able to achieve the SDG 7, which is affordable and clean energy. These study findings are found to concur with the views by Rugină and Badea (2016), who are noted to argue that, energy efficiency measures and renewable energy use, have the potential to contribute towards achieving sustainable development objectives.

In addition, this study seems to suggest that the gold mining operations are implementing energy efficiency measures, which are regarded as adaptation measures, implemented in effort to address the impacts of climate change. This implies that through the implementation of energy efficiency measures, the gold mining operations are seen to reduce their GHG emissions, and enhance the mine's adaptive capacity to the impacts of climate change. In doing this, the gold mining company

is therefore, seen to be implementing some of the key facets of SDG13; which is SDG13.1 that requires strengthening resilience to climate change hazards and disasters; and SDG13.3 that requires to improve capacity on climate change. This study therefore, suggests that, through the implementation of energy efficiency measures adopted as climate change adaptation measures, the gold mining company is able to be improving with adaptive capacity by strengthen its resilience to climate change hazards and disasters, thus achieving its SDG 13, which is action to combat climate change and its impacts. This study finding is therefore seen to support the views by Rugină and Badea (2016) that, energy efficiency measures can be used as a synergy existing between climate change and sustainable development. This is similarly, seen to concur with the views by Beg et al. (2011) that, the implementation of energy efficiency measures can be regarded as an adaptation factor against climate change, and at the same time be used as a measures to optimally consume the energy resource.

In addition to the findings and discussions presented in subsection 5.4, similarly provide insights linking the gold mining companies in achieving the associated SDGs. This study suggests that the gold mining company has developed policies and strategies that have integrated the sustainable development principles and climate change adaptation measures, in an effort to enhance the mine's adaptive capacity towards the impacts of climate change and achieve sustainable energy consumption. The gold mining company's climate change and energy policy is amongst the policies found to contain policy commitments relating to the integration of sustainability principles and adaptation measures into the company's business processes. More so, this policy is seen to make commitments relating to reduction in carbon intensity, implementation of emission reduction activities over a period of time; minimize reliance on fossil based energy sources; and monitor, track and report on the company's climate change impacts, actions and resilience; all commitments seen to enhance the gold mining company's adaptive and resilience towards the impacts of climate change and energy optimization. This therefore implies that, given the fact that the gold mining company has developed such a policy and is seen to be implementing these policy commitments, then this study suggests that, the gold mining company will be able to achieve the SDG13, and in particular specifically SDG13.1 which requires for the strengthening resilience to climate change hazards and calamities.

Further still, in review of the mining company's climate change and energy policy, the study seems to suggest that, given the fact that the gold mining company has developed policies found to have integrated climate change and energy management measures; and by making policy commitments that steer towards the integration of climate change and energy related risks and opportunities into the company's business strategy; the gold mining company is also able to achieve the key facets of SDG13 which is 13.2 that requires to integrate climate change measures in policy. Therefore, these study findings do suggest that the gold mining company is able to make significant contributions towards the achievement of the associated SDGs; however, this study finding is not discussed in the literature and this is new based on this research; therefore there is need to pay more attention to this issue.

5.6 Conclusion

In concluding this chapter 5, subsection (5.1) highlights the introduction to this chapter and subsection (5.2) discusses the impacts of climate change and its consequences on energy optimization in gold mining. Given the study findings, this study seems to concur with existing literature that the gold mining industry is being impacted upon by climate change, causing financial implications due to reduction in mine productivity, paying of carbon tax and due to the physical damage caused to the mine's infrastructure, and due to reduced availability of the water and energy resources. These study findings are therefore, seen to concur with the views by Cox et al. (2022); Gilsbach and Schütte (2019) and Pearce et al. (2011). This therefore, implies that a relationship exists between climate change and energy consumption in the gold mining industry. This is argued from the fact that the drastic changes in temperatures due to climate variability is causing an increase in energy consumption by the gold mining operations, reported to be increasingly utilizing their energy intense equipment driven to either increase cooling or heating effects in effort to combat the extreme weather events caused by climate change. The increase in energy consumption by the gold mining operations due to the impacts of climate change is suggested in this study to have financial implications to the mining business. This study finding is seen to support the views by Fattahi et al. (2018) who argued that most mining companies are still faced with increasing costs associated with their increased energy consumption and implementation of costly mining practices. These findings are similarly seen to support the views by Müller (2018) who also argues

that, energy costs in the mining industry have significantly increased the mining companies' overall operating costs hence having a financial implication on the mining business.

In an effort to address the impacts of climate change, this study seems to suggest that the gold mining operations are seen to be implementing energy efficiency measures and use of renewable energy in effort to address its climate change related risks and energy security. This study finding is seen to agree with the views of a number of scholars like Farrant (2016); Mardani (2013) and Beg et al. (2011) who have made arguments that, energy efficiency measures are implemented to address the impacts of climate change. Furthermore, this study is seen to agrees with the views by Uitto et al. (2017); Owusu and Asumadu-Sarkodie (2016) and Chicco (2010) that, the implementation of sustainable renewable energies is done to mitigate against climate change by reducing GHG emissions and reduction on energy consumption. However, this finding is found to disagree with what is reported in the CDP (2017) report that the South African mining companies will take time to move away from utilizing fossil generated energy and into the use of renewable energy. More so, this study also seems to suggest that the energy efficiency measures implemented by the gold mining operations are effective in achieving the desired goals; however, this study finding is found to contradict some scholars like Uitto et al. (2017); Zeghici and Polizu (2013) and Chicco (2010) who have argued that there is still need for improvement in the implementation of the energy efficiency measures.

In summarizing subsection (5.3), this study suggests that, a relationship exists between sustainable development principles, climate change adaptation and energy optimization in gold mining. This relationship is highlighted, when the gold mining operations are seen to be applying the principles of sustainable development by implementing sustainable adaptation measures to include energy efficiency measures and through the use of renewable energy in the energy mix, in an effort to enhance the mine's adaptive capacity towards climate change and achieve sustainable energy consumption. This study finding is therefore seen to supports the views of a number of scholar like Berg et al. (2017); Uitto et al. (2017) and Nelson and Schuchard (2011) who have argued that, sustainability is the integration of environmental, social and economic principles of sustainable development which can be integrated into mining operations to achieve sustainable development and lead to a positive impact on mining performance. However, the implementation of the sustainable development principle of sustainable energy consumption as suggested in this study is

seen to contradict the views of some scholars like Zeghici and Polizu (2013); and Nelson and Schuchard (2011) who are noted to argue that, it is difficult to achieve sustainable energy consumption within the mining industry, given the fact that mining companies are heavily dependent on the fossil fuel generated energy.

Furthermore, this study is also seen to support the views of a number scholars like Rugină and Badea (2016); Beg et al. (2011) and Davidson et al. (2003) who are seen to argue that, the use of energy efficiency measures can be adopted as adaptation measures implemented to address the impacts of climate change; therefore implemented as climate change adaptation measures. This therefore, affirms that energy efficiency is a synergy existing between climate change and sustainable development; implying that energy efficiency measures are seen to be a cost-effective strategy that includes climate strategies integrated in the development of energy security in effort to respond to climate change and achieve sustainable energy consumption. More so, this study finding concurs with the views by Elum and Momodu (2017); Ley (2017); Rugină and Badea (2016) and Gheorghiu et al. (2011) who have all attested to the fact that, renewable energy projects are implemented as a climate change adaptation measures in effort to achieve energy objectives and climate change adaptation and subsequently achieve sustainable development. Given these study findings and discussions thereof; in an effort to give emphasis the relationship existing between sustainable development principles, climate change adaptation and energy optimization; this study has therefore, demonstrated a framework. This framework illustrates the adoption of the sustainability adaptation measures being implemented as sustainable tools, to integrate sustainability principles and climate change adaptation measures, in an effort to achieve sustainable mining by adapting to the impacts of climate change and achieving sustainable energy consumption.

Furthermore, this study suggests that through stakeholder engagement, the gold mining operations are seen to apply the sustainability principles relating to the inclusion and involvement of stakeholders through an inclusive approach when developing and implementing the climate change adaptation measures. This study finding is therefore, seen to concur with the views of various scholars like Ley (2017); Kolk and Jonatan (2012); and Möhr-Swart et al. (2008) who argued that, a multi-stakeholder partnership should be considered as one of the approaches in integrating climate change and sustainable development, given the fact that stakeholder engagement is a key

strategy in achieving sustainable development and, because of lack of community involvement, achieving sustainable development can be hindered.

This study further suggests that, due to the reluctance and lack of acceptance to implement climate change adaptation measures, and due to limited capital funding coupled with the high costs associated with delays in implementation of climate change related projects; the gold mining operations are likely to be challenged in integrating sustainability principles into its climate change adaptation measures; and not to implement these sustainability adaptation measures as desired. However, from reviewing the company ESG and Annual Integrated reports, there is evidence of sustainability adaptation measures and projects being implemented at the different mining operations; which therefore, implies that the gold mining operations are integrating the sustainability principles and implementing the climate change adaptation measures as desired.

This study further suggests that interventions like: conducting feasibility studies to identify suitable cost effective sustainability adaptation initiatives; integrating of climate change issues into the mining company policies for implementation; and through making financial provisions to fund sustainability adaptation initiatives, the gold mining operations will be in a position to address some of the identified challenges. This study findings are therefore found to concur with what is reported in the ICMM (2003) report and from the views by Bastida (2002) that, research has played an important role in the facilitation of information required in the development of an adaptation strategy. Financing of adaptation science is, however, argued by Leiter (2017) and Wise et al. (2014), to not be enough, and that mining companies are seen to be implementing less of their adaptation actions to address climate change, despite making substantial investments into adaptation science.

As a summary of subsection (5.4), findings of this study and discussions thereof, show that mining company policies and strategies are integrating sustainability principles and climate change adaptation measures in an effort to address the impacts of climate change and achieve energy optimization. This implies that, through the integration of the sustainability principles and adaptation measures into the mining company's business strategies and processes including in the decision making process; the gold mining companies are able to enhance the mine's adaptive capacity to the impacts of climate change and achieve sustainable energy consumption. Therefore, it is observed that the mining company climate change and energy policy contains all the three

themes of this study to include; the sustainability principles, climate change adaptation measures and energy optimization. This policy is therefore, seen to provide guidance on how the gold mining company will take action to reduce its carbon footprint by improving its energy efficiency, which is argued to be done in collaboration with its stakeholders. This therefore, implies that the gold mining company has taken cognizance of the importance of integrating the sustainability principles, adaptation measures and energy optimization measures into its relevant policies and strategies in effort to respond to the transitional and physical risks posed by climate change to the mining business. This study finding is therefore seen to support the views by Rábago et al. (2001) who argues that, through policy development and implementation, sustainable development can be achieved. Also seen to agree with the views by Leiter (2017) and Wise et al. (2014), that mining companies are increasingly developing climate change adaptation policies and projects that continue to integrate adaptation into the mining planning processes. This view is similarly seen to support the views from various scholars like England et al. (2018); Connolly-Boutin and Smit (2016); Spear et al. (2015); Porter et al. (2014) and Cooper et al. (2013), who have argued that climate change adaptation measures can be adopted through policy interventions. Therefore, in collating these study findings and discussions thereof, this study has demonstrated the path in which sustainability principles and adaptation measures can be integrated into the mining company policies and strategies in an effort to achieve sustainable mining.

In subsection (5.5), this study further discusses initiatives that are likely to link the gold mining companies in achieving sustainable development. This was found to be an important aspect to be explored in this study, given that previous studies and existing literature, are noted to show that the mining industry in the sub-Saharan African region is seen to not be achieving sustainable development. This is reported to be attributed to the fact that the mining companies are heavily dependent on fossil generated energy which releases GHGs emissions contributing to climate change; and that the mines are increasing the vulnerability of the mining communities to the impacts of climate change by affecting the availability of the natural resources to these communities. Therefore, in exploring some of the study findings discussed in the subsections (5.2), (5.3) and (5.4), this study suggests that the gold mining company has got the potential to make significant contributions towards the achievement of the associated SDGs. This can be achieved through the implementation of energy efficiency measures (SDG7.3) in an effort to achieve sustainable energy consumption; and through the use of renewable energy in the energy mix

(SDG7.2), both measures adopted as sustainable adaptation measures implemented in an effort to achieve sustainable energy consumption which is SDG7-affordable and clean energy. Furthermore, this study suggests that the gold mining companies are able to achieve SDG13-climate action, through the implementation of both the energy efficient measures and use of renewable energy adopted as sustainable adaptation measures and implemented as climate change adaptation measures. This study finding is seen to agree with the views by Beg et al. (2011) who argued that the implementation of energy efficiency measures can be regarded as an adaptation factor against climate change, and at the same time be used as a measure to optimally consume the energy resource.

More so, these sustainable adaptation measures are implemented by the gold mining company in effort to enhance the mining company's adaptive capacity towards the impacts of climate change by developing and implementing climate change related policies (SDG13.2), observed in this study to have integrated the sustainability principles and adaptation measures. This therefore implies that, through the implementation of the integrated mining company climate change and energy policies and subsequently implementing these policies including the sustainability adaptation measures guided by these policies, the gold mining company will be able to strengthen its resilience to climate change hazards and disasters (SDG13.1) and improve its adaptive capacity to the impacts of climate change (SDG13.3).

These study findings are therefore seen to concur with the views by Rugină and Badea (2016) who argue that, energy efficiency measures and renewable energy use, have the potential to contribute towards achieving sustainable development objectives; including that energy efficiency measures can be used as a synergy existing between climate change and sustainable development. Therefore, this study is seen to agree with what is reported in the World Bank Annual Report (2016) and also argued by Bhattacharya (2015b), that the three dimensions of sustainable development are interlinked; however, what this study seems to not agree with, is that achieving a balance between these three dimensions of sustainable development and the interrelationships between them, is a challenge.

CHAPTER SIX
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter aims at collating the most significant issues that were identified in integrating the sustainable development principles and climate change adaptation measures of gold mining operations; and structuring of these principles and measures into the gold mining company's policies and strategies, in order to build the gold mining operations' adaptive capacity and resilience against the impacts of climate change, and achieve sustainable energy consumption. The study focused on gold mining operations located within the Witwatersrand Basin in South Africa as a case study, and engaged with various literature and mining experts at the gold mining operations including reviewing of various documents for the gold mining company. In this study, the effects of climate change on the energy consumption for gold mining was explored. The feasibility of incorporating sustainability principles into the gold mining operations' climate change adaptation measures and potential challenges associated with this, was also investigated in this study, including exploring the feasibility of integrating the sustainability principles and climate change adaptation measures into the gold mining company's policies and strategies.

The ways in which the gold mining operations are adapting to the impacts of climate change to achieve sustainable energy consumption is discussed in the previous chapter. Including the ways in which the gold mining operations are integrating the principles of sustainable development into their climate change adaptation measures and further integrating these principles and measures into the mining company's policies and strategies, in an effort to enhance the mine's adaptive capacity to the impacts of climate change and achieve sustainable energy consumption; is also discussed in the previous chapter. The relationship existing between the discussed sustainability adaptation measures and the associated SDGs including the feasibility of the gold mining companies in making significant contributions to achieving these SDGs is also discussed in the previous chapter. This chapter is therefore, the final part of this thesis, which is collating the significant empirical findings of this study including the highlights of the discussions, and then provide suggestions for mining policy interventions and for future research purposes.

This chapter is divided into six subsections: The first subsection (6.1) is this Introduction to the chapter; the second subsection (6.2) presents the summary of the research objectives and major finding observed from the empirical evidence by providing answers to the various research questions of this study; the third subsection (6.3) is logical conclusions drawn from the empirical findings and discussions presented in relation to the research aim and objectives of this study; and the fourth subsection (6.4) presents recommendations drawn from this study for mining policy intervention. The fifth subsection (6.5) presents the limitations of the study and suggestions for further research and the sixth subsection (6.6) presents the conclusion to this chapter.

6.2 Summary of the Research Objectives and Major Findings

The study focused on gold mining operations located within the Witwatersrand Basin in South Africa as a case study, and engaged with various literature and mining experts at the gold mining operations including reviewing of various documents for the gold mining company. In this study, the effects of climate change on the energy consumption for gold mining was explored. Furthermore, the feasibility of incorporating sustainability principles into the gold mining operations' climate change adaptation measures and the potential challenges associated with this including the measures implemented to address these challenges, was investigated in this study. More so, this study explored the feasibility of integrating the sustainability principles and climate change adaptation measures into the gold mining company's policies and strategies.

In doing so, this study therefore achieved its research objectives by determining the ways in which the gold mining operations are adapting to the impacts of climate change to achieve sustainable energy consumption. Including establishing the ways in which the gold mining operations are integrating the principles of sustainable development into their climate change adaptation measures and how these principles and measures are integrated into the mining company's policies and strategies, in an effort to enhance the mine's adaptive capacity to the impacts of climate change and achieve sustainable energy consumption. This research further achieved its research objective in determining the relationship existing between the sustainability adaptation measures and the associated SDGs including the feasibility of the gold mining companies in making significant contributions to achieving these SDGs.

In answering the research questions and achieving the research objectives, the following major findings are recorded for this study:

a) A Linkage exists between Climate Change and Energy Consumption in Gold Mining

Gold mining operations are noted to be impacted upon by climate change, affecting the mining productivity due to reduced availability of natural resources to include water and energy resources that are critical for the mining processes. The reduction in mining productivity is noted to have subsequent increase in mining operational costs, causing financial implications to the mining business. Therefore, in understanding that climate change has an effect on gold mining business, this study further found that climate change has an impact on how the gold mining operations consume the energy resource. This is attributed to the fact that due to changes in temperatures caused by extreme climate variabilities, the gold mining operations are seen to increase in consumption of the energy resource through the increased utilization of their energy intense equipment driven to either increase cooling or heating effects, in an effort to combat the extreme weather events caused by climate change. Similarly, the increase in energy consumption was noted to have financial implications to the gold mining business, therefore in an effort to address the impacts of climate change and particularly on the energy resource, the gold mining operations are seen to be conserving the energy resource through the implementation of energy saving initiatives, energy efficiency measures, and use of renewable energy in their energy mix, which measures have been deemed to be effective.

b) A Linkage exists between Sustainability Principles, Climate Change Adaptation and Energy Optimization in Gold Mining

In effort to explore the ways in which the gold mining operations are incorporating the sustainable development principles into their climate change adaptation measures, this study found that, the gold mining operations are implementing sustainable development principles through the sustainable use of its resources particularly the water and energy resources. This study also found that the gold mining operations are applying the principles of sustainable development by implementing holistic business plans found to address all the three elements of sustainable development; social, economic and environmental issues. These business plans are inform of sustainable development projects for example the sustainable energy projects that are designed to

address socio-economic issues and environmental management. More so, this study found that the gold mining operations are implementing the sustainability principles of natural resource conservation, through the efficient use of the energy resource by implementing energy efficiency measures in effort to conserve the energy resource and address the impacts of climate change.

In further establishing the linkage existing between sustainable development principles and climate change adaptation measures, this study found that the gold mining operations are seen to be integrating the principles of sustainable development into their climate change adaptation measures through the implementation of principles relating to sustainable energy consumption, efficient energy use and use of renewable energy in an effort to achieve energy optimization. Similarly, these sustainability principles were noted to be adopted by the gold mining operations to be implemented as climate change adaptation measures in an effort to enhance the operations' adaptive capacity to the impacts of climate change. Therefore, the energy efficiency measures and use of renewable energy are measures seen to have integrated the sustainability principles of sustainable resource use and adopted as adaptation measures. These measures are therefore, being regarded as sustainability adaptation measures, implemented to address the climate related risks and energy security. This study has therefore, demonstrated a framework that shows how sustainability adaptation measures can be adopted as sustainable tools used to integrate sustainability principles and climate change adaptation measures, and implemented by the gold mining operations in an effort to achieve sustainable mining by adapting to the impacts of climate change and achieving sustainable energy consumption.

c) Integration of Sustainability Principles and Adaptation Measures in Gold Mining Company Policies and Strategies

The gold mining company is seen to have developed policies and strategies that have integrated the sustainability principles, climate change adaptation measures and sustainable energy consumption initiatives. An example of these policies and strategies is the gold mining company's climate change and energy policy and strategy found to have integrated the sustainability principles, climate change adaptation measures and energy management; in which policy commitments are stipulated in encouraging stakeholder engagement during the identification of climate related risks and energy security issues, including commitments relating to the need to

integrate the risks and opportunities that are associated with climate change and energy management, and pro-actively integrate the climate change adaptation measures into the mining company's business, in effort the increase the resilience of the mining business and communities to the impacts of climate change. This study finding therefore, shows that through development and implementation of integrated policies, sustainable mining can be achieved. In effort to emphasize this concept, this study has demonstrated a pathway that shows the development of policies and strategies found to integrate the sustainability principles and adaptation measures, in an effort to achieve sustainable mining.

d) Feasible cost effective sustainability adaptation measures to achieve sustainable mining

On the other hand, this study was also interested in exploring what could be some of the challenges faced by the gold mining operations in effectively integrating the sustainability principles into their climate change adaptation measures, in an effort to address the impacts of climate change and achieve energy optimization. In doing so, the study found that the gold mining operations claim that, because of limited capital funding to finance the process involved in integrating the sustainability principles and adaptation measures, the gold mining operations may not be able to effectively integrate the sustainability principle requirements into the development and implementation of their climate change adaptation measures as desired. More so, the lack of sufficient funds is claimed to be causing delays in implementation of these climate change adaptation related projects and sustainable energy projects due to the high costs associated with such projects. Therefore, in an effort to address these challenges, this study notes that the gold mining operations should conduct more feasibility studies and research, so as to attain information and understanding of feasible cost effective sustainability adaptation measures that can be implemented to achieve the objectives of climate change adaptation and sustainable energy consumption and ultimately lead to sustainable mining including addressing the socio-economic issues of the mining communities. In addition to this, it is also noted that the gold mining operations should make financial provisions for capital funding models, in an effort to finance some of these sustainability adaptation measures designed to achieve sustainable mining and address the socio-economic issues of the mining communities.

e) An Interrelationship exists between SDG 7-Affordable and Clean Energy and SDG 13-Climate Action in Gold Mining

Given the empirical evidence and the discussions thereof in this study coupled with the existing literature, implications of these study findings are drawn in a wider context, relating of the linkage existing between the SDGs and the potential for gold mining companies to achieve these SDGs. Literature has shown that the gold mining industry within the sub-Saharan African region is seen to not be achieving its SDGs, and in particular SDG 7- affordable and clean energy and SDG 13- climate action. This is attributed to the fact that mining companies in the region are heavily dependent on fossil generated energy which releases GHGs emissions contributing to climate change. However, the empirical evidence provided in this study and the discussions thereof, show that the gold mining company has developed sustainability adaptation measures found to address both climate related risks and energy security. These sustainability adaptation measures include energy efficient measures (SDG7.3) and use of renewable energy in the energy mix (SDG7.2), which measures are adopted as adaptation measures implemented in an effort to address the impacts of climate change (SDG13) and achieve sustainable energy consumption (SDG7). Furthermore, this study found that the gold mining company is developing and implementing climate change related policies (SDG13.2), observed in this study to have integrated the sustainability principles and adaptation measures. This therefore implies that the gold mining company will be able to strengthen its resilience to climate change hazards and disasters (SDG13.1) and improve its adaptive capacity to the impacts of climate change (SDG13.3). These study findings therefore, shows that there is a relationship existing between the sustainability principles of sustainable energy resource use (SDG7) and efforts to combat the impacts of climate change (SDG13) in gold mining.

6.3 Logical Conclusions

Based on the key findings drawn from this study and discussions thereof, it can be seen that the research questions, aim and objectives of this study have been empirically explored, investigated and achieved, respectively. Therefore, it can be logically concluded that under the present conditions, and based on the findings that informed this research, that:

a) A linkage exists between climate change and energy use in gold mining, where it is observed that climate change is impacting on gold mining activities including how the gold mining operations consume their energy resource. Therefore the gold mining operations are increasingly consuming their energy resource in an effort to combat the impacts of climate change. The increased energy consumption has got financial implications to the mining business, therefore, the gold mining operations are seen to take cognizance of this relationship existing between these two variables (climate change and energy) and the associated climate related risks and energy security. The gold mining operations are therefore, seen to proactively position themselves to adapt to the impacts of climate change and consume energy optimally by implementing energy efficiency measures and using renewable energy in the energy mix; which measures are deemed to be effective in achieving the desired goals.

b) A relationship exists between sustainable development principles, climate change adaptation measures and energy optimization in gold mining. The existence of this relationship is associated with the development of sustainability adaptation measures derived from integrating sustainability principles into climate change adaptation measures in energy optimization. These sustainability adaptation measures include energy efficiency measures and use of renewable energy, seen to be implemented by the gold mining operations in an effort to address climate related risks and energy security, in effort to enhance the mine's adaptive capacity towards climate change and achieve sustainable energy consumption. The importance of engaging with different stakeholders as a sustainability principle for stakeholder inclusion during the development of the sustainability adaptation measures is also emphasized to be quite an important aspect of this process. This therefore, affirming that through the implementation of sustainability adaptation measures, sustainable mining can be achieved.

c) Mining company policies and strategies are seen to integrate sustainability principles, climate change adaptation measures and sustainable energy initiatives, which policies and strategies are used to guide the mining company in effectively and holistically address climate related risks and energy security, by enhancing the mining operations' adaptive

capacity to the impacts of climate change and achieve sustainable energy consumption. The importance of engaging with different stakeholders during the development of such integrated policies and strategies is emphasized. This therefore, affirming that through policy development and implementation, sustainable mining can be achieved.

d) Feasible cost effective sustainability adaptation measures are identified as some of the initiatives to be implemented in an effort to address some of the challenges associated with limited capital funding seen to be preventing the effective integration of sustainability principles into the climate change adaptation measures; and in implementation of climate change and sustainable energy related projects designed to achieve sustainable mining including addressing the socio-economic issues of the mining communities.

e) Taking into consideration of the empirical findings and discussions in this study and based on the existing literature; a relationship exists between the SDG7- affordable and clean energy and SDG13- climate action, in gold mining. This relationship is attributed to the fact that the gold mining company is seen to be implementing sustainability adaptation measures to include implementing energy efficiency measures (SDG7.3) and use of renewable energy in the energy mix (SDG7.2), in an effort to enhance the mining company's adaptive capacity to the impacts of climate change (SDG13- climate action) and achieve sustainable energy consumption (SDG7- affordable and clean energy). More so, the relationship between these two SDGs is emphasized from the fact that the gold mining company has developed policies and strategies that have integrated initiatives that are key facets in achieving both SDGs. This therefore, affirms that the gold mining company has the potential to achieve both these SDGs and ultimately make contributions towards achieving sustainable development.

6.4 Recommendations

Based on the empirical findings, objectives, discussions and conclusions of this study, it is argued that, climate change has an impact on the gold mining operations including impact on how the gold mining operations consume their energy resource, which is consequently having financial implications on the overall mining business. In recognition of this, the gold mining operations are seen to respond to the climate change related risks and energy security, by positioning themselves

to develop sustainability adaptation measures found to integrate sustainability principles and climate change adaptation measures. These sustainability adaptation measures are implemented to enhance the mining operations' adaptive capacity and achieve sustainable energy consumption. Despite being heavily dependent on fossil generated energy and seen to be significantly contributing to the emission of GHGs causing climate change, the gold mining operations have got the potential and an opportunity to make significant contributions towards the achievement of the associated SDGs. Therefore to enhance the gold mining company's efforts to effectively adapt to the impacts of climate change, achieve sustainable energy consumption, and consequently contribute towards the achievement of associated SDGs by 2030; this study makes the following recommendations for policy interventions and opportunities for future research within the mining fraternity.

The policy interventions recommended herewith are presented, taking the mining industry in perspective and in particularly the mining company's policies and strategies that are developed and implemented to enhance mining operations continuous improvements through the adoption of best practices identified from research. Therefore, this study recommends the following mining policies interventions:

a) Mining Companies collaboration on Regional Adaptation Strategies

Literature shows that the sub-Saharan Africa region is to be affected by extreme weather events and South Africa is seen to already be experiencing the strongest decrease in precipitation within the region. It is also reported that the climate variabilities within the region is exacerbating the challenges of the energy resources, which resources are seen to be increasingly consumed by the mining industry in an effort to combat the increased temperatures caused by climate change. Furthermore, the mining industry is also seen to be consuming the fossil generated energy known to be contributing to climate change. These are therefore reported to be some of the contributing factors inhibiting the sub-Saharan African region from achieving sustainable development. It is therefore befitting that the mining companies in the region are seen to explore opportunities for collaboration within the geographic region and share information and best practices including implementation of regional and large scale climate change adaptation strategies.

b) Develop Comprehensive Integrated Mining Policies

Given that policies are important tools used to inform decision making and that climate change adaptation measures can be adopted through policy interventions; it is found that mining company policies and strategies have integrated the sustainability principles, climate change adaptation measures and sustainable energy initiatives, formulated to guide the mining company in effectively and holistically addressing the climate risks and energy security known to be affecting the mining business. It is therefore important to encourage the integration of sustainability principles and adaptation measures into mining company policies and strategies, to provide guidance and practices to be adopted by the mining operations. It is anticipated that such policies will influence and determine the development of site/ Asset specific adaptation initiatives that are designed to focus on the site level energy security and climate change related risks, taking consideration of the socio-economic risks and opportunities for the mining communities. Identification of localized impacts at the site/ Asset level is critical to adaptation planning especially for the mining companies whose facilities or mining operations are widely spread within the country.

c) Developing Integrated Sustainability Adaptation Measures

Literature shows that some mining operations are located in environmentally sensitive regions, and that mining activities are seen to cause environmental degradation and increase the vulnerability of the communities to the impacts of climate change such as temperature increases and water shortages. Therefore, mining companies are seen to support the climate-change commitments of its host communities; however, literature has shown that the measures implemented by the mining companies are geared towards addressing mining related risks affecting mining production and with less emphasis to address the socio-economic issues of the mining communities. Therefore, there is opportunity for mining companies to consider the integration of sustainability principles into its adaptation measures and plans, designed to holistically address the energy security and climate change related risks and opportunities affecting the mining operations and their host communities.

In doing so, the mining companies have the opportunity to explore sustainability adaptation projects that can enhance the mining operations and communities adaptive capacity to impacts of climate change and contribute towards strengthening the socio-economic status of the mining communities. This will therefore, require the proactive engagement with different stakeholders

including the mining communities, during the process of identifying climate change related risks and opportunities and in developing sustainable adaptation measures. These measures are expected to adequately address the climate-change risks and responses, taking cognizance of the sensitivity and adaptive capacity of host communities. The stakeholder engagement process allows for the mining companies to share researched scientific information for site planning and advice on community emergency planning and preparedness practices. It is also noted that as climate change allows new ecosystems to evolve, new issues emerge from this; therefore, it is imperative to collaborate initiatives that addresses the evolving needs of the mining operations and communities affected by climate change.

d) Invest in Feasible Cost Effective Sustainability Adaptation Measures

The gold mining operations are seen to have developed sustainability adaptation measures that have integrated sustainability principles and climate change adaptation measures; to include energy efficiency measures and use of renewable energy into the energy mix. Similarly, it is observed that implementation of these sustainability adaptation measures can drive the mining operations to addressing climate related risks and energy security by enhancing the mining operations' adaptive capacity to the impacts of climate change and achieving sustainable energy consumption. Therefore, mining companies are encouraged to invest more in implementing these sustainability adaptation measures by making financial provisions and capital funding models designed to facilitate the development and implementation of these sustainability adaptation measures. Furthermore, the gold mining companies are encouraged to invest in proactive planning that involves conducting feasibility studies that will inform the suitability of applicable and cost effective sustainability adaptation measures.

e) Integrate Sustainability Adaptation Planning in Mining Strategic Planning

Adaptation planning to climate change is important in proactively developing and implementing actions to reduce the risks and optimize on the opportunities associated with climate change. More so, sustainability is being regarded as an adaptation issue concerning the ways in which the social and economic domains are changing in the environmental domain including the resulting actions. This therefore, implies that sustainability adaptation measures do require actions that transform the interactions existing between the social, economic and environmental domains, in effort to

achieve a sustainable balance among civil society, the economy and the environment. Prior to developing and implementing sustainability adaptation measures, it is necessary to undergo sustainability adaptation planning in an effort to use knowledge obtained from the climate change scenario analysis and climate change assessments, required to shape and implement actions developed from informed decision-making. Therefore, sustainability adaptation planning process will allow for the inclusion of sustainability principles when undertaking adaptation planning processes, so as to develop actions that take cognizance of the social, economic and environmental aspects. This is important for the mining companies because, through sustainability adaptation planning which is undertaken during the strategic business processes; the mining companies will have the opportunity to proactively plan, develop and implement sustainability adaptation measures designed to holistically address the climate change related risks and opportunities affecting the mining operations and their host communities, and achieve sustainable mining and sustainable development.

f) Develop and Implement Initiatives Designed to Integrate and Achieve Associated Mining Related SDGs

Given that this study found that a relationship exists between the SDG7- affordable and clean energy and SDG13- climate action, in gold mining; and that this relationship is attributed to the fact that the gold mining companies are seen to be implementing sustainability adaptation measures to include implementing energy efficiency measures (SDG7.3) and use of renewable energy in their energy mix (SDG7.2) and that the gold mining companies have developed policies and strategies that have integrated initiatives that are key facets in achieving both SDGs. Therefore, this study further recommends that in an effort to enhance the mining company's adaptive capacity to the impacts of climate change (SDG13- climate action) and achieve sustainable energy consumption (SDG7- affordable and clean energy), mining companies should consider developing and implementing initiatives designed to integrate associated SDGs in an effort to achieve sustainable mining.

6.5 Limitations of the Study and Suggestions for Future Research

This study largely confined to the gold mining industry, therefore placing focus on some gold mining operations located within the Witwatersrand Basin of South Africa. This research

concentrated on the integration of sustainable development principles and climate change adaptation measures; including the integration of these principles and measures into the gold mining company policies and strategies, in effort to enhance the mining operations adaptive capacity to the impacts of climate change and achieve energy optimisation. This study also confined its research participants to include only targeted mining employees working in the fields of climate change, energy and sustainable development. Therefore, a systematic adaptation of the gold mining operations to the impacts of climate change will require that the sustainability adaptation measures derived from the integration of sustainability principles and adaptation measures incorporated into the mining company policies and strategies; are adequately implemented. Therefore, the following research gaps have been identified, which are proposed as new areas of research:

a) It is imperative that other mining personnel should be involved in a similar study in an effort to ascertain their views, given the fact that this study confined itself to only targeted employees working in the fields relating to climate change, sustainable development and energy.

b) It is found that the gold mining operations have developed sustainability adaptation measures that have integrated sustainability principles and climate change adaptation measures. Therefore, it is imperative to investigate the success of implementation of these sustainability adaptation measures, claimed to be effective in enhancing the mining operations' adaptive capacity to the impacts of climate change and achieving sustainable energy consumption.

c) To further ascertain that the gold mining operations are effectively implementing their sustainability adaptation measures; it is imperative to investigate how these measures are integrated into the existing mining management systems.

d) Furthermore, research needs to be done to further investigate whether these sustainability adaptation measures are similarly enhancing the mining communities' adaptive capacity to the impacts of climate change and contributing towards strengthening the socio-economic status of the mining communities.

e) In as much as this study suggests that gold mining companies have the potential to make significant contributions in achieving the associated SDGs in the mining sector, through the development of integrated policies and strategies and implementation of its sustainability adaptation measures, it should however, be noted that this conclusion was drawn from the indirect inference made from some of the empirical findings and discussions presented in this study including information gathered from existing literature. Therefore, in an effort to further establish whether the gold mining companies are achieving the associated SDGs, it is imperative to measure and monitor the implementation of these SDGs at the gold mining companies.

6.6 Conclusion to Chapter Six

In summarizing this chapter 6 of the thesis; the first subsection (6.1) provides an introduction to the chapter, and the second subsection (6.2) presents the summary of the achievement of the research objectives and major finding observed from the empirical evidence found from answering the various research questions of this study. This subsection further summarizes the achieved research objectives, that the ways in which the gold mining operations are adapting to the impacts of climate change to achieve sustainable energy consumption has been determined; and that the ways in which the gold mining operations integrate the principles of sustainable development into their climate change adaptation measures has been established. Including establishing that the sustainability principles and adaptation measures can be integrated into the mining company's policies and strategies in an effort to achieve sustainable energy consumption and sustainable mining. Lastly this study achieved its research objective by identifying, assessing and determining the potential initiatives linking the gold mining companies in achieving Sustainable Development Goal 7 (SDG7)-Affordable and Clean Energy; and Sustainable Development Goal 13 (SDG13)-Climate Action.

In summarizing the third subsection (6.3), a logical conclusion is therefore drawn from the empirical findings and discussions in relation to the research aim and objectives of this study, noting that under the present conditions; a relationship exists between climate change and energy consumption in gold mining, therefore in an effort to address risks associated with climate change and energy security, the gold mining companies are integrating sustainability principles and

climate change adaptation. In conceptualizing this relationship, this study developed a conceptual framework to demonstrate how sustainability adaptation measures can be adopted as sustainable tools used to integrate sustainability principles and climate change adaptation measures in an effort to adapt to the impacts of climate change and achieving sustainable energy consumption. Furthermore, this study made a logical conclusion that a relationship exists between sustainability principles and adaptation measures, which are integrated in gold mining company policies and strategies in an effort to provide guidance in their implementation. This relationship is similarly conceptualized in form of a pathway, that this study developed showing how sustainability principles and adaptation measures are integrated into mining policies and strategies in an effort to achieve sustainable mining.

This study further concludes that gold mining operations do consider to implement feasible cost effective sustainability adaptation measures in an effort to achieve sustainable mining. More so this study concludes that an interrelationship exists between SDG 7-affordable and clean energy and SGD 13-climate action in gold mining, and that gold mining companies have the potential to make meaningfully contributions towards the achievement of these goals. Recommendations drawn from this study are presented in the fourth subsection (6.4) where this study makes a few recommendations for policy interventions and opportunities for future research within the mining fraternity. These include; mining companies in the region are seen to explore opportunities for collaboration within the geographic region and share information and best practices including implementation of regional and large scale climate change adaptation strategies; the need for mining companies to consider the integration of sustainability principles and adaptation measures into mining company policies and strategies, so as to provide guidance and practices to be adopted by the mining operations; and encouraging gold mining to invest in proactive planning that involves conducting feasibility studies that will inform the suitability of applicable and cost effective sustainability adaptation measures; further recommend gold mining companies to integrate sustainability adaptation planning into the strategic planning for their mining operations; and lastly recommend that gold mining companies should consider developing and implementing initiatives designed to integrate associated SDGs in an effort to achieve sustainable mining.

Limitations to this study are presented in the fifth subsection (6.5) where it is noted that this research was largely confined to the integration of sustainable development principles and climate

change adaptation measures into gold mining company policies and strategies. This study was largely confined to the gold mining industry, particularly gold mining operations located within the Witwatersrand Basin of South Africa and only focused on targeted mining personnel identified as research participants found to be knowledgably in the fields of climate change, energy and sustainable development. The integration of sustainable development principles and climate change adaptation measures; and their integration into the gold mining company policies and strategies, in effort to adapt to the impacts of climate change and achieve energy optimisation was the main focus of this research. In light of these limitations, this study therefore identified a few gaps in this study therefore making the following propositions that, it is imperative that other mining personnel should be involved in a similar study in an effort to ascertain their views. The success of the identified sustainability adaptation measures should be investigated including determining how these adaptation measures are integrated into existing mining management systems; and whether through the implementation of these adaptation measures, the gold mining operations are in position to make contributions towards strengthening the socio-economic status of their host communities; and ultimately make significant contributions in achieving the associated SDGs particularly within the mining sector.

6.7 Overall Thesis Conclusion

It is known that South Africa being a mining-intense country and located in the sub-Saharan African region, is being affected by extreme weather events which are increasing the country's vulnerability to climate change impacts and therefore reducing the chances of achieving sustainable development. The mining industry is one of the sectors being affected by the impacts of climate change and yet this sector is one of the most energy intensive industries significantly contributing to GHG emissions through operation of energy intensive processes. South Africa being a mining intense country, it is however, noted that South African mining companies are slowing in the efforts to reduce emissions and address climate change, therefore needing to further integrate climate change into their risk management. In light of this, mining companies are being pressured to make strong commitments towards implementation of sustainable development principles for sustainable mining.

This study therefore aimed at investigating how sustainable development principles and climate change adaptation measures are interlinked and structured; and embedded in a gold mining

company's policies and strategies, in an effort to build the mining operations' adaptive capacity and resilience against the impacts of climate change and achieve energy optimization. The challenges that can potentially prevent the effective integration of the sustainability principles and adaptation measures were also explored. Using a case study approach, this study was centred on the gold mining operations located within the Witwatersrand Basin of South Africa. Research data was collected from multiple sources, therefore employing a mixed method approach by applying the concurrent triangulation technique. Different analytical tools of policy, content and inductive data analysis, and descriptive statistical data analysis were applied.

The research questions, aim and objectives of this study have been empirically explored, investigated and achieved, respectively. Given the present conditions, and based on the findings found from undertaking this study, it is evident that climate change is impacting on how gold mining operations are consuming their energy resources, and that gold mining operations have the ability to develop and implement sustainability adaptation measures derived from integrating sustainability principles into climate change adaptation measures in an effort to achieve energy optimization. Integrated mining policies and strategies can be used to guide the mining company in effectively and holistically address climate related risks and energy security. In affirming the existence of both relationships, this study therefore developed a conceptual framework demonstrating how sustainability principles can be integrated into climate change adaptation measures; and a pathway showing a roadshow of how these sustainability adaptation measures can be further integrated into the mining company policies and strategies in an effort to holistically enhance the mining operations' adaptive capacity and achieve sustainable energy consumption. This study further found that feasible cost effective sustainability adaptation measures are some of the initiatives implemented by the gold mining companies in an effort to enhance the effective integration and implementation of sustainability principles into the climate change adaptation measures. In addition, the gold mining company has the potential to achieve both SDG 7 and 13 and ultimately make contributions towards achieving sustainable development.

Based on the research findings and conclusions drawn from this research, this study makes a number of recommendations for mining companies to explore opportunities for collaboration within the geographic region and share information and best practices including implementation of regional and large scale climate change adaptation strategies. This study further recommending

that mining companies should consider integrating sustainability principles and adaptation measures into their mining company policies and strategies, in an effort to provide guidance and practices to be adopted by the mining operations. More so that, mining companies are recommend to consider the integration of sustainability principles into their adaptation measures, plans and strategies, designed to holistically address the energy security and climate change related risks and opportunities affecting the mining operations and their host communities. In doing so, mining companies are encouraged to invest more in implementing these sustainability adaptation measures.

Despite the research information drawn from this study, it is also noted that this study was largely confined to gold mining operations located within a specific region of South Africa, and that the study confined its research participants to include only targeted mining employees working in the fields of climate change, energy and sustainable development. Therefore, it is imperative that other mining personnel should be involved in a similar study in an effort to ascertain their views. Furthermore, it is necessary to further investigate the success of implementation of the identified sustainability adaptation measures, claimed to be effective in enhancing the mining operations' adaptive capacity to the impacts of climate change and achieving sustainable energy consumption. More so determine whether through the implementation of these sustainability principles, the mining operations can enhancing the mining communities' adaptive capacity to the impacts of climate change and positively contribute towards strengthening the socio-economic status of the mining communities; including monitoring whether the gold mining companies are achieving the associated SDGs.

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LIST OF APPENDICES

APPENDIX 1: ETHICS CLEARANCE CERTIFICATE

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Nadunga

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H19/05/16**
PROJECT TITLE	Integration of sustainable development principles and climate change measures in energy optimization: A study of [redacted] Gold Mines in South Africa
INVESTIGATOR(S)	Ms I Nadunga
SCHOOL/DEPARTMENT	Geography, Archaeology and Environmental Studies/
DATE CONSIDERED	24 May 2019
DECISION OF THE COMMITTEE	Approved
EXPIRY DATE	31 July 2022

DATE 01 August 2019 PP **CHAIRPERSON** (Professor J Knight)

cc: Supervisor : Professor M Simatele

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to completion of a yearly progress report.**

Signature 05,08,2019 Date

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

APPENDIX 2: RESEARCH QUESTIONNAIRE USED IN THIS STUDY

School of Geography, Archaeology and Environmental Studies

Department of Geography and Environmental Studies

INTERVIEW QUESTIONNAIRE GUIDE

OVERVIEW

The following Interview Questionnaire Guide has been developed to provide information relating to the sustainable development principles, climate change adaptation measures, and energy optimization in gold mining. The following questions will help determine the different ways within which gold mines have integrated climate change adaptation measures and sustainable development principles in its mining processes and how these measures and principles are structured and imbedded in the company policies and strategies in order to build its adaptive capacity and resilience towards climate change impacts, and achieve optimal energy consumption as an adaptive strategy.

BACKGROUND REVIEW

1. What Company do you work for?
2. What position do you hold in this Company?
3. What are your major responsibilities?

TECHNICAL INFORMATION

Climate change and energy use in gold mining:

1. How has climate change affected the mining activities?
2. What has the company done in addressing these impacts from climate change?
3. How has climate change impacted on the energy consumption?
4. What are some of the practices that have been implemented to reduce the energy consumption?
5. How effective have each of these practices reduced on the energy consumption?
6. What do you think can still be done by the mining company to further conserve energy?

Sustainable development principles implemented to adapt to the impacts of climate change and optimize energy use:

1. What are some of the sustainable development principles practiced in the company?

2. How are these sustainable development principles incorporated in the mining activities?

3. How are these principles of sustainable development applied to address the impacts from climate change?

4. In what ways are these principles of sustainable development applied to optimize energy consumption?

Integration of climate change adaptation measures and sustainable development principles in the energy optimization:

1. What are some of the climate change adaptation measures being implemented at the gold mining operation?

2. In what ways is the implementation of these climate change adaptation measures addressing energy optimization?

3. How is the company integrating sustainable development principles into the implementation of these climate change adaptation measures?

4. How do you think the company can further integrate the sustainable development principles into the implementation of these climate change adaptation measures?

Challenges:

1. What are some of the challenges being faced in the implementation of these climate change adaptation measures?

2. How are these challenges being addressed?

3. What challenges are being faced in the integration of the sustainable development principles and climate change adaptation measures?

4. How are these challenges being addressed?

5. What can still be done to address these challenges?

Additional Information:

1. Which mining company documents can be referred to, that are relevant to support the responses above?

2. Who else should I present this questionnaire, in order to learn more about this research?

School of Geography, Archaeology and Environmental Studies
Department of Geography and Environmental Studies

INTERVIEW QUESTIONNAIRE GUIDE

OVERVIEW

The following Interview Questionnaire Guide has been developed to provide information relating to the sustainable development principles, climate change adaptation measures, and energy optimization in gold mining. The following questions will help determine the different ways within which the gold mines are integrating climate change adaptation measures and sustainable development principles in the mining processes and how these measures and principles are structured and imbedded in the company policies and strategies in order to build its adaptive capacity and resilience towards climate change impacts, and achieve optimal energy consumption as an adaptive strategy.

BACKGROUND REVIEW

1. What Company do you work for?
2. What position do you hold in this Company?
3. What are your major responsibilities?

*TECHNICAL INFORMATION (**please tick "√" the appropriate response in the box provided**)*

CLIMATE CHANGE AND ENERGY USE IN GOLD MINING

1. How has climate change affected the mining activities and impacted on energy consumption?

Climate change impacts on energy and mining activities	**Tick were applicable**
Affected mine productivity	
Increased carbon footprint	
Increased health and safety risks	
Induced energy saving initiatives	
Introduction of carbon tax	

Increase in mine operational costs	
Climate change hasn't affected mining activities	
Others (Please specify)	
Not applicable/ not sure	

2. What has the company done in addressing these impacts from climate change?

Measures implemented to address climate change impacts	**Tick were applicable**
Implementing, monitoring and reporting on performance of efficiency measures	
Compliance with legal requirements	
Sustainable use of resources	
Monitoring carbon footprint	
Payment of carbon tax	
Others (Please specify)	
Not applicable/ not sure	

3. What are some of the practices that have been implemented to reduce on energy consumption?

Measures implemented to reduce energy usage	**Tick were applicable**
Implemented energy saving initiatives	
Implemented energy projects	
Monitoring equipment efficiencies	
Awareness raising	
Capital funding	
Use of renewable energy	

Conducting audits	
Monitoring and reporting on environmental performance	
Implemented policies and procedures	
Others (Please specify)	
Not applicable/ not sure	

4. How effective have these practices reduced on the energy consumption?

Measures implemented to reduce energy usage	**Tick were applicable**
Effective	
Not Effective	
Effectiveness still needs to be proved	
Not applicable/ not sure	

SUSTAINABLE DEVELOPMENT PRINCIPLES TO ADAPT TO THE IMPACTS OF CLIMATE CHANGE AND OPTIMIZE ENERGY USE

Integration of climate change adaptation measures and sustainable development principles in the energy optimization:

1. What are some of the sustainable development (SD) principles practiced in the company?

SD Principles practiced by the mine	**Tick were applicable**
Sustainable use of resources (energy and water)	
Implement energy efficiency measures	
Biodiversity protection to prevent pollution	
Maintenance and reuse of equipment	
Implementing rehabilitations processes	
Use of renewable energy	
Commitments stated in the Safety, Health and Environmental policy	
Part of the mine productivity	

Conducting feasibility studies	
Others (Please specify)	
Not applicable/ not sure	

2. How are these principles of sustainable development (SD) being applied to address the impacts from climate change?

SD measures implemented to address climate change impacts	**Tick were applicable**
Legal compliance	
Paying Carbon Tax	
Providing capital funding	
Associated operational cost reduction	
Reduced carbon footprint	
Implementation of projects	
Implement energy efficiency measures	
Others (Please specify)	
Not applicable/ not sure	

3. What are some of the climate change adaptation measures being implemented by the gold mining operations:

Climate change adaptation measures	**Tick were applicable**
Implement energy efficiency measures	
Monitoring and reporting on performance of efficiency measures	
Compliance with legal requirements	
Sustainable use of resources	

Monitoring carbon footprint	
Payment of carbon tax	
The company does not have climate change adaptation measures	
Others (Please specify)	
Not applicable/ not sure	

4. How is the company integrating sustainable development principles into the implementation of these climate change adaptation measures?

Integration of SD to implement climate change adaptation measures	**Tick were applicable**
Use of renewable energy	
Mine rehabilitation	
Sustainable use of resources	
Community empowerment	
Awareness raising	
Community engagement	
Others (Please specify)	
Not applicable/ not sure	

5. In what ways are these principles of sustainable development (SD) being applied to optimize energy consumption?

SD measures implemented to achieve energy optimization	**Tick were applicable**
Implementing energy efficiency measures	
Mine departmental structuring	

Capital funding	
Reduced carbon footprint	
Implementing energy saving initiatives	
Conducting internal and external audits	
Others (Please specify)	
Not applicable/ not sure	

6. In what ways is the implementation of the climate change adaptation measures addressing energy optimization?

Climate change adaptation measures to achieve energy optimization	**Tick were applicable**
Implemented energy projects	
Implement energy efficiency measures	
Conduct feasibility studies	
Conducting audits	
Measuring greenhouse gas emissions reduction	
Monitoring carbon footprint	
Others (Please specify)	
Not applicable/not sure	

CHALLENGES

1. What are some of the challenges being faced in the implementation of these adaptation measures?

Challenges faced in the implementation of the climate change adaptation measures	**Tick were applicable**

Limited capital funding	
Limited process efficiency and technology	
Mine productivity	
Legal compliance	
Associated operational costs	
Others (Please specify)	
No challenges	
Not applicable/ not sure	

2. How are these challenges being addressed?

Measures to address these challenges	**Tick were applicable**
Conducting feasibility studies	
Mine productivity	
Risk management	
Implementing projects	
Capital funding	
Legal compliance	
Improved security measures	
Others (Please specify)	
Not applicable/ not sure	

3. What challenges are being faced in the integration of the sustainable development (SD) principles and climate change adaptation measures?

Challenges faced in the integration of SD principles and climate change adaptation measures	**Tick were applicable**

Associated costs	
No drive to change	
Legal compliance	
Delayed project implementation	
Others (Please specify)	
Not applicable/ not sure	

4. How are these challenges being addressed?

Measures to address these challenges	**Tick were applicable**
Conduct feasibility studies	
Include these aspects into mine processes	
Provide capital funding	
Challenges must be identified	
Others (Please specify)	
Not applicable or not sure	

ADDITIONAL INFORMATION

1. Which mining company documents can be referred to, that are relevant to support the responses above?

2. Who else should I present this questionnaire, in order to learn more about this research?