Assessing climate change risk and resilience of JSE-listed companies

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A Dissertation submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Master of Science

Johannesburg, November 2021

DECLARATION

I declare that this dissertation is my own, unaided work. It is being submitted for the Degree of Master of Science at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

Signature of candidate

Signed on this 16th day of November 2021 at Johannesburg.

ABSTRACT

The future of social and ecological systems has become more uncertain and more unpredictable due to global climate change. For businesses to continue creating business value while also contributing to the sustainable development and climate change mitigation and adaptation agendas, they will need to rigorously assess climate change risks and opportunities as well as implement creative and adaptive solutions to survive and thrive in this uncertain future. The aim of my research was to contribute to our understanding of climate change integration into risk management and business strategy by exploring the climate risk landscape of eighteen JSE-listed companies and their adoption of a systems approach towards enhancing resilience to climate-related risks in a developing economy.

The study made use of quantitative and qualitative methods by conducting report analysis followed by semi-structured interviews to gain more insights into climate-related risk assessment, risk management and resilience thinking in companies from the mining, construction, agriculture, forestry, and fisheries sectors. Company reports and documents for the period FY:2016- FY:2018 were analysed to assess the extent and nature of climate change disclosure and to create climate-related risk maps for each of the sectors. Through the report analysis, companies were further scored against an adapted social-ecological-systems resilience framework to assess the state of resilience to climate change over this period.

Results from the report analysis showed that the mining sector had higher levels of disclosure on climate change and addressed climate related risks and interconnections better compared to the other sectors. The mining sector was also found to have a higher state of resilience to climate change than the other sectors and accordingly companies seemed to be more successful at integrating climate change consideration into their business planning, strategy, and policies. The construction sector had the lowest state of resilience to climate change and attributed this to their position in the project value chain as well as financial constraints. My findings suggest that there is commitment from a few South African companies to address business and community challenges in an integrated manner, thus creating shared value. This commitment however needs to extend further, as the impacts of climate change will affect all sectors directly or indirectly and the severity of these impacts may only ever be truly realised in real time. The study highlights the importance and urgency of collaboration between businesses, government, and society in addressing climate change. By enhancing social-

ecological systems resilience to climate change and its disturbances, we may reduce the severity of climate change related risks and impacts during unprecedented times.

DEDICATION

I dedicate this dissertation to my lovely mother, Elizabeth Mashiane, and to my aunt, Josephine Manaka. Thank you for your unconditional love and support. I will forever be grateful for your patience and your continuous investment in my personal development. I hope this work brings you as much pride and joy as it has brought me.

ACKNOWLEDGEMENTS

Firstly, I would like to express my sincere gratitude to my supervisor, Dr Ute Schwaibold for her support and encouragement throughout the entire process. Thank you for the enthusiasm you showed towards this research and for sharing your expertise. The motivational talks and advice received from you have helped me through some really challenging moments - academic and personal.

I would like to thank my school department for their support and assistance. A special thanks to my committee members for sharing their time and expertise with me during the proposal phase of this research.

Thank you to the National Research Foundation (Grant number: 116958) and the Post-graduate Merit Award from the University of the Witwatersrand for their financial contributions towards my tuition fees and living expenses as I completed this dissertation.

To my lab mates in the urban ecology and sustainability lab, thank you for the laughter and encouragement. Your kindness, tips and tricks have made every step of these two years so much more enjoyable.

Lastly, I would like to thank my family and friends for holding a safe space for me to always express myself as I wish. I am grateful for your constant love and understanding. You have been an incredible support structure, thank you.

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AIR	Annual integrated report
CDP	Carbon Disclosure Project
CSIR	Council for Scientific and Industrial Research
FY: 2016, 2017, 2018	Financial years 2016, 2017, 2018
GHG	Greenhouse gas
GRI	Global Reporting Initiative
GRPS	Global Risks Perception Survey
IPCC	Intergovernmental Panel on Climate Change
JSE	Johannesburg Stock Exchange
PwC	Pricewaterhouse Coopers
SES	Social Ecological System
TCFD	Task Force on Climate-related Financial Disclosure
UNFCCC	United Nations Framework Convention of Climate Change
WEF	World Economic Forum

CHAPTER 1: INTRODUCTION

Over many years, anthropogenic activities (e.g., urbanisation, globalisation, population increase and increased resource consumption) have caused substantial damage to the environment which resulted in degradation of and changes to ecosystems (IPCC, 2007; Abdallah, Michaelson, Shah, Stoll, & Marks, 2012; Hoegh-Guldberg *et al*., 2018). The increasing greenhouse gas (GHG) emissions have exacerbated climate variability (Hoegh-Guldberg *et al*., 2018). This change has then led to a more unpredictable and uncertain future for social-ecological systems (SES). Businesses being integral parts of these systems are thus also exposed to this uncertain future and have a key role to play in preparing for it (Cogan, 2006; Fiksel, 2006; Nhamo & Swart, 2012). For a long time, businesses have focused on reducing their impacts on the environment and increasing their climate change mitigation efforts with the hopes of returning the environment to its previous functional state. However, it has become clear that these changes will not be reversible any time soon and will have significant consequences for business and society.

The World Economic Forum (WEF) publishes an annual Global Risks Report which provides an overview of the year's Global Risks Landcape and identifies the priority areas that need action in that year. This global risks landscape is based on survey responses from almost 1000 participants who are decision makers from academia, public and private sectors as well as civil society regarding their perceptions on the most critical global challenges for business and society. The responses from the annual Global Risks Perception Survey (GRPS) are captured in a global risks landscape and a risks-trends interconnections map. The global risks landscape 2019 is based on the World Economic Forum's (WEF) global risk perception survey 2018-2019 where individual global risks (economic, environmental, geopolitical, societal, and technological) are assessed by survey respondents in terms of likelihood of occurrence and severity of impact on a scale of 1 to 5. In terms of likelihood of occurrence, five environmental risks were listed in the top ten risks in 2019, compared to two technological risks, two social risks and one economic risk. Similarly, five environmental risks were listed in the top ten risks in terms of severity of impact compared to two technological risks, two social risks and one geopolitical risk (WEF, 2019). Looking at the risks-trends interconnections map of 2019, the changing climate was described as a trend

with great strength and strong connections to social risks such as water crises and food crises as well as other environmental risks such as extreme weather events, biodiversity loss and ecosystem collapse, natural disasters, failure of climate change mitigation and adaptation and man-made environmental disasters. Although not strong, the map also shows connections to economic risks, geopolitical risks, technological risks, and other societal risks. Extreme weather events, natural disasters and failure of climate change mitigation and adaptation have been ranked as three of the top five global risks in terms of severity of impact since 2017 (WEF, 2019). These same environmental risks have been ranked as three of the top five global risks in terms of likelihood of occurrence for 2018 and 2019.

Climate change, inequality, and poverty have been continuously elected and described as wicked challenges which are not easy to define and to date there is no definite definition of what constitutes a wicked challenge. Past literature however has described the concept of wicked challenges to have the following characteristics: they are complex and difficult to define clearly with solutions that are unknown, ever-changing and these challenges have unknown consequences (Commission, 2007; Batie, 2008). There is also no timeframe to solutions and the views and perspectives of different stakeholders are what define the problem or create knowledge on the problem. The outcomes are said to be unknown and there are multiple feedback loops. Values of the different stakeholders are in conflict and these complex systems are not reducible (Brown, Harris, & Russell, 2010). Further, every wicked challenge is thought of as being unique and that there may be multiple explanations for each (Peters, 2017). Given that climate change is a wicked challenge, crossing this planetary threshold could have severe impacts on businesses and society such as major resource shortages, more legislation limiting adverse environmental impacts and shifts in market attitudes (Winnard *et al*., 2014; Duckett *et al*., 2016).

From the WEF and other studies (see Moser & Tribbia, 2007; Rahmstorf *et al*., 2007; Agder, Dessai, Goulden, & Hulme, 2009; Ford *et al*., 2010; Stocker *et al*., 2013; Hoegh-Guldberg *et al*., 2018; WMO, 2018; USGCRP, 2018), it is clear that climate change is a global challenge which has had and will continue to have detrimental impacts globally. Some regions are more vulnerable to climate change than others and similarly some economic sectors are more vulnerable to climate change than others. Our world is changing at a rapid rate, which exacerbates climate change vulnerability. While society and the economy are subject to environmental change, there is great uncertainty in the timing and scale of the predicted biophysical impacts of climate change and this presents a challenge in its perception as a risk

to businesses (Linnenluecke *et al.*, 2013). There has been a growing consensus that there is an urgent need for climate action as indicated by the COP21 (Conference of Parties) Paris Climate Agreement. This agreement was ratified by over 110 countries and was entered into in early November 2016, while in late November 2016 at the Marrakesh Climate Conference 196 governments indicated support to implement the Paris Agreement (Burleson, 2016). Future climate risk awareness can induce shifts in the market sentiments and thus impact the global financial markets (USGCRP, 2018). If companies do not fully understand their climate risks, it could result in a financial shock when a disturbance such as an extreme weather event occurs. The impacts caused by disruptions in operations or supply chain translate to huge financial losses. Corporate leaders need to better understand what environmental risks mean for their businesses.

The business environment has become increasingly complex, thus making it difficult to identify and understand potential risks and adapt accordingly. Finding find new ways of mitigating and adapting to global risks is thus imperative. Businesses play a key role in society and are expected to head the response to global challenges. Business decisions to invest in research and design which implements clean technologies and resource efficient measures shapes the role they play in climate change mitigation and adaptation (Biagini & Miller, 2013). Businesses also have large influence in the political decisions regarding climate change regulations. These global challenges such as climate change will require stronger resilience (Linnenluecke, Griffiths, & Winn, 2013). In the resilience theory of sustainability, resilience is "the capacity of a system to absorb disturbance and re-organize while undergoing change so as to retain essentially the same function, structure, identify and feedback" (Walker, Holling, Carpenter, & Kinzig, 2004, Folke C. , et al., 2010). Corporations are subject to external disruption, thus it is imperative for them to be resilient so that they can cope and survive whenever there is a crisis or a shock to the business. Beyond an individual company's well-being and success, the focus also needs to be on building the resilience of the entire social-ecological system (SES) that the company is embedded in (Fiksel, 2006; Haywood, Brent, Trotter, & Wise, 2010). Social-ecological systems are human (social) and natural (ecological) systems that are highly coupled, complex, and integrated and they behave in non-linear ways as well as have thresholds in their dynamics (Folke, 2006; Biggs, Schlüter, & Schoon, 2015). The elements within and between these social-ecological systems are strong connections and provide system feedbacks . Businesses that facilitate a resilient social and natural system can create more value and succeed in that system, thus contributing

to the sustainable development and climate change adaptation agendas. My study will essentially be an assessment of how climate change is perceived, experienced, reported on and responded to by certain economic sectors in South Africa. Understanding the perceptions of the risks and opportunities of climate change is necessary as perception and behaviour are strongly linked and will influence how these practitioners (i.e., sustainability managers) make decisions and respond to climate change risks and the challenges it presents (see Moser & Tribbia, 2007; Moser & Luers, 2008; Agder, Dessai, Goulden, & Hulme, 2009). Similar research has been done across different sectors separately (see Moser & Tribbia, 2007; Ogden & Innes, 2008; Eberlein & Matten, 2009; Ford *et al*., 2010; Gbetibouo, Ringler, & Hassan, 2010; Morton, Bretschneider, Coley, & Kershaw, 2011, Carlton & Jacobson, 2013), allowing me to add a comparative data set with an African study which further assesses resilience . This is particularly important for a developing country like South Africa which is more susceptible to the impacts of a changing climate. This research therefore delved into climate change related risks of these key economic sectors, the strategies that companies have adopted to promote systems resilience to climate change as well as the challenges in adopting resilience-based strategies in these sectors.

1.1 Aim and objectives

The aim of this research was to advance our understanding of how select South African companies which were representative of different economic sectors addressed and integrated climate change into their risk management and business strategy to promote systems resilience.

Objective 1: To explore the climate change risk landscape of select JSE-listed companies.

Objective 2: To analyse the extent to which select JSE-listed companies address SES-resilience to climate change in their strategic management and decision making.

1.2 Layout of Dissertation

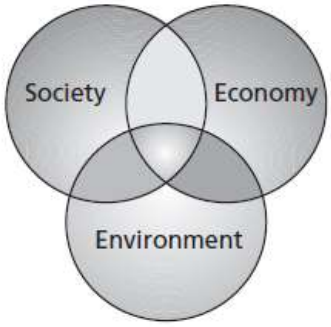
My dissertation consists of five chapters, a reference list and three appendices.

Chapter 1 provides an introduction to the dissertation and establishes the research aim and objectives. Chapter 2 provides a broad literature review of sustainable development and sustainability reporting in South Africa, the shift from impact to risk to resilience, climate change science and projections, business and climate change and the importance of building resilience. Chapter 3 is written up as a research paper and addresses objective 1, providing an assessment of climate change risks identified by JSE-listed companies across three economic sectors, and Chapter 4 is also written up as a research paper and focuses on the assessment of the extent to which companies approach resilience. A general discussion that consolidates the findings and discussions of Chapters 3 and 4 is given in Chapter 5. This is then followed by a conclusion and a presentation of research limitations and recommendations moving forward. A combined reference list for all the chapters is provided at the end of the dissertation, followed by three appendices. The figures in the dissertation are numbered continuously.

CHAPTER 2: LITERATURE REVIEW

2.1 Sustainable development

In 1987 the Brundtland Commission published the report 'Our Common Future' in which the concept of sustainable development was defined as development which "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987 p. 54). Essentially, sustainable development entails managing the use of available resources in a way that does not compromise the availability of these resources necessary for the growth of future generations. Since the 1980s, several discourses around sustainable development have emerged. The three spheres of sustainability have been a popular model in the explanation of sustainable development with the social, economic, and environmental aspects represented as three separate spheres and sustainability being the centre where those spheres overlap (Elkington, 1994) . In this three-sphere model (Figure 1a) all spheres interact with one another but are not interdependent and they are depicted to be of equal importance. However, in practice the environmental and societal dimensions were neglected as the economic dimension carried more weight for decision making (Cato, 2009). For a long time, this three-sphere model was important in influencing policy makers (Barkemeyer *et al.*, 2014). Our understanding of sustainability evolved over time to view the economy as a component of social relationships (society), both of which are embedded in the natural environment (Figure 1b). This view is referred to as the three-dependency model and it views the spheres as being nested within one another, highlighting the interdependencies of the three dimensions (Cato, 2009).



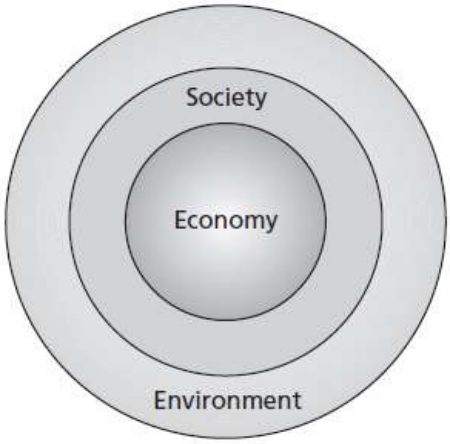


Figure 1: The evolution of sustainability from the 3-spheres model (1a) to the 3-dependency (nested) model (1b), Cato (2009)

Applying sustainability in practice has often been a challenge- achieving it, measuring it, maintaining it, and understanding its relevance to organisations (Wayne & MacDonald, 2004). To present sustainability in a more accessible way, the triple bottom line (TBL) concept was developed which allows organisations to assess and report on how they perform in each of the three spheres. Although it was the most commonly used model for corporate sustainability for a long time, it has often given preference to the financial bottom line over the social and environmental bottom lines (Wayne & MacDonald, 2004) . The most current model being used is the six capitals model which represents the influences of business activities on the capitals (Figure 2). This model is more closely aligned with the nested model in that the social and economic capitals are seen to be limited by the available natural capital (IIRC, 2013), which helps with understanding the application of sustainability theory in businesses.

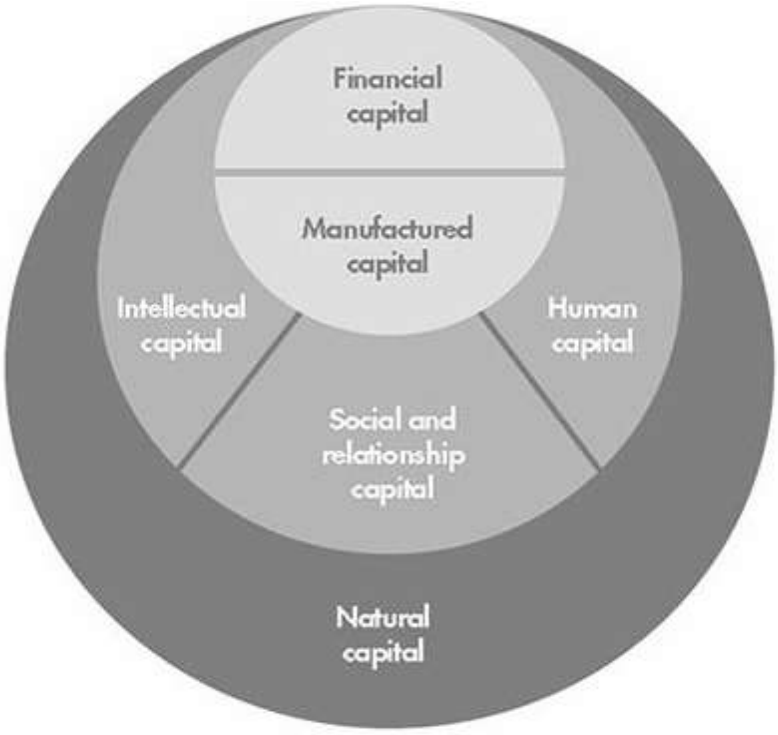


Figure 2: The six capitals model of sustainability (IIRC, 2013)

The private sector has great potential for addressing and overcoming the many social, economic, and environmental issues associated with the 'unsustainable' elements of development. Agenda 21: Programme of Action for Sustainable Development has emphasised the necessity of partnerships with the private sector, therefore business support is vital for achieving sustainable development (UNCED, 1992). Drivers for increased business responsibility include lack of government capacity, rapidly deteriorating natural and social environments, increased public awareness of environmental and social issues, higher environmental and social standards and controls and the availability of technologies (Visser, 2004; Gray, 2006; Adams & McNicholas, 2007; Ans, 2008; Hahn & Kuhnen, 2013). Stressed upon in the literature is the need for governance, operational and strategic procedures to internalise environmental concerns (Robinson, 2004; Redclift, 2005). To achieve this, several guidelines have been published over the last three decades to guide business towards conducting themselves more responsibly and thus more sustainably. Guidelines such as the ICC Business Charter for Sustainable Development (1991, last updated 2015) and OECD guidelines for Multinational Enterprises (adopted 1976, last updated 2011) contain principles of sustainable development in business. Other sustainability codes and standards developed include multinational codes of conduct (e.g. Kyoto Protocol), aspirational principles and compacts (e.g. Agenda 21 and Rio Declaration), fair trade initiatives (e.g. Ethical Trading Initiatives), governance guidelines (e.g. King Report of Corporate Governance), reporting and assurance standards and protocols (e.g. Global Reporting Initiative), and investment screening (e.g. FTSE JSE Responsible Investment Index, Carbon Disclosure Project, and Equator Principles). The Global Reporting Initiative (GRI) is the presiding set of guidelines for business sustainability disclosure based on the triple bottom line framework (GRI, 2016). However there has been argument presented on how problematic the triple bottom line is with regards to sustainability, as businesses just report on indicators that they deem relevant to stakeholders (Barkemeyer *et al*., 2014). Businesses report incompletely or narrowly and claim to be moving towards sustainability and thus the triple bottom line is misleading. Some criticism attracted by the concept of sustainable development includes its vagueness, challenges in quantifying whether certain activities promote sustainable development and the oxymoron of the concept itself as it essentially proposes increased industrial output while bearing in mind the environmental or resources limitations (Robinson, 2004).

2.2 Sustainability reporting in South Africa

South Africa's constitution is one the few globally that recognises sustainable development as a human right (Du Plooy, 2006). Inequality has been the biggest challenge to address since democracy in South Africa and HIV/ Aids, unemployment, poverty, skills shortage, capital reform and climate change are other interconnected challenges (Du Plooy, 2006; Hamann, 2006). Businesses' commitment to and investment in the Sustainable Development Goals has provided a conducive environment to do business, thus South Africa has gradually progressed in meeting the targets (Stafford-Smith *et al*., 2017; Ghosh, 2020). Catalysts for change in the South African corporate sustainability agenda include legislative reform, globalisation, stakeholder activism and codification (adapting guidelines voluntarily for self-regulation). Post-Apartheid South Africa's legislation was revised and statutes for sustainable development and corporate governance were introduced which strongly reiterated international trends (de-Villiers & Vorster, 1995; Visser, 2004; Ramlall, 2012). Globalisation has resulted in many companies raising their sustainability standards to reach market expectations, resulting in a significant increase in sustainability reporting and environmental management certification. Stock exchanges have corporate governance requirements that listed companies must conform to in order to remain listed (Visser, 2004). Social and environmental indices also have corporate sustainability requirements. Increased stakeholder activism has also led to improved public transparency (Burns, Audouin, & Weaver, 2006). South African companies have adopted guidelines and standards to voluntarily self-regulate ethical, environmental, and social issues.

There has been a call for more comprehensive and improved environmental reporting guidelines and standards in the country and there is also a need for businesses to increase environmental reporting disclosure. In South Africa, the King Reports on Corporate Governance (King I, II, III and IV) play a considerable role in promoting environmental reporting. The King reports propose companies to report on their triple bottom line (TBL) in terms of the GRI guidelines (GRI, 2016; IoD, 2016). These King codes are incorporated into the JSE listing requirements. One requirement of King IV is integrated sustainability reporting and disclosure which means that companies listed on the JSE have an obligation to submit integrated annual reports (JSE, 2010). In these mandatory requirements, companies need to follow the principles laid out in the King code or if not, explain why they were not applied- all of this reflects the JSE's active drive for sustainability reporting. It is for this

reason that my study will only look at JSE-listed companies as they are expected to report on their environmental performance.

2.3 Shifting from impact to risk to resilience

There has been argument that the triple bottom line's focus on environmental impacts due to business practices resulted in the belief that business activities could be moderately modified instead of re-designed to achieve corporate sustainability (Ählström, Macquet, & Richter, 2009). This model inspired the emergence of numerous tools (such as environmental and social impact assessments) which address the impact of businesses activities on the environment and society and the consequences of those impacts (Gormley, Pollard, & Rocks, 2011). While the notion of business activities causing significant impact on the other spheres of sustainability is well established, there has been recent recognition that such impacts may potentially cause a ripple effect and these impacts may be felt by business itself. Risk management attempts to minimise or manage business risk by planning for the inevitable ripple effect from the business activities (Anderson & Anderson, 2009). Risk management traditionally assessed financial risks and over time included environmental and social risks arising from business activities. Risk management typically employs a risk matrix to assess the scale and severity of potential risks to the business. Such a matrix will provide the probability of occurrence and severity of consequences of the particular risk and steps can then be taken to prevent or minimise this risk (Chiles & McMackin, 1996; Cabinet-Office, 2002; Anderson & Anderson, 2009; Aven, 2010). Corporate sustainability could result in reduced vulnerability and increased benefits for businesses while also allowing the society, environment, and whole economy to benefit. While the traditional risk management approach has been useful in planning for predictable risks, this will not be sufficient for the cascading unpredictable, uncertain, and interconnected risks that will be faced as a result climate change (Peck, 2004). The uncertain business environment will require adaptive capacity that sees companies surviving through the unpredictable recurrent disturbances due to the impacts of climate change (Fiksel, 2006; Haywood, Brent, Trotter, & Wise, 2010). Adaptive capacity is the capacity of system features to influence resilience (Folke C. , et al., 2010). Indeed, impact assessments are still essential and are still conducted by businesses, however they need to be complemented by a paradigm shift which understands and better prioritizes environmental risks to businesses and their social-ecological systems. There will thus be a need to promote

resilience in order to better prepare for such an uncertain future. A system's resilience is its "ability to continue maintaining structure and functioning in the event of a shock" (Folke *et al*., 2002; Walker B. , Holling, Carpenter, & Kinzig, 2004; Haywood, Brent, Trotter, & Wise, 2010; Haywood, 2016). Although it is now applied in various disciplines, the concept itself originates from the ecological domain and is characteristic of a system (Berkes & Folke, 1998; Carpenter, Walker, Anderies, & Abel, 2001; Fiksel, 2003). Humans (i.e., society and business) and nature function in interconnected social-ecological systems that have complex interactions. It is due to our better understanding of this interconnectedness that the resilience concept now includes the system's ability to absorb, withstand, recover, and reorganise itself in response to a shock or disturbance while maintaining its functionality (Holling, 2001; Carpenter & Gunderson, 2001; Walker B. , Holling, Carpenter, & Kinzig, 2004; Berkes, Colding, & Folke, 2009; Haywood, 2016).

The resilience of ecological or industrial systems may be reduced by the loss of flexibility or diversity as well as loss of spare capacity and thus long-term sustainability may be undermined (Korhonen & Seager, 2008). While risk can manifest in environmental, socio-political, and financial dimensions and the premise of hazards being known informs the perspectives of risk in business strategies, these standard approaches to risk assessment become obsolete when considering the complex interactions between the various risk dimensions which cannot simply be modelled quantitatively (Korhonen & Seager, 2008). In contrast, resilience theory does not require a description of specific hazards and the purpose is rather to understand how a system could respond and adapt when forced by a stressful event or a disruption to its normal functioning. The resilience perspective differs from the risk-based perspective in that it is more concerned with how an organisation would respond to unexpected and unusual events which disrupt business (Korhonen & Seager, 2008). The risk-based approach alone would thus not be suitable for a challenge such as climate change as the uncertainty of changes to multiple complex interactions means that one cannot forecast events or impacts (direct or indirect) to business (Haywood, Brent, Trotter, & Wise, 2010). Although the resilience theory has recently been incorporated into sustainability approaches, evidence suggests that businesses are mostly considering continuity (the ability to quickly recover after a business interruption to ensure survival) and not resilience (ability to absorb, recover and reorganize while maintaining functionality during a business interruption) in their approaches (Cerullo & Cerullo, 2004; Haywood, Brent, Trotter, & Wise, 2010). The environmental impact reduction targets and environmental risks addressed in corporate

disclosures are mostly part of financial disclosures. Environmental risks were not often disclosed or addressed as part of corporate reporting, while systems thinking with regards to this has hardly been explored (Hoffman, 2005; Firth & Colley, 2006; Eberlein & Matten, 2009).

2.4 Climate change science: observed trends and projections

Climate change is defined by the Intergovernmental Panel on Climate Change (IPCC pg. 544, 2018) as "a change in climate that can be identified by changes in the mean and/ or variability of its properties and that persists for an extended period, typically decades or longer". However, the United Nations Framework Convention of Climate Change (UNFCCC) in their definition of climate change clearly distinguish between natural variability and anthropogenic climate change and state that anthropogenic climate change is in addition to the natural climate variability observed over comparable time periods (UNFCCC, 1992). According to them, climate change is characterised by long-term increased average global temperatures, widespread changes in precipitation amounts, changes in wind patterns and ocean temperatures as well as changes in the frequency and intensity of tropical cyclones as a result of increasing atmospheric greenhouse gas concentrations, and there has been scientific evidence presented in the IPCC 5th report attributing climate change to anthropogenic activities (Hoegh-Guldberg *et al*., 2018; IPCC, 2018).

There has been an uneven distribution of temperature increases globally and some regions experience greater increases than others. MacKellar *et al.,* (2014) reported decreases in rainfall as well as decrease in the number of rainfall days across areas in South Africa. Droughts have intensified and become widespread over southern Africa (Fauchereau *et al*., 2003). Generally, southern Africa is characterised by a warm climate and South Africa's southernmost part has a Mediterranean climate. Mid-latitude cyclones influence the winter rainfall experienced by South Africa's Cape region (Hobbs, Lindesay, & Bridgman, 1998). Over the last century, Africa has experienced an increase in average land-surface temperatures and its rate of temperature change is over twice the global rate of temperature change estimates (Osborn & Jones, 2014). It is expected that temperatures will continue to increase across Africa and thus evapotranspiration is also expected to increase, resulting in severe consequences for water stress in Africa and particularly South Africa (Niang *et al*., 2014). Rahmstorf *et al.* (2007) reported on the global sea-level rise (SLR) and it is said that

anthropogenic global warming as well as sea-level rise will continue (Stocker, *et al*., 2013). This is because of the timescales of climate processes and feedbacks, regardless of whether greenhouse gas emissions are reduced or stabilised. Southern Africa has been observed to have high inter-annual and inter-decadal variability in rainfall due to the El-Niño-Southern Oscillation (ENSO) phenomenon (Fauchereau, Trzaska, Rouault, & Richard, 2003; Phillipon, Nouault, Richard, & Favre, 2011). Extreme wet and dry years in southern Africa cause floods and droughts. There has also been an observed decrease in rainfall and decrease in number of rainfall days between 1960-2010 over parts of South Africa (see MacKellar *et al*., 2014). The global warming trend has been consistent with the trend over southern Africa, with an increased number of hot extremes and decreased number of cold extremes (Stocker *et al*., 2013). Heavy storms resulting in flood events are expected to be altered in their timing, magnitude, and distribution due to climate change. Evidence suggests that the intensity and spread of droughts have increased across southern Africa (New *et al*., 2006; Masih *et al*., 2014). In the parts of southern Africa where average temperature increases and average rainfall declines have been projected, the frequency of droughts is also projected to increase (Stocker *et al*., 2013). Yet despite these projections, there is still a high degree of uncertainly in terms of the probabilities of particular climatic conditions in future. Future levels of atmospheric greenhouse gas concentrations influence climate change projections, while societal behaviours as well as policy choices play a key role in determining these future greenhouse gas emission levels (Davis-Reddy, 2017; Hoegh-Guldberg *et al*., 2018).

In many regions forest structure, composition and biogeography could be altered by climate change impacts such as increased frequency, duration and severity of drought or heat stress. Climate induced physiological stress could potentially result in increases in tree mortality. Wildfires and insect outbreaks are other climate-related processes that interact with these trees in the forests. While episodic forest tree mortality occurs, climate-driven forest tree mortality could worsen this due to the link between drought and tree mortality. (Allen *et al.*, 2010) presented a global assessment of forest tree mortality associated with drought and heat stress. This means that forests could have an increased vulnerability to climate change as tree mortality rates may increase in response to droughts and heat. There is also literature linking the increased tree mortality to drought and heat in southern Africa (see Viljoen, 1995; Foden *et al*., 2007; West *et al*., 2012).

2.5 Business and climate change

While South Africa has transitioned to being a service-sector dominated economy, the primary and secondary sectors still play a significant role in this economy and they dominate in terms of energy consumption and having low energy efficiency (Du-Plessis & Smit, 2006). Primary sectors have traditionally been the root of South Africa's economy mainly due to favourable agricultural conditions and the country's wealth of mineral resources (Fedderke & Pirouz, 2002). The tertiary sector on the other hand has been the main driver of economic growth since the 1990's. Historically the mining; construction; agriculture, forestry & fishing; whole & retail trade; and transport sectors have played significant roles in South Africa's economy by generating high earnings, creating employment (direct and indirectly), and generating tax revenues as well as contributing to the overall output of the country (Federke & Mariotti, 2002; Du-Plessis & Smit, 2006). From the period of 1990-1998, the mining sector steadily decreased, the agriculture, forestry, and fisheries sector steadily increased, the building and construction sector decreased, manufacturing sector increased slightly, while the services sector has seen a gradual increase in the contribution to the GDP (Fedderke & Pirouz, 2002). These trends have continued over the past two decades while the services sector seems to be contributing the most in terms of GDP (STATS SA, 2018).

The impacts of climate change for most economic sectors may be exacerbated by the critical vulnerabilities as many of these sectors directly depend on the environment by primarily using natural resources for their business activities. For the improvement of strategic adaptation responses, it is essential to understand future climate change predictions and their potential impacts in southern Africa. Projections of future extreme temperatures suggest an increase in annual frequency of very hot days (temperatures exceeding 35℃) (Stocker *et al.,* 2013). This means that sectors which are susceptible to extreme temperatures will have increased risk in future. Other extreme weather events such as droughts and heavy storms will pose increased direct and indirect risks to all sectors. Companies at most risk are those faced with long-term capital investments decisions, those in sectors where climate and the weather is integral in production (for example construction and agriculture), and those industries that are heavily reliant on either infrastructure or transport in their supply and demand chains. The mining sector, construction and built environment sector as well as the agriculture, forestry and fisheries sectors are of interest in my study due to their sensitivity to climate change and the role they play in the South African economy.

Due to the complex impacts that drought and heat stress (which are projected to potentially increase in frequency, duration, and severity) have on tree mortality, the forestry sector in South Africa is faced with a threat. Past literature indicates that all forest types are vulnerable to the anthropogenic changing climate, including those in environments that are not usually regarded as water limited. Some forests are already shifting in response to the changing climate. As climate change may potentially trigger widespread forest die-off (Allen *et al*., 2010), it is of interest how the forestry sector analyses climate risk and what adaptation strategies they have in place. Agriculture and forestry are therefore huge concerns for South Africa with regards to climate change.

The South African built environmental & construction sector has contributed to climate change and is impacted by it. Construction materials will still be in demand given that South Africa is a developing country and the basic needs of the populations, such as housing, have not been met (du-Plessis *et al.,* 2003). Practices in this sector therefore need some change in order to adapt to the projected impacts of climate change. On the same spectrum of sector vulnerability to climate change, research such as the study by Ford *et al.,* (2010) found that the mining sector is sensitive to climate-related conditions and it is expected that future climate change will adversely impact the mining sector. While companies acted on managing climate-related impacts, they identified energy costs and uncertainty as common barriers for climate change adaptation. The perception is that mining operations are adversely impacted by climate change and that future climate change projections are threats to the mining industry, however despite this perception there is still very little action being taken in preparing for future impacts. Efforts for reducing greenhouse gas emissions were however being made by the sector (Ford *et al*., 2010).

A shift is needed from businesses positioning themselves as disconnected entities from social ecological systems to them acknowledging their integral part of these complex and interconnected social ecological systems. Resilience has been placed at the forefront of sustainability and social and ecological systems are viewed as interdependent in both the concepts of sustainability and resilience. Sustainability is systemic in nature so any models seeking to promote sustainability should also be systemic (Linnenluecke & Griffiths, 2010) . Social ecological systems are complex and adaptive and entail social and ecological networks and their intra-actions as well as interactions (Folke *et al*., 2004).

CHAPTER 3: CLIMATE CHANGE RISK ASSESSMENT IN JSE-LISTED COMPANIES

Abstract

While the changing climate presents uncertainty for the future for businesses and societies, efforts have shifted from mitigation measures to adaptation measures. The interest to understand business approaches to address climate change and how it is incorporated into decision making has grown. Due to increased pressure from stakeholder concerns, businesses globally have started including climate change related risks into their annual reporting. This study assessed the climate change risk landscape of eighteen JSE-listed companies by analysing company reports and documents from the mining, construction, agriculture, forestry, and fisheries sectors for the 2016- 2018 period. From this, risk interconnections maps were created for each sector and seven interviews conducted with sustainability managers from these sectors gave further insights into the climate change risk landscape and the challenges related to integrating these into risk management and business strategy. In my study, the mining sector disclosed more on climate change than the other sectors, and consequently identified more climate related risks which they clearly linked to other environmental, social, and economic risks for their businesses.

3.1 Introduction

This chapter is an assessment of the climate change-related risks identified by the sample JSE-listed companies across the three economic sectors of interest. It begins with an introduction on risk and discusses the cases of the ‘Deepwater Horizon Spill’ and the ‘Cape Town Day Zero’ as examples of environmental risk for businesses. It then discusses the global risk landscape which provides the context for the emerging climate change risks for businesses and how these risks are interconnected. This is followed by the methodology used in analysing the climate change risk landscape of the JSE-listed companies. The chapter then presents a discussion of the climate change risk landscape of the sample companies in these sectors ; the integration of climate change into long-term business planning and the need for more South African businesses to promote system resilience to climate change.

3.1.1 On understanding risk

Assessing levels of risk is commonly based on a combination of the likelihood of occurrence and the severity of impact (Kaplan & Garrick, 1981; ISO, 2002; Lindley, 2006). More recent definitions highlight that risks are not only limited to events, consequences and probability, and that uncertainty should be included in defining risk (see Cabinet-Office, 2002; Renn, 2005; Aven & Renn, 2009). Furthermore, risk can be described using a frequency-based approach and/or the alternatives approach which includes uncertainty regarding underlying factors that influence the event and the outcome (Aven, 2010).

Managers' perspectives on risk have been more closely related to the notion of economic loss (Chiles & McMackin, 1996) and different disciplines treat risk differently. Risk definitions are not only context dependent but could also be objective (inherent in the situation, for example throwing dice) or subjective (one's perception or assessment of a situation). In business one wants to manage risks and drive growth. Probabilities are the basis of prevailing risk perceptions and decisions, however, there have been arguments that these definitions are quite narrow, and that uncertainty should replace the probability component in the risk concept as it is possible to overlook or underestimate critical uncertainty aspects if one moves directly to probabilities (Aven, 2010). There may be potential surprises that are not considered if the critical uncertainty aspects are misjudged. In the context of risk assessment and decision making, the choice of the risk perspective is important (Aven, 2010).

Other principles and measures are necessary in risk assessments for challenges with large uncertainties. Climate change is regarded as a complex challenge and even with all the modelling and projections, there are still some uncertainties. We need a more nuanced information basis regarding risk (or rather climate change as a risk) to provide support for decision making in business. As it is, past trends cannot reliably predict future changes and the high complexity of climate change means it may evolve very differently to what is expected. The dilemma often encountered by corporate executives in their decision making is the decision about which risks are acceptable. While decision makers are primarily concerned with the 'target risk' (existing risk one aims to solve), interventions to reduce this risk can trigger what is referred to as 'countervailing risk' which are new risks created while trying to solve existing risks (Hansen, von Krauss, & Tickner, 2008; WEF, 2019). Trade-offs need to

be made between these two, the competing risks of the alternatives decisions therefore need to be identified and carefully weighed out.

3.1.2 Environmental risk: cases of the Deepwater Horizon spill and the Cape Town 'Day Zero'

The BP Deepwater Horizon oil spill is a good example for the ripple effect of environmental risk in a complex social-ecological system. In 2010 an explosion on this rig resulted in the death of 11 employees and the injury of 17 employees. Over 4 million barrels of oil spilled into the ocean despite several attempts to contain the spill, all of which failed (GPO., 2011). The spill affected many industries that depended on the Gulf coast for income, resulting in dire economic impacts. Furthermore, public disapproval regarding BP's then chief executive saw his replacement in that same year, the company spent more than $40 million in immediate clean-up and recovery costs and a further quarter of market value were lost by the following year (GPO., 2011; Pallardy, 2019; Uhlmann, 2020) . BP's ultimate responsibility (due to negligence and time-saving measures) was linked to decisions regarding the installation process of the defective concrete cap which resulted in the disaster. It was also found that opportunities for preventing the blowout were missed when early indications of a problem were ignored by the employees aboard the rig (GPO., 2011). Numerous marine animals were affected by the oil leakage including birds, mammals as well as turtles. An estimated 800 000 birds died in areas affected by the spill, including 12% of the endangered brown pelicans. These enormous social and environmental impacts subsequently increased the risk profile of other oil-related organisations globally. In essence, the impact became a significant risk to BP as well as the whole oil transport and refinery sector. This example indicates the ramifications of inadequately assessing risks and the importance of adding uncertainty in risk assessments. Events with low probabilities and high consequences are often inadequately captured by the expected (Haimes, 2004), thus in addressing risk the scope needs to extend beyond expected values. Even though businesses employ specialised management tools to address their risks, there has been only modest progress of integrating environmental and social risk into traditional risk management (Gormley, Pollard, & Rocks, 2011).

In the Western Cape Province, South Africa, the threat of 'Day Zero' (the day by which dam levels were expected to have been depleted and the city of Cape Town's taps were expected

to run dry, (Maxmen, 2018; WWF, 2018) was a big social-economic risk linked to the changing climate. The already existing water risk was exacerbated by climate change, leading to one of the most multi-year severe droughts in South Africa in the past decade (Archer *et al*., 2019; Ziervogel, 2019). Businesses had to find ways to continue operating in this context. Broken down to provincial level, most of South Africa has medium-to-high risk and low-to-medium risk water stress levels under normal conditions, while Western Cape and some parts of the Northern Cape have high risk water stress levels (Gassert, Reig, Luo, & Maddocks, 2013; Aqueduct, 2018). Drought conditions which were experienced in the country resulted in water restrictions across provinces from early 2017. Extreme water restrictions were implemented in the City of Cape Town from January 2017 onwards (Modise, 2017; Palm & Smith, 2017), requiring distribution points for residents to collect their allocated water amount per person. 'Day Zero' which was anticipated for April 2018 was pushed back several times, (Jacobs, 2018, Walton, 2018). Businesses had to find ways of operating as efficiently as possible during that period of drought conditions and water restrictions. Some businesses saw declines in business while others had to close down temporarily as they could not survive in such an operating environment. The hospitality industry for example saw massive drops in tourists and guests and had to be creative in their strategies to still attract guests and ensure survival (Yates, 2018). The risk of a 'Day Zero' provides a good example of a climate-related risk which had a ripple effect on businesses and societies and highlights the need for business to better prepare for unanticipated disturbances which may result due to climate change impacts.

3.1.3 Global risks landscape

Failure of climate change mitigation and adaptation is a key risk which could give rise to other business relevant risks such as water crises, natural disasters, and extreme weather events. These could in turn result in cascading risks in other categories, which can be seen, for example, where societal and geopolitical risks like involuntary migration and regional conflict could be triggered by extreme weather events such as droughts (WEF, 2017; WEF 2019). The past 10 editions of the World Economic Forum's Global Risks Report have consistently featured interconnected environmental risks in the top five global risks in terms of perceived likelihood of occurrence and severity of impact (WEF, 2021). In a 2021 Global Risks Perceptions Survey, climate change was ranked first in the top five drivers that

determined global developments. The risks interconnection between "failure of climate change mitigation and adaptation" and an "increased risk of water crises" has also been ranked as important (WEF, 2017; WEF 2021). The risks "extreme weather events", "failure of climate-change mitigation and adaptation" and "natural disasters" have been moved up from the average in terms of likelihood of occurrence and severity of impact over the last ten years (see Figure 3).

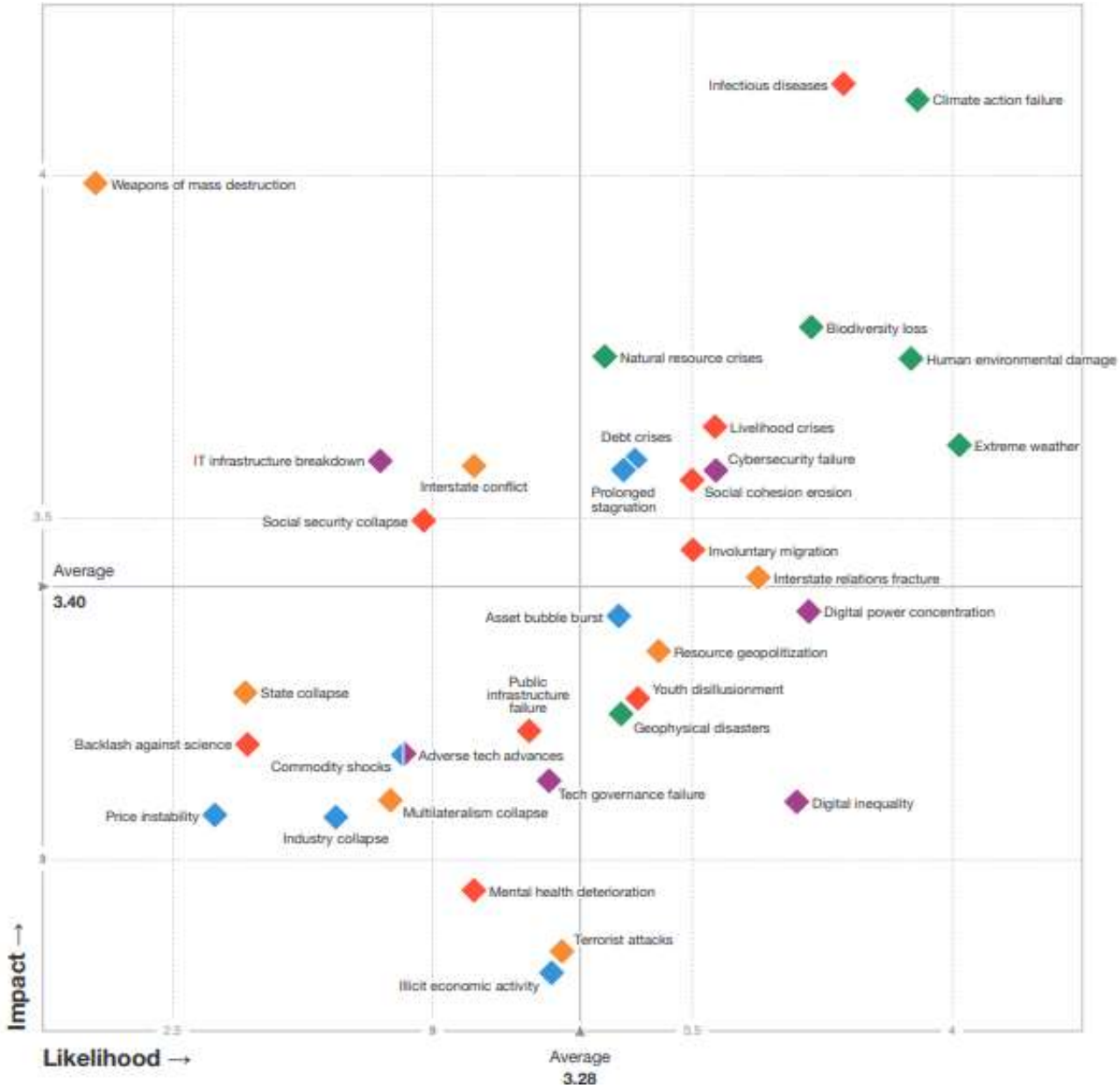


Figure 3: Global risks landscape 2021 (pg. 12) indicating higher than average perceptions of environmental risks (WEF, 2021)

Strong relationships have been identified between the changing climate and large-scale involuntary migration. Further strong connections are evident between extreme weather events and failure of climate-change mitigation and adaptation. The "failure of climate change mitigation and adaptation" and "extreme events" risk interconnection was cited most frequently by Global Risks Perception Survey respondents (WEF, 2021). The relationship between climate change and ecosystem health is not one way. While climate change affects ecosystems health, these ecosystems are also vital for carbon sequestration, temperature regulation and other services. Additionally, societal stability is also threatened by fragile ecosystems as we depend to a great extent on the natural environment for resources (Spalding *et al*., 2016). Climate-related disasters could have significant impacts on the agricultural sector and may result in food insecurity for many globally (WFP, 2018). According to Slubowski (2017), environmental disasters (e.g., extreme weather, floods, hurricanes, and floods) have increased supply chain disruptions by 29% since 2012. Climate change currently strains the global food system and according to the IPCC (2018), this changing climate will have dire impacts on food security should average global temperature increases exceed 1.5ºC. It is also noteworthy that the 2014 - 2018 period was recorded as the hottest in history and climate factors like drought conditions already affected yields in the food system (WMO, 2018). Energy intensive companies are faced with considerable climate-related liabilities and costs. Potential downstream impacts on inputs and the effects of physical environmental changes mean that even industries that depend less on energy intensive technologies are faced with critical climate change risks. Investors cannot make fully informed decisions without information on climate-related risks of the companies they invest in (Stern, 2007). There is a need to understand the nature and extent of physical, transitional and liability risks resulting from climate change in industry. The risks indicated in the global risks landscapes and their interactions indicated in the WEF risk-interconnections map provide a clear picture of the emerging risks that climate change poses for business. It is of interest to know whether these align with what is reported on and experienced by South African companies. This study thus looked at the extent to which JSE-listed companies address climate change in their business strategy, integrate climate-related risks into their risk management and further connect these to other environmental, economic, social, technological, and geopolitical risks.

3.2 Methods

3.2.1 Report analysis

Eighteen Johannesburg Stock Exchange (JSE)-listed companies were chosen for this study, initially from the top 200 and extending upwards where necessary. These companies belonged to three sectors and six companies were assessed from each (mining; construction; agriculture, fishing & forestry). The companies' annual integrated, sustainability and Carbon Disclosure Project (CDP) reports from FY: 2016- FY: 2018 were examined and sections of these reports that covered climate risk and resilience information were considered for analysis. The reports were obtained from the company websites and the CDP website. These selected companies that are listed on the JSE make their reports available to the public and these are regarded as necessary for communicating the companies' strategy, performance, and governance. Environmental management (including climate change management) performance is thus also covered in these reports. While sustainability reports were expected to have more thorough information regarding the environmental performance of a company (Hooks & van Staden, 2011), not all companies published these which is why annual integrated reports (AIRs) were analysed as well. Additionally, reporting to the CDP is voluntary and while not all the companies did this, it was an important component to analyse as it gave in-depth information on the strategy, performance and governance linked to climate change risk.

I analysed the content of annual integrated, sustainability and CDP reports of the selected companies by firstly doing a keyword search for any climate related terms (i.e climate change; weather conditions; temperature extremes; rainfall; drought; storms, energy usage etc). This was then followed by a thorough analysis of the reports to identify and record any explicit and implicit climate change related content. The reported climate change-related risks were examined for possible links to other social, environmental, geopolitical, economic, and technological risks in the reports and recorded. The reported climate change-related risks were used to create risk-interconnections maps for each sector to identify how different sectors covered climate-related risks and understood the complexity of the consequences. The network and content analysis tool NodeXL (Smith, *et al*., 2010) was used to create these risk-interconnections maps and the Harel-Koren Fast Multiscale algorithm was used to layout the maps. I then compared the interconnections recorded from the report analyses to those presented in the WEF's 2019 & 2020 risks-trends interconnections maps.

3.2.2 Interviews

I conducted semi-structured interviews with the sustainability managers of several of the selected companies to gain more insight into how they understand risk and systems resilience to climate change and how they address these in their business management. This was done as a two-phased approach which included a pilot interview to test the interview style and questions for the rest of the interviews. The questions for the interviews were informed by the findings from the report content analysis as well as the indicators for each principle given by the CSIR and PwC SES-resilience framework (see Figure6, Chapter 4). I further consulted the work done by Kitsikopoulos (2018) on strategic environmental risks in annual reports and management practices as well as the work done by Robson (2019) on four SES resilience principles in South African integrated reports to guide some of the questions for the interviews. Since this part of my research involved human interaction, ethics clearance was applied for and obtained from the University of the Witwatersrand Human (non-medical) Ethics Research Committee. The ethics clearance certificate was issued on 29 August 2019, protocol number H19/07/18. In total, seven interviews were done with three interviews in the mining sector, two interviews in the construction sector, and two interviews in the agriculture and fisheries sector. The interviews ran from November 2019-April 2020 and were used as a triangulation method to confirm what was found in the reports and understand the challenges in climate change risk management.

Thematic analysis is an analysis used to identify and examine patterns of meaning from semi-structured interview dataset (Boyatzis, 1998; Braun & Clarke, 2006). This type of analysis drew out the factors concerning issues faced by the sectors of interest in addressing climate change in their businesses and drew on both implicit and explicit types of themes. Post transcription of the interviews, the full dataset was examined, and a coding frame was developed to guide thematic analysis. This examination of interview results was done manually and not entered into qualitative statistical packages for several reasons. While the research generally sought to explore sector-based variation and/ or similarity across sectors, the study did not have sufficient participant in each sector to make valid comparisons. The discussion of themes from interview results were thus still presented to reveal the idiosyncratic tangents of meaning while attempting to reveal sector-based threads from the data.

3.3 Results

3.3.1 Report analysis

The majority of the companies in this study sample addressed climate change in either their annual integrated reports, sustainability reports and/or CDP reports. Disclosure on climate related matters was highest in the mining sector and lowest in the agriculture, forestry, and fisheries sector. This was due to the fact that all the selected companies in the mining sector published separate integrated and sustainability reports as well as CDP reports in which climate change was covered (Figure 4). In contrast, companies in the agriculture, forestry and fisheries sector seldom published separate sustainability and integrated reports, with only three out of six companies even participating in the CDP. In the sustainability and integrated reports, not all companies in this sector addressed climate change related matters or risks. In the construction sector however, more companies participated in the CDP but did not publish separate sustainability and integrated reports and in the integrated reports published, not all companies addressed climate change (Figure 4). These results are based on the explicit reporting of climate change indicators and climate related risks in the company reports and/or policy statements. Companies that participated in the CDP seemed to disclose on climate change even in their sustainability and integrated reports, whereas those who did not participate in the CDP either did not address climate change at all or addressed it vaguely in their sustainability and/or integrated reports.

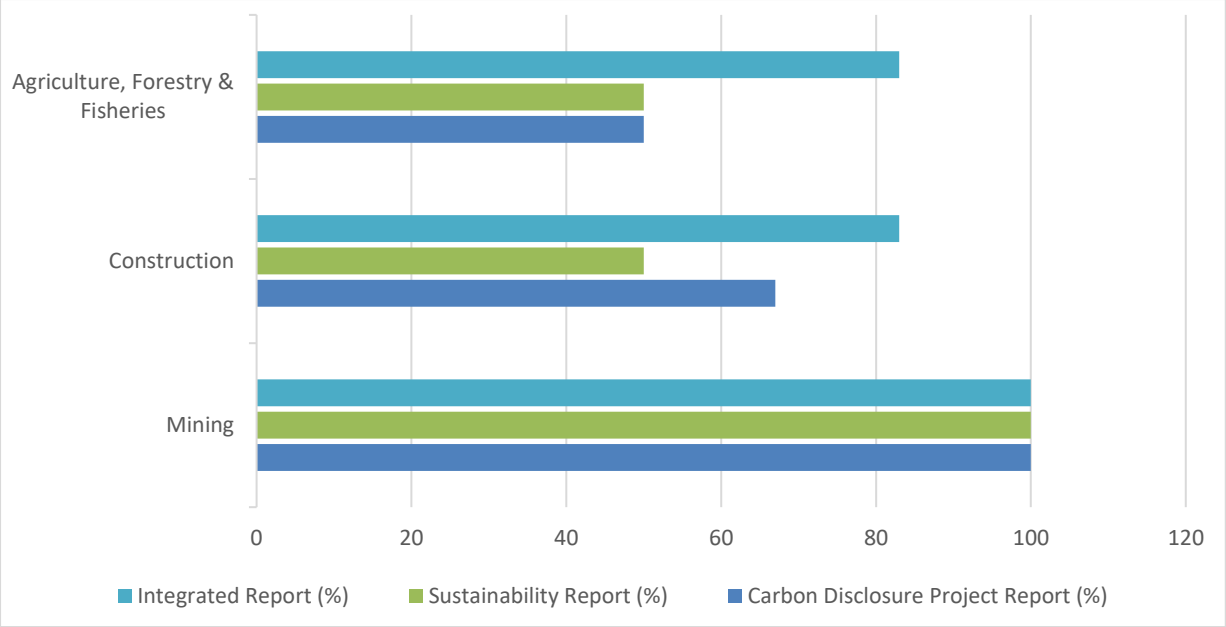


Figure 4: Climate change disclosure (%) in various reports from the mining, construction; agriculture, forestry, and fisheries sectors

The risk-interconnections maps developed for each sector were based on the climate change disclosure in the company reports to see the potential links between environmental, social, and economic risk factors. These risk maps thus illustrate the complexity and interconnectivity of environmental, social, and economic risks related to climate change, as reported by South African businesses in the different sectors. Figure 5, Figure 6, and Figure 7 indicate the climate-risk interconnections identified by the mining, construction, agriculture, forestry, and fisheries sectors respectively. Companies in the mining sector identified more climate-related risks in comparison to companies in the construction or agriculture, forestry, and fisheries sectors. The mining sector further identified more interconnections between climate risks and other business risks, followed by the agriculture, forestry, and fisheries sector, while the construction sector tended to have a linear identification of climate risks with little interconnections to other business risks.

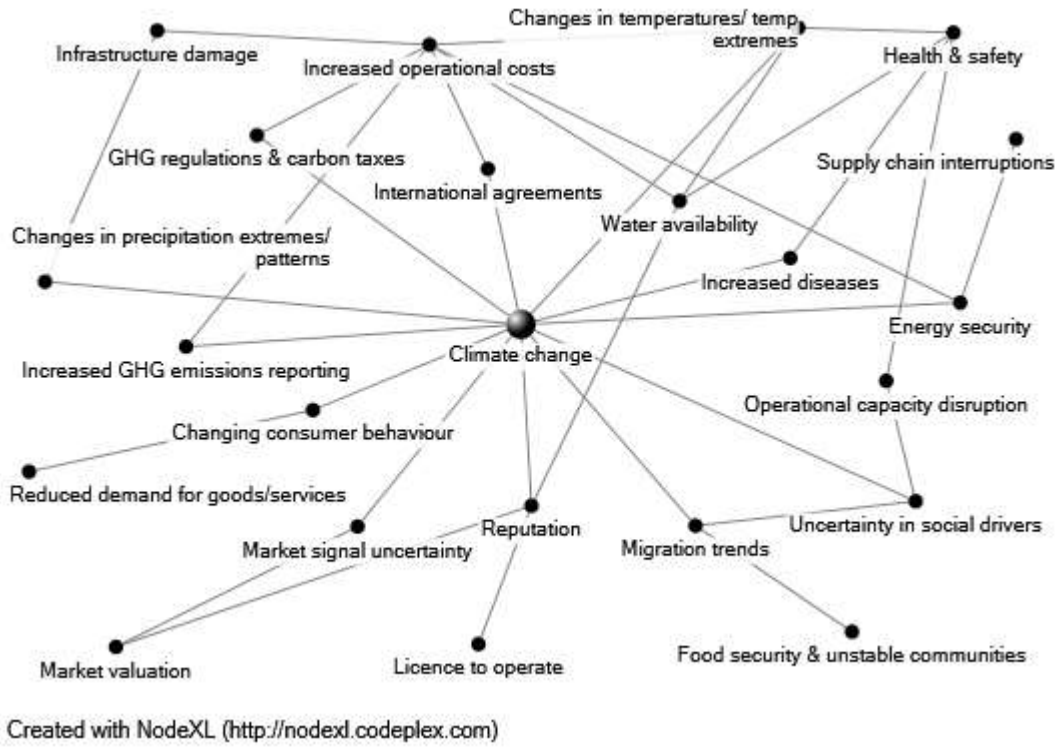


Figure 5: Risk map of climate-related risks identified in annual integrated, sustainability and CDP reports in the mining sector

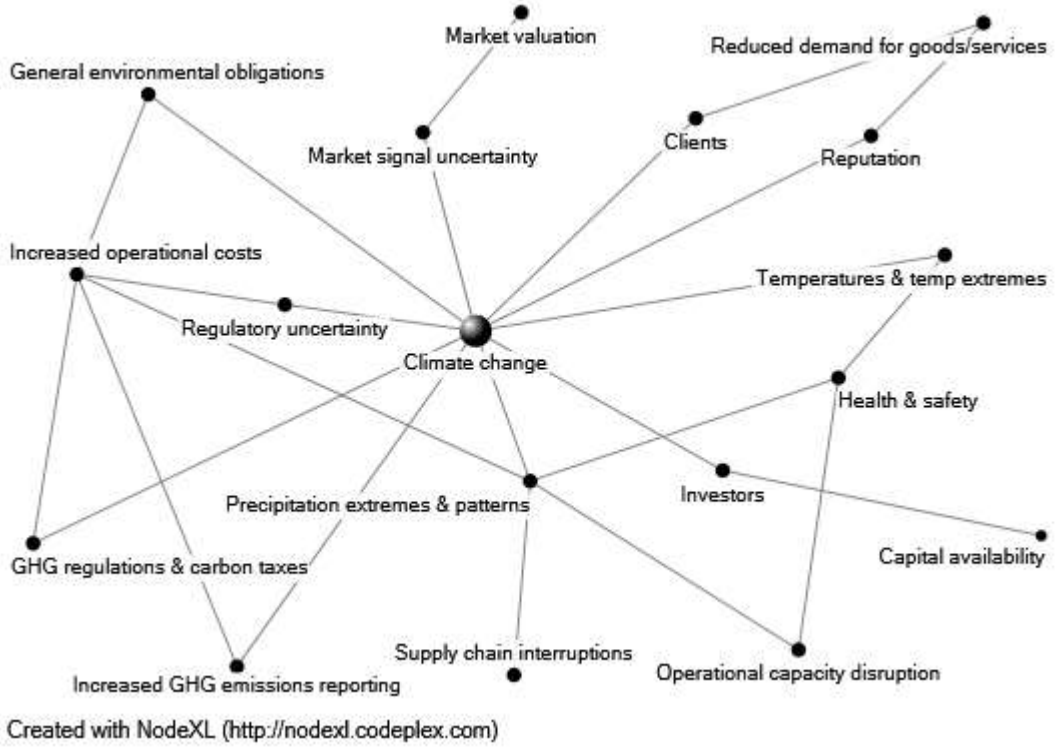


Figure 6: Risk map of climate-related risks identified in annual integrated, sustainability and CDP reports in the construction sector

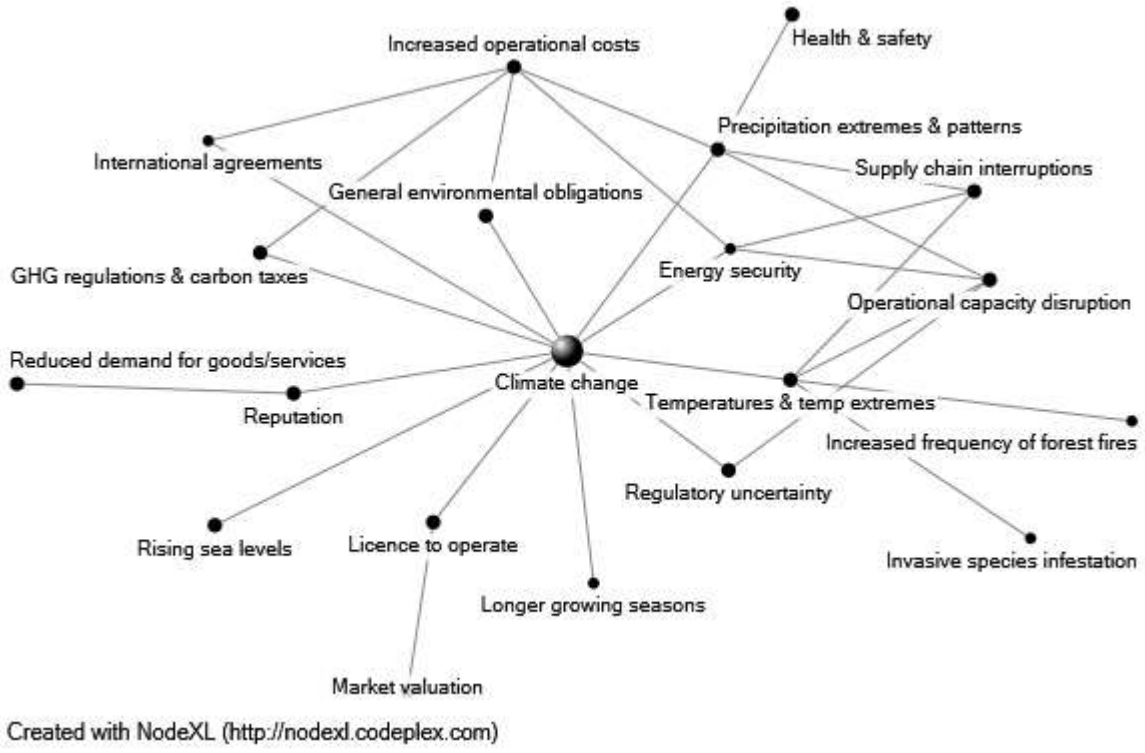


Figure 7: Risk map of climate-related risks identified in annual integrated, sustainability and CDP reports in the agriculture, forestry, and fisheries sector

The strongest links which were addressed by nearly every company were between water availability, regulatory risks, changes in temperature, and energy security, and these were all linked to increased operational costs. Several companies also linked water availability and the effects of extreme temperature changes to the health and safety of their employees and neighbouring communities. Mining and construction companies further directly linked this health and safety aspect to disruptions in their operational capacity. The links which were marginal were between climate change impacts and market signal uncertainty, market valuation, reputation, and a license to operate. The connections between these risks were seldom identified with a few companies only going as far as identifying the link between each risk to climate change, but not to each other. Some of the climate risks identified were marginal due to being sector dependent, such as the rising sea levels being identified by fisheries companies, the invasive species infestation and increased frequency of forest fires being identified by forestry companies (Figure 7). Surprisingly, links between climate change, migration trends, food security and unstable communities, and uncertainty in social drivers were only identified by mining companies.

3.3.2 Interviews

The interview analysis that follows presents results as discussions of twelve main topics. The results of how climate change is understood and perceived by the respondents is presented. This is followed by the immediate organizational risks from climate change and how climate-related risks are linked to other organizational risks. The section then provides results pertaining the responsibility for an organization's climate change risk management and reporting as well as the important of climate related risks in an organization's risk assessment. Results pertaining to the challenges in climate change risk management and the monitoring of environmental impacts are presented. These are followed by results on organizations' accountability towards maintaining system integrity and the restoration of natural and social capitals. The vision on governance and shared learning and governance structure on climate change issues results are described. The results of an organizations provisions for sustainability innovation are then presented. The section ends off by presenting results pertaining the organizations' measures to build adaptive capacity and mitigation responses of social-ecological systems (SES) to climate change.

Understanding of climate change

Six of the seven interviewees indicated a belief that climate change is caused by rising greenhouse gas emissions and exacerbated by anthropogenic activities. The interviewee who indicated that they do not believe climate change is real stated that climate change had nothing to do with their organisation (agriculture sector) and that the phenomenon would still have occurred at the same rate regardless of human activity. The interviewees who acknowledged the validity of climate change attributed this to the publicly available data on climate change science and the observed trends from their own climate related data collection. Mining company respondents further recognised that the causes for climate change are not as important as the urgent need for them to respond through mitigation and adaptation measures. They also noted that adaptation would mean accepting that our systems will enter new states and can never return to previous states as a result of climate change, but organisations were not at that stage yet.

Immediate organisational risks from climate change

The physical risks that were most often cited included water supply and availability, power supply (energy security), droughts, increased temperatures, and more frequent extreme weather events. Additionally, risks to employee health as a result of extreme temperature changes in the working environment were identified by the mining and construction sectors. Most of the respondents further raised carbon tax, regulatory uncertainty, and reputational risks as concerns for their companies. In the construction sector, an increased fuel cost (a risk driven by other climate-related developments) was also identified as a big risk due to them being a fuel heavy industry.

Connections between climate change related risks and other company risks

Water availability and supply was common in all the answers. The construction and mining sectors acknowledged that their operations in remote areas which are water scarce means they have to share this resource with neighbouring communities. Long periods of drought would thus directly impact their operational capacity and pose a threat to their license to operate. In response to this, mining companies worked with municipalities to help with the maintenance of water infrastructure and thus minimise water loss. There was also an anticipation of risks that have occurred in the past (in the construction sector), however magnitude was unknown due to the unpredictability of climate change.

Contrasting responses from agriculture, forestry and fisheries sector were given where one company only assessed immediate company risks without considering broader community risks and how that could impact their company, while the other noted a continuous assessment of climate risks and factoring these into business as well as looking into alternative water and energy supply sources. Mining sector respondents were more thorough in their answers with further mentions of product transport risk to their supply chain, increases in insurance premium costs, and the cost of capital as a risk as investors were not investing in companies which adversely contribute to climate change. This limited institutional funding for projects and increased the interest paid on debt for mining companies.

Responsibility for organisation's environmental risks assessment, management, and reporting

All the interviewed companies had specific people appointed for the assessment, management and reporting of environmental risks, inclusive of climate change risks. These ranged from sustainability managers and risk officers to risk or HSER committees which included environmental risk (and climate change risk) in the overall risk assessment. There seemed to be strong support from the board and their executives regarding this. One mining participant went on to mention that

> "*this is evident in seeing that it is part of our strategy and part of our balance scorecard (targets and objectives for the year) and that it gets signed off at group level by the board and by the executive. However, on the ground we actually get involved with the operators as they are the people who are directly impacted first by the risk, maybe not a heavy equipment operator but certainly someone who manages a tailings dam in that region of the operation*."

The company undertook climate risk assessments at operational and group levels in order to understand where their risks are for their major facilities, thus top-down and bottom-up approaches were used to integrate climate change well into business.

In construction, a top-down approach seemed to be more common as the executive management had to provide the necessary tools, support and resources for the employees executing operations on site. Any guidance and implementation of environmental (more specifically climate-related) risk assessment and management was believed to only come from top management.

Importance of climate-related risks in organisation's risks assessment

Consensus was that climate-related risks are extremely important to companies as they filtered into the top ten or fifteen material company risks. Climate risk was evolving to become a high priority as it was a recent phenomenon, and the effects were being seen more frequently:

> *"The increasing frequency of events and the fact that there is more data available and more people being vocal about it means the corporates have no choice but to sit up and pay attention to it".*

Mining companies noted that they were still in the evolving phase of integrating climate risks due to the current legislative framework causing uncertainty as it did not enable them to generate their own electricity above a certain output. Costs related to alternative energy and a primary reliance on Eskom were other issues noted by six companies (three mining, one construction, and one agriculture).

In the construction sector on the other hand, a chief risk officer was given a risk register of the company's environmental risks, however this was not really given importance or taken seriously unless a client requested such information. They noted that the easiest way for them to understand the extent of how bad a situation is if they can quantify in monetary terms.

> *"Everything from the sustainability division was only given importance if it was a requirement from clients. Our main client was government and they themselves did not take it seriously. But there were cases in meetings where some board members (for example non-executives) who serve on different boards of other companies would ask relevant questions around climate change issues, however as a company it was not taken seriously".*

Challenges in climate change risk management

The overarching challenges identified included difficulty in understanding scientific data, regulatory uncertainty, misalignment of strategic and climate change planning and innovation costs.

The difficulty in fully understanding scientific data was cited as a challenge due to climate models maturing but sometimes those models did not give usable data for all the areas in which the companies operate. Translating the data down to a regional level was a challenge for the companies and it was faced from a more forward-looking perspective as better data would give better regularity in a company's own climate risk assessments.

The uncertainty with regards to government direction around the management of climate risk was a challenge as current regulations are not accommodating towards independent power

production. There is thus uncertainty as to what individual entities can do and what collaborations would be needed in the sectors rather than working as individuals.

The five-year strategic plan for corporates (especially the construction industry) challenged companies as it did not compliment the long-term planning necessary for climate change strategic planning and implementation.

Costs of innovation presented a big challenge to construction sector as they were currently not in a financial position to afford high spending on new innovative developments that can assist with the saving of the environment. Efforts were thus being made to find a balance between getting a positive yield on what they want to achieve and saving as much money as possible.

Monitoring environmental impacts and product life cycle impacts

General consensus was that environmental impacts were indeed being measured through a wide range of indicators and there were carbon emissions and energy reduction targets in place. While some companies cited the compliance aspect as being hard to ignore, they believed that their participation in the CDP showed that their motivation for monitoring impacts went beyond compliance. Admittedly however, one agricultural sector respondent stated that the primary motivation was to comply and just reduce environmental resource use:

> "*Our company is in the business of making money and we do not measure the monetary value of this reduction the motivation is really just to reduce these inputs".*

Another respondent in construction gave a different reason why it is just for compliance purposes, stating that environmental managers were trying to push for going beyond just measuring these impacts, but senior management only took such concerns seriously when it affected company profits. Additionally, in this sector, monitoring these impacts became challenging due to the ever-changing working environment. Monitoring their fixed sites (their corporate offices) was possible, but the project-based nature of their operations meant they had relatively short life cycles and their clients took over the life cycle parameters once the project was completed.

The mining respondents added perspective as to why decoupling was a challenge for their sector as, through their climate change mitigation efforts, they created opportunities to reduce their energy costs, subject to reducing their carbon emissions. Such opportunities would have a financial benefit to operations, but the mining processes are becoming more difficult, so the requirements become more intense. There is a constant trade-off between still making expected financial returns versus reducing carbon footprints in line with aspirations.

Accountability towards maintaining system integrity and defining value creation

Generally, in the construction and agricultural, forestry and fisheries sectors, accountability was mainly due to addressing business needs and was a reactive measure instead of a proactive one. In construction, respondents believed that people generally care about the environment but at work they had to work according to certain systems and have to meet certain deliverables, so they instead concentrate on that and forget about their personal core values. The primary focus was on the finance capital with limited focus on the natural and social capitals. Concern was more about profits and while the universal concept of sustainability was somewhat understood in the boardroom, the behaviour did not change.

> *"As an organisation though we are not really accountable to the system as we are measured only on making a profitable project, unless it is a mandate from the department (government)".*

The mining sector participants noted publishing aspirational policy statements for the environment and society, thus indicating their commitments to maintaining system integrity with structures, systems, and teams in place to work towards this.

> *"We obviously work within the expectations of the regulator in the region but where possible we aim to go beyond compliance, although this is debatable as the regulator's expectations generally require one to go beyond compliance anyway. There is definitely a strong commitment from us towards environmental stewardship and the well-being of our communities and our relationship with them which all speak to the social-ecological environment in which we work".*

There were dedicated teams for climate and energy management and for water management which went beyond their own water but also looked at the catchments in which they (the

companies) operated in. This indicated a deep commitment from the mining sector to conduct their business in a more responsible or sustainable manner.

Restoration of natural and social capitals

While rehabilitation was done at the end of construction projects, construction companies were constrained by not owning the sites they operate in so they could not rehabilitate beyond their clients' mandates. Due to this, there was also nothing which compelled them to restore other capitals of their systems. Restoration initiatives in the agriculture, forestry and fisheries sector were company specific and there was no collaboration with other stakeholders in implementing these initiatives.

In the mining sector, the primary and obvious motivation was the legal requirement to have provisions for restoration. However, in the same space they set their group guidance which was aligned with the top 30 peers in the world and aligned with ICMM requirements. The second motivation was from a humanitarian perspective as they had communities close by and had to return the land to a functional state. Companies in the sector set guidance in terms of what the expectations were based on mine closure plans. One of their focus areas (also expected by regulators) was progressive rehabilitation which meant that, where possible, they rehabilitated damage as they mined and not only at the end.

Vision on governance and shared learning and governance structure

Generally, a top-down structure was the primary approach and only one agricultural company and two mining company respondents shared that it was a combination of top-down and bottom-up approaches. While some organisations had no aspirations of shared learning around climate change issues, others gave elaborations of learning from their own research and from external stakeholders. Their interactions with stakeholders meant that there was a lot of information sharing on environmental and climate related matters.

The respondents who cited evidence of both governance structure approaches, visionary governance and shared learning on climate change further stated that white papers and policy statements on climate change were published on their websites (in addition to the reports) and

exercises on organisational climate change resilience were conducted and used in internal risk assessments.

Provisions by the organisation for sustainability innovation

Respondents in the construction and agricultural sectors typically did not refer to provisions for sustainability innovation, specifically for research and design around climate change as their current systems were already quite energy and resource efficient. For example, construction sector respondents referred to the recycling of oil in their plants as well as the treating and reuse of wastewater as resource efficient measures. There were various types of incentives for such innovations in the different sectors. In construction, the encouragement for such innovation existed but one company noted that they instead used informal means and manners as rewards. In the agriculture, forestry and fisheries sector the reduction of energy and GHG emissions formed part of the performance assessment for the executive committee while low-level employees could be awarded with meal vouchers, a braai or product hamper.

In mining sector, mitigation strategies were developed and funded through the operating and capital budget and part of this looked at optimizing systems and a better transition to cleaner renewable energy. There was also extensive engagement in industry with peer groups, coupled with academic and non-academic research and innovation towards this. Provisions were not just in the organizations as a lot of work was also done within the community to educate people, which then addressed behavioural change. Programs were in place to try creating awareness for the broader community. There were also engagements with employees and KPIs around environmental issues including climate change in this sector.

Measures to build adaptive capacity and mitigation responses of SES to climate change

All respondents stated that there were no specific strategies for the adaptive capacity of their SESs to climate change however this was something that needed to be worked on as part of their adaptation approach. There was acknowledgement of building resilience to climate change beyond company resilience however this was a work in progress. The construction sector however stated that they have always been reactive and that perhaps there was not enough opportunity to carry out mitigation and adaptation measures even for themselves so

they would not think as far as their communities' resilience. Client demands again are cited as a huge driver for this as most responsibility belonged to the client and it was out of the construction company's scope. The company instead got dictated to stay within parameters outlined by the client, other than that they could only take responsibility for their direct operations from an environmental perspective and that hardly covered the greater communities that they operated in.

3.4 Discussion

Climate change risks and opportunities for businesses can be in the form of GHG regulations, evolving products and markets, evolving shareholders and consumer perceptions as well as competitors' actions (Cogan, 2006; Firth & Colley, 2006; Mills & Lecomte, 2006). The physical impacts of climate change may affect business processes, fixed assets, and resource availability. Previously, climate change adaptation was relatively new in business and usually referred to in a few paragraphs in either Corporate Social Responsibility (CSR) reports or CDP documents (Stanny & Eli, 2008). The importance of the business community in climate change adaptation has since gained more acknowledgement (Amran, Wong, & Hashim, 2016; Tang & Demeritt, 2018). In my study, most of the companies that disclosed on climate change matters in more than one document (i.e AIR, sustainability report, CDP reports or climate change white papers) tended to address climate change in more depth than those who did not disclose in more than one document.

As indicated in section 3.3.1, the mining sector addressed climate change more frequently than the other two sectors through a higher level of disclosure on climate change issues in various reports. The higher level of disclosure from the sector suggests that they are able to address climate change issues in more depth than the other two sectors. It is thus not surprising that the mining sector identified more climate-related risks and a higher interconnectivity between climate change and other business risks compared to the other two sectors. This may suggest an association between increased disclosure and a better assessment of climate change risks and better mitigation and adaptation strategies. What was surprising however was that greater disclosure in the construction sector (compared to the agriculture, forestry, and fisheries sector) did not translate to a better assessment of climate related risks as this sector tended to have a linear identification of climate-related risks with very few interconnections to other business risks. The higher climate change disclosure in the

mining sector compared to the other sectors suggests that it is more committed to addressing climate risk and integrating it into its organisational strategy and risk management. A business' response to climate change can influence whether its reputation is a risk or an opportunity and companies often only report on their successes with regards to climate change or environmental impacts (Chatterji, Levine, & Michael, 2007).

My results pertaining to the importance of climate-related risks in the construction sector mirrored a finding from Vogel (2009) where the construction group interviewed had pushed environmental concerns higher onto the business agenda (or rather efforts were made towards this), however getting support from senior level was accompanied by external prodding. In my study, even though climate change was a concern, it was only one of a range of other risks that the sector dealt with. While top management was found to understand climate change to a certain extent, due to the companies not being measured on it, they did concentrate on it and assessments were voluntary. This differed from the mining sector which is under constant pressure from global communities and the sector itself to improve on their environmental and social performance and so companies compete for a good reputation and have to be on par with their peers. It has been predicted that the costs of not disclosing increase with the higher levels of scrutiny. From Stanny and Eli (2008), companies which were scrutinised more were more likely to disclose on climate change related information and this may explain why the mining sector in my study disclosed more on climate change and better identified climate-related risks. Over the years there has been increasing pressure and petitioning for the Securities and Exchange Commission's requirements to include companies' disclosures on material climate-related information in their corporate disclosures. With the CDP being the largest effort by institutional investors to solicit climate change information from companies, it not only informs investors about companies' climate change-related risks but also informs managers about investors' concerns (CDP, 2016). Another finding by Stanny & Eli (2008) was that voluntary climate change disclosure was related to company size and foreign sales. Such a finding of a positive relationship between company size, foreign sales and disclosure suggested that multinational companies had more motivations to disclose, and this was possibly due to a higher level of environmental scrutiny and regulation.

Previous literature has also shown that companies in industrial, mining, energy and service sectors tend to voluntarily disclose on climate change issues more frequently, which corresponds with my findings in (Figure 4). There has also been an observation of companies

disclosing greenhouse gas emissions voluntarily to gain competitive advantage and legitimisation in current markets (see Rankin, Windsor, & Wahyuni, 2011). Voluntary disclosures can thus be a useful tool for meeting stakeholder demands for socially responsible business practices (Cho & Pattern, 2007). The emphasis has shifted from climate change mitigation to climate change adaptation and the use of clean technologies has increased in the mining sector for the transition to a green economy. In research by Aleke & Nhamo (2016), the climate change documents of most mining companies acknowledged the significant threat posed by climate change to their activities and that adaptation strategies needed to be implemented urgently. Clarkson, Li, Richardson, & Vasvari's (2007) findings suggested that, while energy-intensive companies invested in new assets, these are not necessarily cleaner technologies which reduced carbon emissions, thus such companies avoid disclosure on carbon-related information. Furthermore, energy intensive companies were not found to be more likely to disclose. This contradicts the findings in my research where energy intensive companies were more likely to disclose on climate change.

According to a study in Bangladesh by Nurambi (2016), two main issues that contribute to companies' non-disclosure attitudes toward climate change in the country were related to regulation and a company's culture of social accountability. A lack of regulation (for climate change reporting) attributed to companies' disinterest in disclosing climate change matters. Due to climate change reporting not being a legal obligation in that country, it was not regarded as an important matter by management. Interview results from my research also indicated regulatory concerns to one of the major challenges for companies in their assessments, management and reporting of climate-related matters. However, the regulatory uncertainty- as opposed to a lack of regulation- was the concern for participants in my study. While climate change was noted to be important, the regulatory uncertainty was cited to restrict companies in their efforts to address climate-related matters, and subsequently their reporting on these. This strong emphasis on regulatory issues means that climate change must be taken seriously by governments, otherwise a *laissez-faire* response may result and lead to lower levels of climate change disclosures from businesses.

Organisational culture can foster adaptation actions as managerial endorsement increases access to necessary resources for implementation and/ or the extent of cross-organization engagement and collaboration (Berkhout, Herlin, & Gahn, 2006). A strong culture of corporate responsibility can thus be considered beneficial to the delivery of projects that go beyond minimum standards along with corporate direction that incorporates high

sustainability standards. A weak culture of corporate responsibility may be expressed as companies' management not willing to disclose climate change information, which contributes to low levels of climate change reporting (Nurambi, 2016). While most of the companies in my study sample disclosed on climate change in at least one type of annual report, the organisational culture may possibly explain the lower climate change disclosure particularly in the construction and agriculture, forestry, and fisheries sectors. One reason for the management of small companies being reluctant to report on climate change was the primary concern about costs and the perception of disclosing climate change reporting not being directly beneficial to the company.

Language is strongly related to awareness and perception as a general lack of understanding around climate change has been raised. The terminology used (resilience vs adaptation) led to lack of willingness on engaging climate change issues especially in the context of inadequate skills in the industry. Climate change communications and language could thus be a barrier to adaptation related action not only in the construction but also in the agriculture, forestry, and fisheries sector.

One of the reasons there is an inadequate incorporation of climate change strategies in the construction sector is the lack of client demand. Client demands for projects responding to climate change is strongly influenced by their (client) own perceptions of climate related risks. The level of client's demand is further related to language use, the state of regulation and prices that clients are willing to pay. Reported findings in section 3.2.2 are in line with previous research indicating that industries address climate change if they believed their clients or communities are not interested in it (Moser & Luers, 2008; Morton, Bretschneider, Coley, & Kershaw, 2011). This could also be related to the perceived unaffordability of climate change initiative as clients do not perceive actions for addressing climate change to be worth the extra expenditure of money and time. Falling margins and greater competition between companies means that construction companies are then reluctant to suggesting any innovations which may increase prices for clients, similar to Morton, Bretschneider, Coley, & Kershaw (2011). More effort is also needed to increase industry efficacy and community willingness to address climate change. While the construction companies in this study were willing to implement initiatives addressing climate change, some perceived their community to have very little appetite for them (lack of acceptability by general public). These results are consistent with existing literature by Morton, Bretschneider, Coley, & Kershaw (2011) and Waters, Barnett, & Puleston (2014) who noted that stakeholder's desirability to address

climate change influenced the action likely to be taken by companies in addressing climate matter. This then creates a barrier in effectively addressing climate change.

Climate change affects multiple aspects of a complex social-ecological system with interacting units which are dynamic and adaptive, thus increasing the complexity of the consequences. There thus needs to be an appreciation for the absence of a central control in complex systems as any change to a complex system can be catalysts for larger events (Mitchell, 2011). Dialogue and interaction are needed between businesses, stakeholders, and climate scientists for overcoming the barriers and their interpretations. In this research, the mining sector showed greater strategic-level thinking around climate change assessment and management compared to other industries, and this is in line with initial explorations research by (Vogel, 2009). However, reflection is needed on climate change adaptation and climate risk implications on the risk management aspect and the overall business strategy. This study has mapped out the climate change related risks landscape for three economic sectors in South Africa. It has also identified and addressed the challenges faced by companies in these three sectors in their climate risk assessment and management. It has highlighted the mining sector as performing better than its peer sectors in the climate risk assessment and management, as per disclosure on climate change. It reiterates the necessity of integrating climate change into long-term business planning. A holistic approach is needed due to the systemic nature of climate risk, in order to identify and understand the full range of potential impacts. Beyond mitigation and adaptation efforts, South African businesses need to build resilience of the systems in which they operate in order to also be able to thrive or continue operating in these systems. This is addressed in Chapter 4 which follows.

CHAPTER 4: SOCIAL-ECOLOGICAL-SYSTEMS RESILIENCE TO CLIMATE CHANGE IN JSE-LISTED COMPANIES

Abstract

Climate change has become increasingly noticeable and has gained recognition as an emerging risk to business which could have adverse impacts in the absence of sound adaptation plans. Business efforts towards climate change adaptation need to focus on building resilience to better adapt and respond to climate related risks. Businesses further need to improve social-ecological systems (SES) resilience as this determines the success of businesses in those systems, thereby influencing business resilience itself. Through report analysis, this study applied the PwC & CSIR (2016) Social-Ecological Systems Resilience Framework to assess the extent to which systems resilience to climate change across three sectors in the South African economy for the period FY:2016- FY:2018 was integrated by companies. The mining sector was found to have greater systems resilience compared to the construction, agriculture, forestry, and fisheries sectors in all the years. There were also significant differences found within the sectors which highlighted that some businesses within these sectors had proactive efforts to build such systems resilience while others had a more reactive approach to challenges such as climate change as it was not seen as a material risk to their businesses. More collaborative efforts are needed in business for the learning and governance of climate change and embracing accountability towards social-ecological systems. Companies are further encouraged to participate in the Carbon Disclosure Project and apply the Task Force on Climate-related Financial Disclosures recommendations to better address climate change and promote systems resilience towards it.

4.1 Introduction

This chapter is an assessment of the extent to which the selected JSE-listed companies addressed SES-resilience to climate change. It begins with an introduction of the resilience concepts and further discusses the shift from a risk-based perspective to a systems-resilience based perspective. In so doing it provides elaboration to the SES-resilience framework used as the basis of this research. The chapter then discusses the methodology used in conducting

the research and presents the results thereof. This is followed by a discussion of how the selected companies from different sectors promoted systems-resilience to climate change and how they included this in their business strategies, management, and report.

Our planet is in an emergency due to growing environmental degradation and the society crossing planetary boundaries, one of them being climate change (Abdallah, Michaelson, Shah, Stoll, & Marks, 2012). Climate change implications are potentially wide-ranging, catastrophic, and intersecting, and some impacts may not be predictable due to the complexity of the climate system. The changing environmental, societal, demographic, and technological patterns threaten systems and may result in new vulnerabilities (IPCC, 2018; WEF, 2019). The physical impacts of climate change can threaten social ecological systems by breaching historical thresholds for resilience and beyond this, multiple systems can be affected at once (Linnenluecke & Griffiths, 2010; Stocker *et al*., 2013; USGCRP, 2018). Being ill prepared for what is to come could result in society missing the point at which such challenges may be addressed.

4.1.1 The resilience concept

Differences in exposure, vulnerability and adaptive capacity will shape the different risk profiles of individual companies. The internal capabilities and resources of those companies will drive their feasibility profile for solutions. A risk that cannot be mitigated needs adaptation so that the system's vulnerability to impacts is reduced (Krumdieck, 2011). For progression towards sustainability, risk-based strategies are insufficient and need to be supplemented by system resilience-based strategies. The environmental strategies employed in businesses need to be expanded from risk-based approaches to resilience-based approaches as their concerns have also expanded from environmental management to business sustainability (sustainable development). It has been suggested that building and maintaining resilience in uncertain, complex, and dynamically evolving systems needs investment in flexibility, adaptability, system diversity as well as reserve capacity (Korhonen & Seager, 2008). The resilience of the organisation- not of the larger socio-economic or socio-ecological system- has always been more important from a business perspective. In some cases, there have been total transformations in the marketplace where adaptation was unsuccessful and technological innovation was usually the exogenous stressor (Brown, Harris, & Russell, 2010). Adaptation, transformation, and evolution may be the only

successful strategies should some unpredicted catastrophic events occur. Systems therefore need to build resilience to cope with turbulent external environments. Reducing a system's exposure and sensitivity to a disturbance as well as increasing available responses can mitigate the impact of disturbance on the system and thereby reduce vulnerability (Bhamra, Dani, & Burnard, 2011). Resilient businesses are said to proactively manage their adaptive capacity and their strategies are proactive and resource efficient (Krumdieck, 2011).

4.1.2 From risk to systems resilience

The society in which businesses operates in needs to succeed in order for the businesses themselves to succeed (Haywood, 2016) . This means that, in addition to an individual company's well-being and success, the focus needs to also be on the entire system that the company is embedded in. Businesses must develop leadership that is risk-management and resilience-based. Businesses that facilitate a resilient social and natural system create more value (Haywood L, 2016). In times of unparalleled global change, resilience can be used as a 'way' of addressing sustainability as well as managing risk. A social-ecological-system can be resilient by either adapting to maintain itself in a specific arrangement or transforming to a completely new arrangement. Adaptability and transformability of a SES enable its resilience by enabling the systems to negotiate change, external pressures, and uncertainty through self-organization (for adapting) and/or innovation (for transforming) (Folke C. , et al., 2010; Sterk, van de Leemput, & Peeters, 2017). Broader systems resilience needs to be embedded in business strategy, management and reporting and the guidelines by the CSIR (Council for Scientific and Industrial Research) and PwC (Pricewaterhouse Coopers) give seven principles to assist in doing so. These are broadly described as the systems principle, risk and adaptation principle, decoupling principle, well-being principle, restoration principle, collaborative governance principle and the innovation and foresight principle (Figure 8) (CSIR. & PwC., 2016; Haywood, 2016).

For measuring and achieving social-ecological-system's resilience, review templates for each principle are provided by the CSIR & PwC guidelines to see how far a business is in addressing this systems resilience (CSIR & PwC, 2016). There are indicators provided for each principle, so a business can define what their current and desired states are.

- The systems principle assesses whether the organisation recognises that it is operating in a broader social-ecological system that is shared with various other users. The organisation is therefore accountable for its impacts (direct and indirect) beyond its physical boundaries.
- The risk and adaptation principle addresses an organisation's risk landscape and its mitigation and adaptation approach extending beyond immediate business risks, thus looking at the social-ecological system's vulnerabilities and thresholds.
- The decoupling principle allows for a separation (i.e., decoupling) of an organisation's financial growth from its natural resource use as well as environmental impacts.
- The well-being principle assesses whether an organisation understands the significance of employee well-being and of system well-being to the organisation's value creation.
- The restoration principle looks at the organisation's financial investment towards the restoration of the natural and social capitals that it relies on, in efforts to building systems resilience.
- The collaborative governance principle looks at whether collaboration with stakeholders is facilitated by organisational governance in order to have shared learning towards adaptive management.
- The innovation and foresight principle is about establishing integrated management for intergenerational justice.

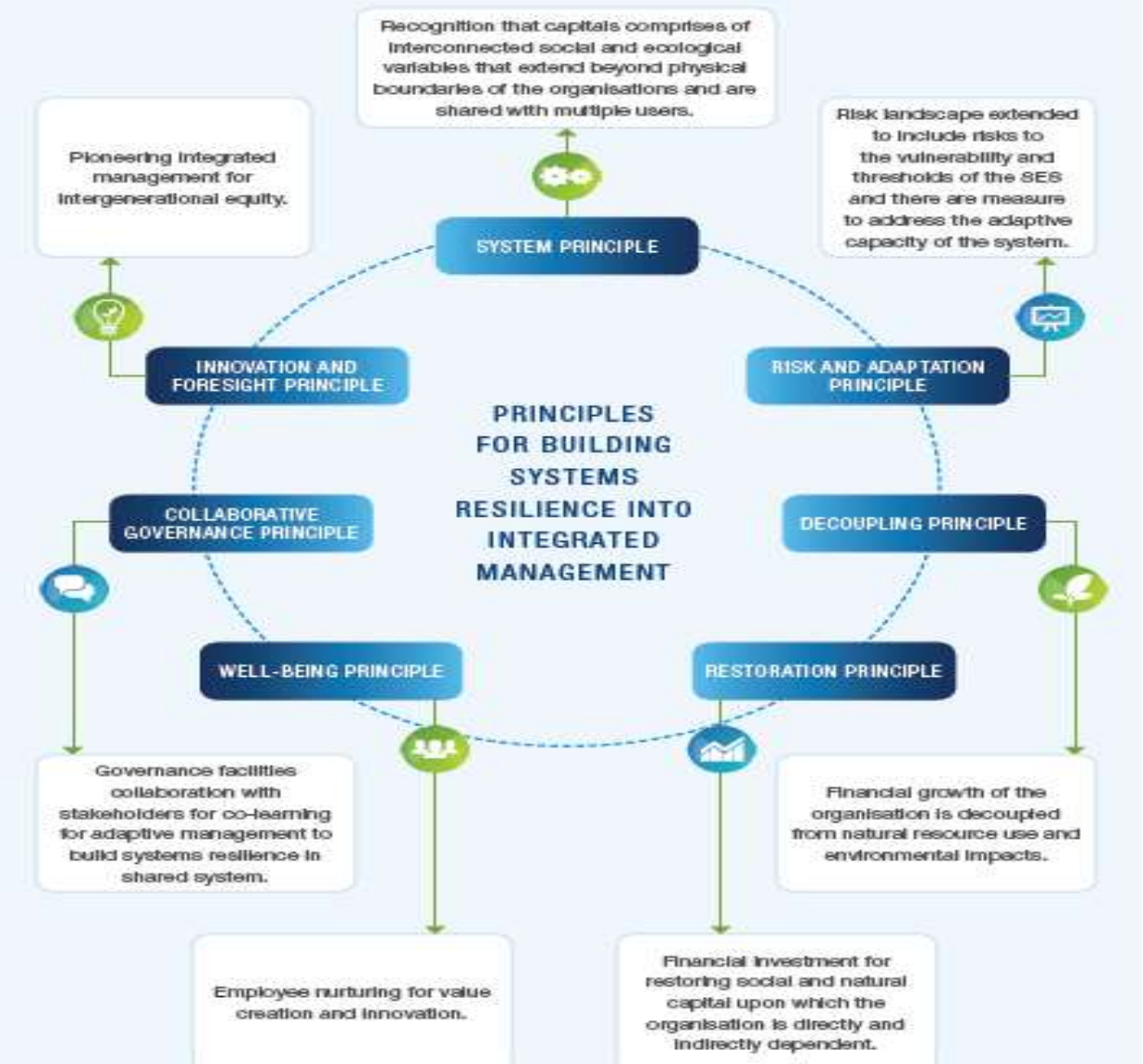


Figure 8: The CSIR & PwC social-ecological systems framework (pg. 7) used in the analysis of systems resilience (CSIR & PwC., 2016)

These seven principles for embedding social-ecological systems resilience into business strategy are based on the sustainable development goals and resilience theory. Businesses that implement these principles could link resilience to their business strategies and reporting and thus would be able to make a significant contribution to building social-ecological systems resilience (CSIR. & PwC., 2016; Haywood L, 2016).

Climate change is among the emerging risks faced by businesses and it could impact a business' value creation ability. Climate change may result in adverse business impacts such as declining financial performance, increased costs, and business interruptions. Businesses that are resilient can thereby adapt and respond to emerging risks such as climate change. The

World Business Council for Sustainable Development (WBCSD) and the World Economic Forum (WEF) have highlighted the necessity to develop resilience so that both society and business can overcome the global challenges we currently face. Promoting social-ecological system resilience is important for business resilience as the system's resilience determines how successfully the businesses operating in that system will function. The system's ability for responding and adapting to change will determine future business risks. When critical thresholds are approached, the system's resilience is compromised and so its ability to support the success of businesses will decrease (Bhamra, Dani, & Burnard, 2011; CSIR. & PwC., 2016). In essence it may end up in a state whereby value creation is not sustained anymore. By building social-ecological systems resilience, the businesses would be able to continue to operate and create value for that system and they would also be able to see opportunities that come from this changing climate (Winnard *et al*., 2014; CSIR. & PwC., 2016). Furthermore, they would be able anticipate as well as adapt to the risks that may arise.

Boardroom discussions on transition strategies and financial exposures of climate change have been increasing since the Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD) recommendations were released in 2017. These recommendations are for the disclosure of clear, consistent, and comparable information on risks and opportunities presented by climate change. Adopting these recommendations widely would not only ensure that climate change effects are routinely considered in investments and business decisions but would further help companies in better communicating key climate-related information (TCFD, 2017). Thus, there has been more mainstreaming of the assessment of climate change financial risks. Investors and governments are also responding to climate risks by increasingly requiring listed companies to disclose climate risks. Beyond the disclosure of climate risks, companies need strategies and business planning which promote systems resilience in the face of disruption resulting from climate change impacts. This study aimed to analyse the extent to which the sample JSE-listed companies integrated principles of social-ecological system (SES) resilience to climate change through their strategic management and decision making.

4.2 Methods

The study involved a sample of eighteen companies listed on the Johannesburg Stock Exchange (JSE) belonging to the mining (n=6), construction (n=6), agriculture, forestry &

fisheries (n=6) sectors. The selection of these sectors was based on them being direct impactors, their dependence on the natural environment, and also on the basis of the FTSE Russell (2018) Industry Classification Benchmark (ICB). The sectors were identified to be direct impactors in that the operations had direct impacts on the environment and the use of natural resources as a primary commodity meant that they would be first to feel the direct physical and transitional impacts of climate change on their businesses.

The companies' annual integrated reports, sustainability reports and CDP reports were assessed for the period of FY: 2016- FY: 2018, these documents were publicly available and accessed from the company websites and the CDP website. To analyse the extent to which sample companies in a sector integrated resilience principles into their planning and operations (as reflected in their reporting), these reports were assessed against the CSIR and PwC (2016) resilience roadmap principles (see Figure 8) and a scorecard was adapted from this framework (see Appendix A). An assumption in this research is that if these principles are addressed, the company is likely to be contributing to the resilience of the broader SES system. However,the resilience of the SES system will also be affected by other factors beyond the company or the sector).

The scorecard included all seven of the original social-ecological-systems (SES) resilience roadmap principles with a total of 20 indicators. The framework was adapted by adding a "below basic" state in the criteria of 17 out of the 20 indicators and thus each of these indicators had a range of possible scores from 0-3 (see Appendix A). A score of zero= report did not address indicator at all; one= report addressed indicator with limited mention with regards to climate change; two= indicator was addressed sufficiently with regards to climate change; three= indicator was addressed in depth with regards to climate change. Appendix A provides the specific definitions and scores applied for each indicator. The total social-ecological-systems resilience scores (possible maximum of 60) for each company were then calculated and comparisons were made between the sectors and within the sectors themselves for the period of FY: 2016 - FY: 2018. Thresholds were applied to these SES-resilience scores as follows: an SES-resilience score of 0-20 was interpreted as a below basic-basic state of resilience. An SES-resilience score of 21-40 was interpreted as a basic-evolving state of resilience. An SES-resilience score of 41-60 was interpreted as an evolving-leading state of resilience. Descriptive statistics were run using Microsoft Excel for Microsoft 365 (V 2103). A Shapiro-Wilk test was done using Statistica (V14.0.0; ©TIBCO Statistica 2020) to determine whether the data were normally distributed and based on that, a general Linear

Model (GLM) was used to test whether YEAR or SECTOR were predictors for significant differences in SES-resilience scores. The average principle scores for each sector were calculated for 2016, 2017 and 2018. These were expressed as percentages to allow for comparison of principles despite an unequal number of indicators forming part of each principle score. To test for differences between the SES-resilience principles, the data were arcsine-transformed in Excel before testing.

4.3 Results

Although the PwC and CSIR (2016) framework is applicable to a range of risks, it is appropriate to interpret the results of the assessment presented in the chapter in terms of climate change risks which were specifically mentioned in the adapted framework scorecard (see Appendix A).

4.3.1 Differences across the sectors in 2016, 2017 and 2018:

There was a significant difference in the state of social-ecological-systems resilience between the different sectors from 2016-2018 as shown by Figure 9 ($F_{(2,51)}$= 46.499; p<0.001). The post-hoc Tukey HSD analysis was conducted, and results indicated that the resilience scores of the mining and construction sectors differed significantly (p<0.001) and so did the resilience scores of the mining and agriculture sectors (p<0.001). The test results further indicated that the resilience scores of the construction and agriculture sectors were not significantly different (p=0.971).

These differences in total scores of SES-resilience between the sectors can be attributed to the marked differences in scores of the principles themselves between the sectors (see Figure 10), with the mining sector scoring higher for all the principles of the adapted SES-resilience framework in all three years. Figure 10 indicates the principles which are the main contributors to the SES-resilience sector differences shown and described in Figure 9. These are the systems, collaborative governance and the innovation and foresight principles. While there was a noticeable difference in total scores of SES-resilience between the years, the GLM results indicated that such a difference was not significant ($F_{(6,26)}$= 0.239; p= 0.959) and the post-hoc analysis confirmed this.

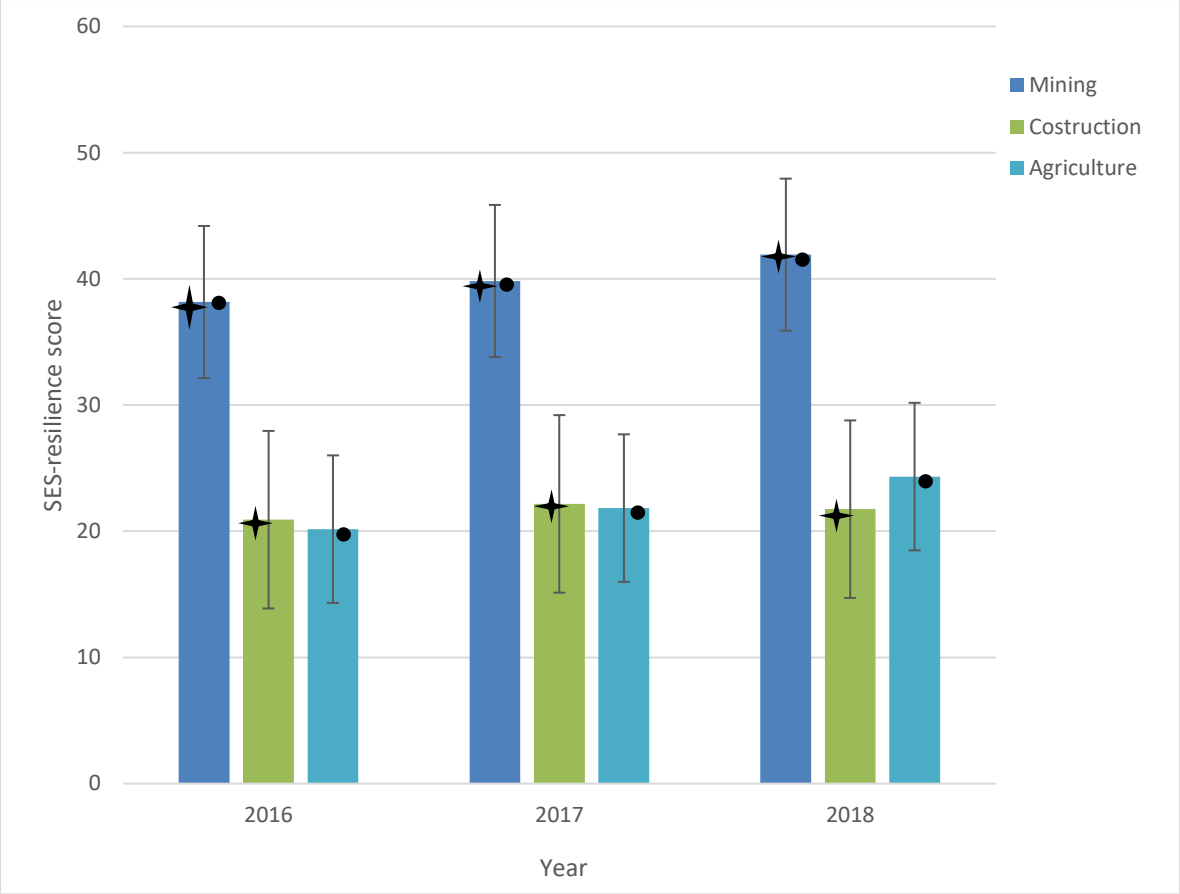


Figure 9: Average social-ecological-systems resilience scores (±SD) in the mining, construction, and agriculture & fisheries sectors in 2016- 2018

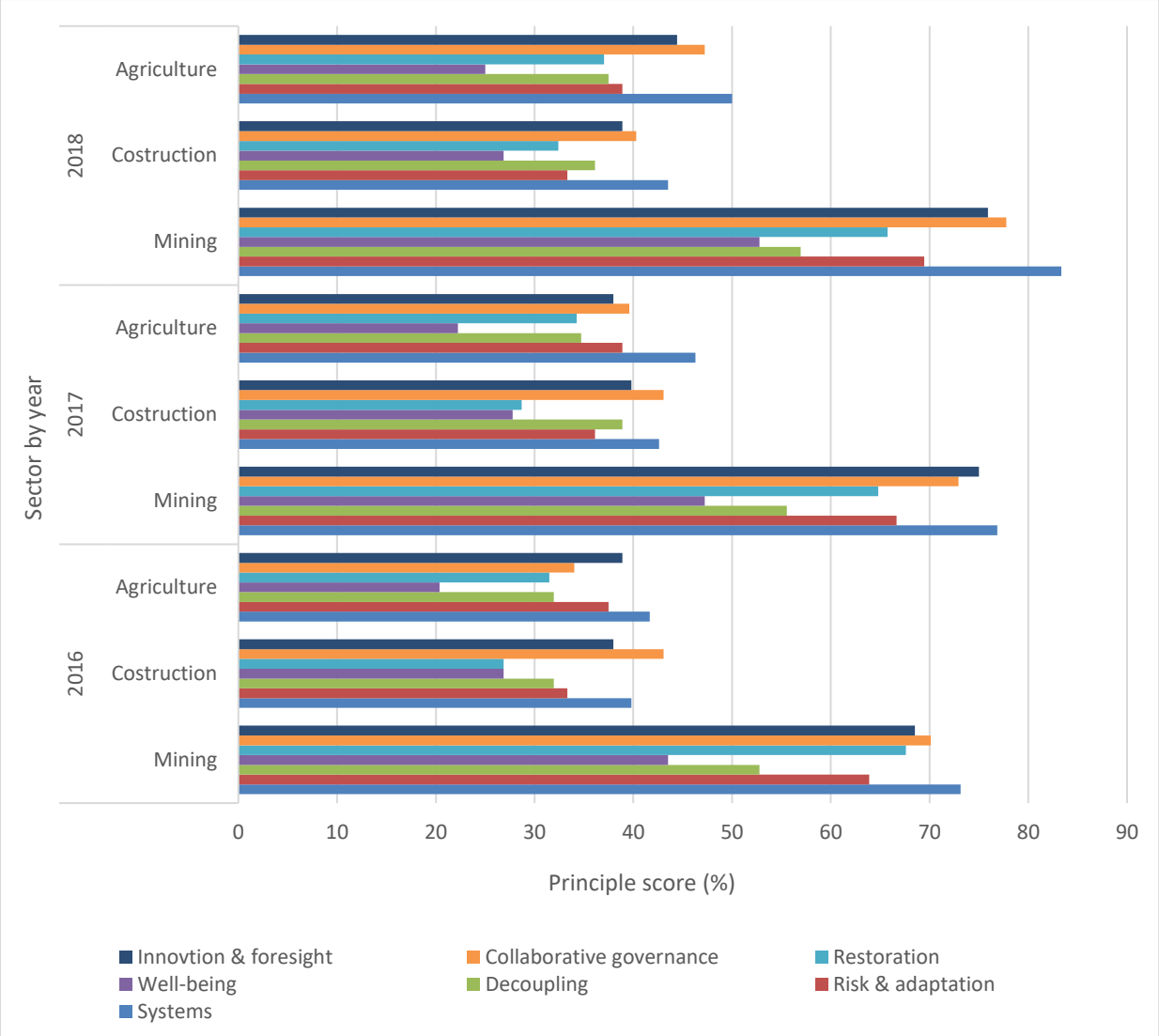


Figure 10: Average SES-resilience principle scores (%) of the mining, construction, and agriculture & fisheries sectors during the period 2016-2018

4.3.2 Differences WITHIN the sectors in 2016-2018:

While the mining sector generally does better than the other two sectors, there are some notable differences seen within the sector itself. While some companies scored quite high for SES-resilience across the years (Figure 11, mining company m.B and m.E), there is one company (mining company m.F) which scored a little over 50% for SES-resilience across the years. Statistical results found that the differences between the SES-resilience scores within this sector were significant ($F_{(5,11)}$ = 309.7784; p< 0.001) and where exactly these differences were, can be found in Appendix B, Table 1). Although the difference in total SES-resilience scores of all the companies from 2016- 2018 was not significant (see section 4.3.1), this still suggests that the mining sector is committed to building SES-resilience to climate change. It also suggests that the sector most companies in the sector are encouraging visionary and shared learning on climate change issues among their peers.

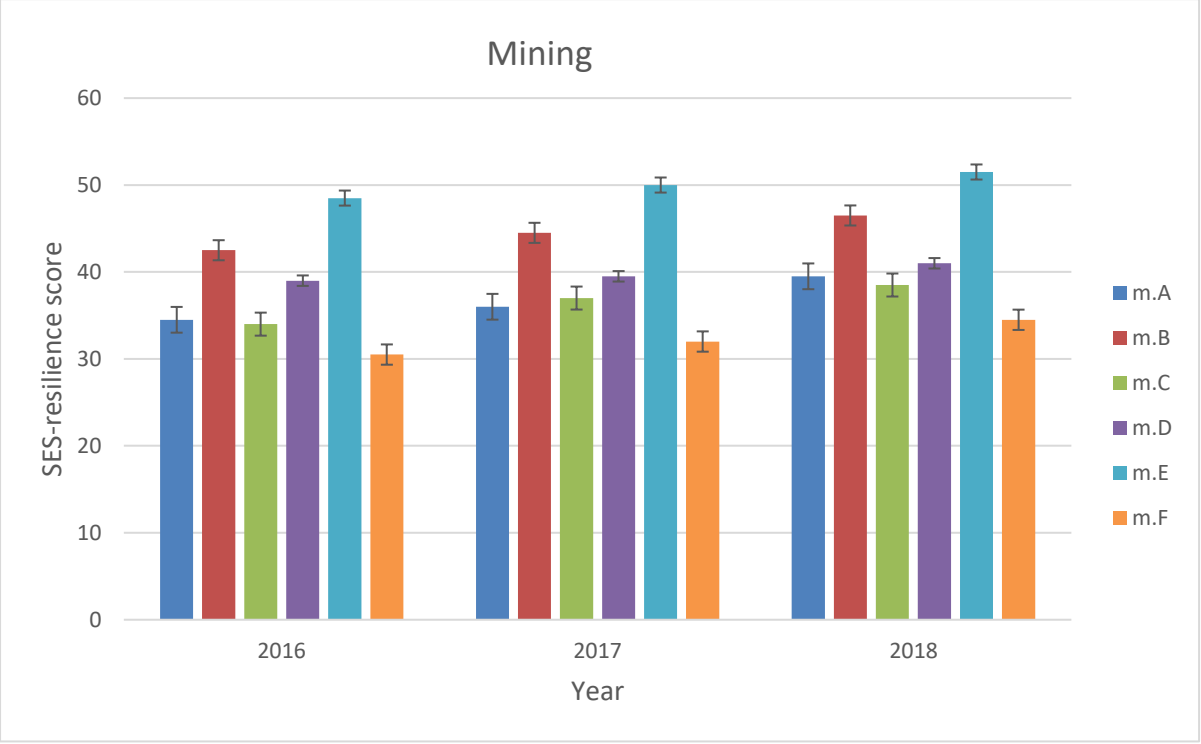


Figure 11: Differences in total SES-resilience within the mining sector in 2016-2018

In the construction sector only one company (Figure 12; construction company c.E) was scored as average just above 50% of the total potential SES-resilience score. The rest of the

companies scored in a range of 20%- 48% and this accounted for the low SES-resilience averages in the sector. There are also notable differences between construction companies c.C & c.D and construction companies c.E & c.F across all the years and statistical results indicated that there were significant differences between companies scores in this sector ($F_{(5,11)} = 45.97563$; p<0.001). Appendix B, Table 2 shows which companies' SES-resilience scores differed significantly. While all companies scores increased from 2016- 2018, construction company c.B increased in 2017 but decreased in 2018. This result could potentially be attributed to a decline in the disclosure on climate change issues as the company had not participated in the CDP in 2018 and the framework assessed and scored based on what was disclosed in the integrated reports only.

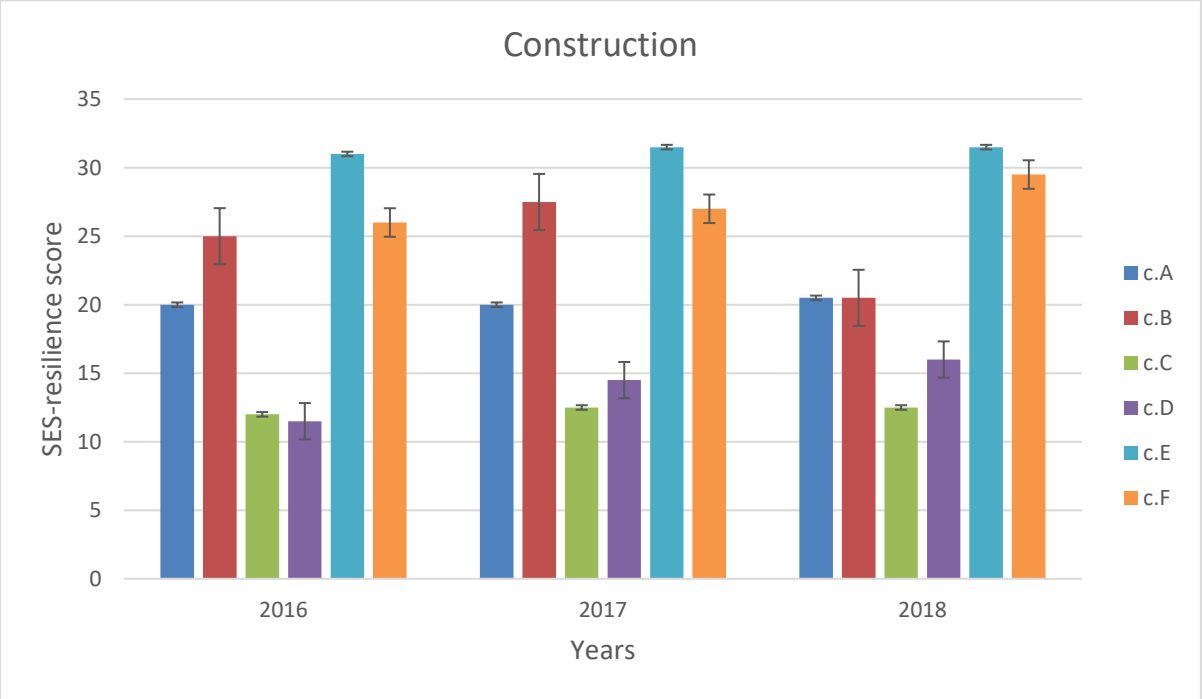


Figure 12: Differences in total SES-resilience within the construction sector in 2016-2018

In 2016 and 2017 all the companies in the agriculture, forestry and fisheries sector scored below 50% in SES-resilience and only in 2018 two companies (Figure 13; company af.E and company af.F) scored 50% and 50,83% respectively in SES-resilience. There is also a clear difference between the lowest scoring company af.A and the highest scoring company af.E which marks the vast differences in promotion of SES-resilience within the sector. Differences between companies' SES-resilience scores within this sector were significant

($F_{(5,11)}$= 151.0818, p< 0.001) and Appendix B (Table 3) shows where these differences were. Generally, an increase was seen in the SES-resilience scores for all companies across the years with the biggest increase seen in 2018 for 4 out of the 6 companies in the sector.

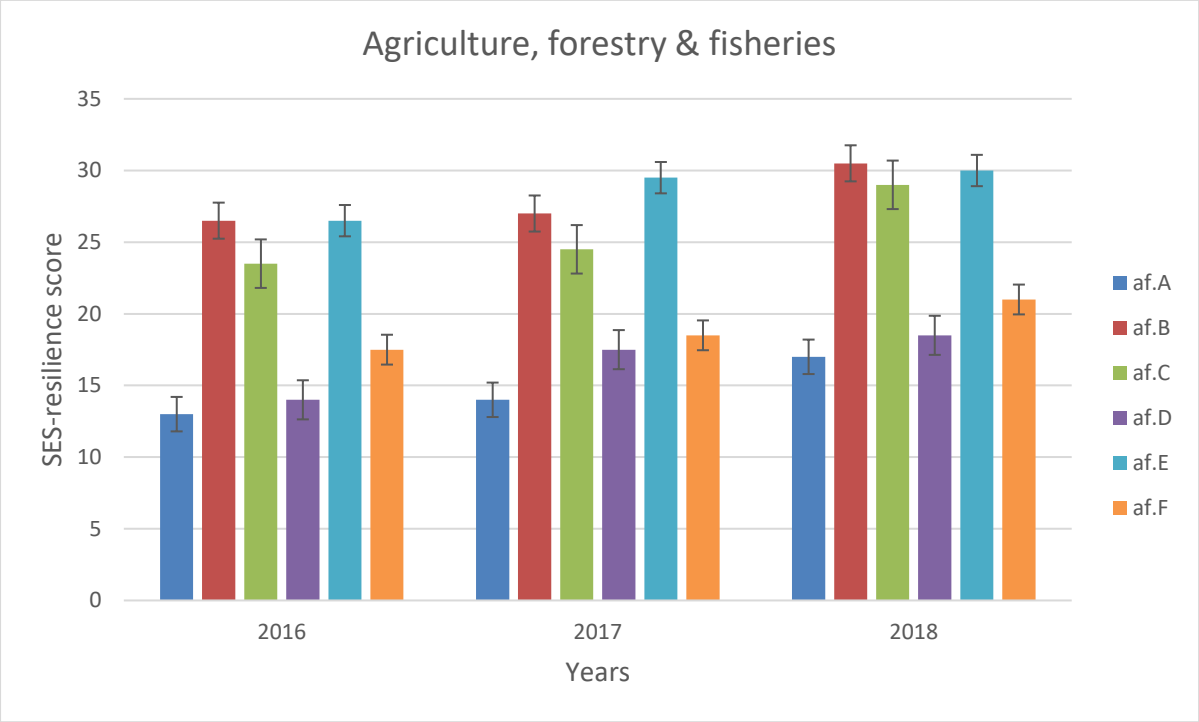


Figure 13: Differences in total SES-resilience within the agriculture, forestry & fisheries sector in 2016-2018

4.4 Discussion

The motivation for companies disclosing their emissions is either financial, reputational and/ or regulatory (see Hoffman, 2007; Knox-Hayes & Levy, 2011; Sullivan & Gouldson, 2012; Matisoff, Noonan, & O'Brien, 2013; Tang & Demeritt, 2018). These motivations determine how carbon reporting might influence a company's internal business processes and performance. However, evidence on carbon reporting driving considerable emission reductions is limited. Energy intensive companies are typically reporting due to financial motivations, whereas non-energy intensive companies report due to reputational motivations (Sullivan & Gouldson, 2012). On the other hand, companies or sectors that are economically regulated typically reported for the regulatory motivation. Companies increasing their reporting of climate change issues use this reporting as a means of gaining key stakeholders' favour by illustrating their climate change commitment (Sullivan & Gouldson, 2012).

External stakeholder pressure has been mentioned as a driver for voluntary reporting beyond minimum reporting requirements (Tang & Demeritt, 2018), while some companies voluntarily report to differentiate themselves from their competitors (Matisoff, Noonan, & O'Brien, 2013).

In the study by Tang & Demeritt (2018) the fear of being perceived as a bad corporate citizen was a strong incentive to continue reporting even though the firms perceived little to no practical value in doing so. Previous literature has identified finance as big motivation for environmental reporting (see Hoffman, 2007; Knox-Hayes & Levy, 2011), where emissions were associated with overall corporate expenditure. The difficulty for energy intensive firms to make absolute emissions reductions is due to output and growth being closely tied to energy consumption. Thus, claims of making significant emissions reductions are usually stated in relative terms or in terms of net-zero (offsetting). This is true in the case of the companies assessed in my sample it was noted that there was nothing more the companies could do regarding efficiency as they were already quite efficient. This was observed more especially in the construction and mining sectors in this study sample, and it ties in with the findings of basic-evolving states of the decoupling principle (Figure 10) across all the sectors. In terms of the regulatory motivation, carbon reporting is done as the companies are legally obligated to do so and it also protects them from publicity which may come from failure to comply (Eberlein & Matten, 2009). In this regard, reporting may just be one of the things companies have to do just to avoid harsh penalties due to compliance failure. However, one of the internal company benefits of carbon reporting is that collating emissions data in the necessary formats propelled companies to strengthen their internal coordination and set up new reporting lines. Another benefit of carbon reporting is raising climate change and GHG emissions awareness in general within companies (Hahn & Kuhnen, 2013). This was especially true for the sample companies in the agriculture, forestry, and fisheries sector of this study as most of them noted aspirations to better address climate change in the near future and having dedicated teams for collecting and reporting on material climate-related matters. As awareness increases, companies also become more selective about the voluntary indices they engaged with, based on how they suit the company’s needs and priorities.

In my study, the mining sector did particularly well (evolving-leading states) in the systems, collaborative governance, restoration, and innovation & foresight principles, likely due to the fact that this sector has received widespread media attention regarding their operations and

impacts on the environment for much longer than the other two sectors. Such media attention has increased the pressure from various stakeholders and investors and has thus forced the mining sector to be more accountable towards system integrity (see Bond & Mottiar, 2013; Aleke & Nhamo, 2016; Matabesi & Marais, 2018). While this was initially a reaction to a specific pressure, the companies in this sector have become more proactive in formalising programs which implement business strategy and performance where whole system thinking is embraced. The acknowledgement of being imbedded in a SES was indicated through the company integrating social and ecological elements beyond their operational boundaries and there was movement towards a balanced focus on this integration. The reputational component has been a significant factor driving mining companies to acknowledge their role in a broader social-ecological-system as they need to keep their license to operate, and the fixed location of operations means that they have to address all social and environmental issues that arise as and when they arise. For example, although the Marikana protests were due to economic issues being raised (demand in salary increases), they show how grave and quickly such issues escalate. These violent short-lived Marikana protests further fused social, labour, environmental and other interests (see Bond & Mottiar, 2013). While the need and demand for higher wages was not to directly increase or improve the adaptation capacity of employees and their families to global environmental changes, capital resource may potentially directly or indirectly build the climate change resilience of employees and communities and this is why income disparities is one of the indicators of the well-being principle. Access to financial resources may potentially increase the adaptive capacity of societies and firms and thus aid in building systems resilience to global environmental challenges such as climate change (see Trabacchi & Mazza, 2015) , as adaptability is one of the integral features of resilience. Most social and sustainability issues in communities are historical, layered, and need commitment from companies operating in those communities in order maintain their social license to operate.

Neglecting to rehabilitate mining sites after operations have stopped has been perceived by communities as mining companies leaving communities with the negative long-term consequences of mining activities (Matabesi & Marais, 2018). Mining communities have complained that mining companies and their activities disturb access to natural resources that they otherwise would have and protests over service delivery (including access to such resources like water) have been common. Local benefits have also been the source of some protests by these communities as they believe they are being excluded from benefits of their

own resources (Matabesi & Marais, 2018). Mining companies are required to have environmental management plans (EMPs) even before their projects begin which would largely explain why the sector scored modestly well in the restoration principle. The approval of projects being dependent on these environmental management plans forces the sector to not only financially invest in restoring the social and natural capitals that it relies on but to also collaborate with other partners and networks. Historically such activities were completed in isolation but the increasing intention to build skills, systems, value chains and livelihoods has seen more mining companies aiming/ intending to increase collaborations to achieve this (see Du Plooy, 2006; Aleke & Nhamo, 2016; Matabesi & Marais, 2018).

In my study, most companies in the mining sector facilitated collaboration with stakeholders to co-learn and generate knowledge towards adaptive management. This was seen through for example the adoption of top-down and bottom-up governance structures for climate change issues and some companies in the sector embracing integrated thinking with accountability and transparency being present in decision making on climate change issues. There is also a culture of learning and adapting to feedback from a broad range of sources being embraced. This was indicated by the mining sectors high scores for the collaborative governance principle (in Figure 10) which were higher than the collaborative governance scores of the other sectors throughout the years. This has been quite the opposite in the construction and agriculture & fisheries sectors as most companies largely learned about climate change from behavioural and outcome observations of other companies and adapting with the use of best practice or the benchmarks available to them.

The basic-evolving states of the collaborative governance and restoration principles in the construction sector (see Figure 10; less than 45% and 35% respectively for all the years) may be accounted for by the nature of business operations in this industry. Companies in this sector have cited that the nature of their business is to complete projects on the client's site and once that is done, they departed and continued with other projects, so they were not responsible for what happens once they left. This may explain why they do not seem to link the impacts of their activities to the restoration of the social and ecological capitals in which they thrive. Past literature (see for example Waters, Barnett, & Puleston, 2014; Hurlimann *et al*., 2018), has indeed indicated that the construction sector's position in the building supply chain may limit the capacity to act on climate change. The sector primarily built structures designed by one supply chain stakeholder and paid for by another stakeholder. There is thus no long-term interest in addressing climate change risks. In such instances, the importance of

client requests on projects integrating climate change is highlighted. The sharing of information on new products and processes within the construction sector and to the general public is an opportunity for addressing climate change however the state of the collaborative governance principle in this sector suggests little is being done in this regard.

Businesses in the mining sector also scored high in the innovation and foresight principle which indicates that they focus on business planning for the long term, and they further conduct research and design programmes which support sustainability and innovation, directly addressing their business needs and further enhancing long-term viability of the system which supports their operations. This is in line with findings by Haywood, Brent, Trotter, & Wise (2010) who showed that some businesses were proactive and funded research which mapped their SESs to identify resilience points for long-term sustainability. Adopting a longer-term perspective (20 years and beyond) on business planning and management is necessary as it is challenging to accomplish the required change in a short-timeframe due to the complexity of SES resilience.

Sector variation in building systems resilience may be a result of several reasons including the size of the company and how long it has been listed on the JSE, its geographic footprint, its position in the value chain of that sector, or changes in business environment such as recent mergers or acquisitions. The voluntary CDP participation and the number of years of participation may also impact how well a company does in building systems-resilience (indicated by a high SES-score) to climate change as the questionnaires set in CDP allow for more in-depth engagement with climate change. Along with the differences observed in systems resilience within the sectors, there were instances wherein the systems resilience score of a company declined over the years (see Figure 12, construction company c.B). This may have been mainly attributed to no CDP participation in that particular year (2018), among many other factors which may have played a role. The company had previously reported on climate change related issues in AIRs as well as CDP reports however in 2018 the company did not participate in the CDP and so climate change was only addressed in the annual integrated report. The lack of finance or resources has been cited by the company as a reason for not participating in the CDP in 2018. Beyond the lack of participation in the CDP in that year, these financial constraints cited may have also been a reason for the reduced focus on resilience as resources and efforts would have to be diverted to other business matters which are perceived to require more urgent attention. While climate change was addressed in annual integrated report, it is not addressed in the same magnitude or in-depth as

it would have been addressed in the CDP due to the limited scope of the AIR addressing material matters that affect the business only. Since my assessment of systems-resilience to climate change was solely based on disclosure and reports which were publicly available for the 2016-2018 period, the particular company resilience score declined as they were assessed on limited available information published in their AIR. This finding emphasizes the contribution of the CDP in business disclosure on climate change and climate related risks are being addressed in their governance, targets, strategies, and planning. That being said , it is important to not draw the conclusion that insufficient disclosure on climate change means that companies are not addressing it at all. My finding of a decline in state of systems resilience possibly as a result of reduced disclosure of climate change issues does however indicate that climate change was not seen as material enough to report on in depth in the available reports and would suggest that there were insufficient strategies to address it or build the resilience of the systems that the business is imbedded in at that particular period. I further acknowledge that adopting climate change into business strategies and planning may take a longer timeframe to show considerable improvement, which could explain why differences in resilience scores over the years (Figure 9) were not significant.

South African businesses such as those in this research sample have been addressing sustainability aspects of their operations on a short-term basis and through a reactive nature, responding to common corporate challenges such energy efficiency. The unpredictable nature of global change causes uncertainty in forecasts and planning and more South African businesses are recognising the importance of understanding risks to the external ecological system and the need to improve social-ecological-system resilience (Haywood, Brent, Trotter, & Wise, 2010). Sustainability science thus needs to be extended into the field of business management.

This paper has contributed to the literature on systems resilience to climate change in the South African corporate economy and reiterates the need for businesses to move from seeing itself as separate of and competing with the SESs they are embedded in but rather as part of those systems and co-evolving in them. While the assessment presented in the research is valid in light of the PwC and CSIR, 2016 framework used, other resilience frameworks may have different principles/criteria and assess the companies and sectors' SES resilience differently. The research has highlighted the differences in how sample companies in these three sectors assess climate risk and include systems resilience in their business strategies, management, and reporting. The mining sector has taken a leading role in this regard, yet

there is still more to be done and companies (in all the sectors) stated aspirations to reach desired states of these principles and the framework in the near future. The study also highlights the importance of CDP participation in helping companies, and more broadly helping industries, in addressing climate change and building resilience towards climate change. Building SES resilience increases the system's capacity to cope with surprises. Business strategies and policy should therefore embed the perspective of needing to account for resilience in a changing world.

CHAPTER 5: DISCUSSION AND CONCLUSION

This chapter rounds up the findings of Chapter 3 and Chapter 4, their interrelations and notes the limitations related to the research. The section begins with discussing the integration of climate change into business strategy by highlighting the results related to climate change disclosure and the climate change risk landscape in the selected JSE-listed companies. This is followed by discussing the promotion of systems resilience in the selected JSE-listed companies and the possible implications for the sectors and the South African corporate landscape. The chapter ends off by noting the limitations to this research and recommendations for future research.

5.1 Integrating climate change into business strategy and building systems resilience

Physical climate change risks may result in increased and potentially unpredictable socioeconomic risks. Leaders thus need to comprehend the new climate reality, its potential impacts on their organisations and how to prepare for such a reality . Climate change is a shared crisis meaning it needs a shared response (collaboration). The nuances that make confronting climate change so complicated need to be well understood first so that risk can be addressed, which is what this research sought to do. The research scope in chapter 3 explored the extent of climate change disclosure, the risk landscape of climate change in South African businesses, and the challenges faced in addressing climate risk. The research scope in chapter 4 explored a systems-based approach to climate change resilience in South African businesses.

In the current globalized business, climate change has become more significant and developed countries are legally enforcing that companies listed on stock exchanges disclose their climate change information (UNFCCC, 2014). The higher levels of disclosure on climate related risks in mining companies (Figure 4) not only helps investors and stakeholders make informed decisions but it also helps the sector in better addressing climate change and building systems-resilience towards it. Considering the potential cascading impacts of climate change on economies, societies and ecosystems, climate change disclosure needs to better reflect climate risks to businesses and their social ecological systems. Mining companies better identified these climate related risks and their interconnections, thus adopting a systems approach to climate risk assessment. This finding (Figure 5) relates to the

finding of the mining sector having better scores for the risk & adaptation principle compared to other sectors (Figure 10). These subsequently matches my finding of the mining sector having significantly better state of SES resilience than the other sectors over the three-year period (Figure 9). The construction and agriculture, forestry and fisheries sectors had similar levels of disclosure on climate change risk (Figure 4) and their states of SES resilience from FY: 2016 to FY: 2018 were also not significantly different from each other. A basic-level assessment of climate change risk cannot sufficiently guide companies' management and disclosure of climate change. Rather, this assessment of climate change risk should have a holistic, long-term, and strategic focus (Whiteman et al, 2013; Kitsikopoulos, 2018; Sun et al, 2018). More uptake of the TCFD recommendations could help in this regard.

Significant differences were found for the total SES-resilience scores within all the sectors in my study (see Figure 11, Figure 12, and Figure 13). This suggests that more companies in these sectors need to take a proactive approach by encouraging a culture of shared learning around climate change and adapt to feedback from various sources, including their own research. This is encouraged as opposed to a reactive approach of largely learning around climate change through observations of behaviours and outcomes of other organisations. Highlighted in this research, is the need for better collaborations within sectors , between sectors and with other external stakeholders such as policymakers, non-governmental organisations, and civil society groups when it comes to addressing climate change. Radical changes in the management practices of most companies will also be necessary for this progression in sustainable development , especially seeing that there was a lack of strategic climate change risk focus in reports and from interview responses. Although it is necessary to increase the priority on environmental risks at higher management level (Haywood L. , 2016), my research points out that this has also not been the case with regards to climate change. Even with climate related risks being acknowledged as important for some companies, they tend to get blurred out along the reporting lines and become less prioritized on material issues needing urgent attendance.

The complex and uncertain nature of a global challenge such as climate change raises challenges for decision and/or policy makers in public governance and business settings (McMillan & Overall, 2016). Climate change may be regarded as a wicked problem due to its dynamic complexity and its exact causes and outcomes being uncertain- and these are said to be inherent characteristics of wicked problems (Batie, 2008). Linear solutions or models thus cannot be applied to solving wicked challenges as such solutions are usually deterministic

and would not bring optimal outcomes. Climate change and other environmental risks need to be prioritised by companies, more so due to the large amount of climate science data presented.

The necessary steps for an effective response include climate change risk being integrated into the decision-making and the adaptation pace and scale being accelerated. Climate change needs to be considered when looking at supply chain management, capital allocation and product development. A comprehensive risk assessment strategy which includes transition and liability risk, physical risk and their interplay is needed. For this integration we need changes in operating models, mindset, tools, and processes. The current models of quantifying risk need to be re-looked at (the uncertainty associated with them is due to them possibly lacking geographic granularity and not considering the ever-changing nature of climate change). To accelerate adaptation pace and scale, coordinated action from multiple stakeholders may be required. The keyways of doing so include reducing exposure and building resilience. The composition of an integrated strategy depends on company (company specific); how climate change-related risks and opportunities are perceived as well as sector specific regulations that the companies belong in.

The shift from impact-to-risk-to-resilience in the South African corporate space has been slow and gradual. One may even claim this shift is far too gradual given the urgency of climate change and its potential impact on economies and societies. This was indicated by the mainly linear identification of climate related risks, the lack of their prioritization to company strategy and the lack of strategic management of these in annual reports. The linear, reactive, and short-term approaches still displayed in environmental management of many companies assume stable and predictable systems whose impacts can be controlled (Jabbour *et al*, 2012; Sterk, van de Leemput, & Peeters, 2017). This however is not the case where climate change is concerned hence the need for multi-level, holistic and long-term systemic approaches to this challenge. Findings by my current research as well as past research, see Comyns, Figge, Hahn, & Barkemeyer, (2013) and Kitsikopoulos, (2018), illustrated this slow shift and essentially illustrated the lack of progression towards corporate sustainability. The risks to businesses, resulting from their own activities, and the rest of the social and ecological components of SESs would be better reflected in company reports and management responses if such a shift were distinct. In other words, the said risks would be better reflected if this progress in corporate sustainable management were explicit. This step is however imperative given the high climate change risk exposure of the businesses from the sample

sectors in the research. Strengthening SES-resilience will enable businesses to operate sustainably and to recover from recurrent disturbances resulting from climate change.

5.2 Conclusion

While businesses are perceived to be large contributors to environmental degradation due to their resource use, business processes and products outputs, corporate South Africa has gradually realized that a change to an ecosystem's health presents threats to business operations and to their long-term sustainability. The quantitative and extensive qualitative nature of this research provided a thorough understanding of common key challenges faced by South African businesses in their efforts to address climate change and the linkages between these challenges. While the traditional risk-based approach is suitable for predictable events, the resilience-based approach more suitable for the organisational response when unexpected, unusual, and unpredictable events occur. Considering that climate change may result in such unexpected and unpredictable events, a paradigm shift is thus needed in business from a mechanistic viewpoint to a systemic viewpoint. A social-ecological-systems approach may help businesses understand the climate change resilience of the systems that they are embedded in and help them in adapting to climate risk to ensure their sustainability. The path taken by South African businesses in their understanding and application of recent developments towards sustainability is not one which can be done in isolation. It needs concerted efforts, more support, and collaboration between the sectors, private & public stakeholders as well as civil society.

Indeed, some companies in the research sample need to better identify climate change risks while others have identified these risks but have not integrated them with their mainstream risk management processes. This research may offer opportunities for South African companies to better prioritize climate change into their operations by highlighting the importance of a systems approach in addressing climate change. In appreciating the interconnected of climate change risks to other environmental, social, and economic risks as visualized in the maps presented in this research, businesses may understand and prioritize the need to build systems resilience to climate change risks and other risks. The research further offers South African companies the opportunity to realize the long-term perspective required in climate change planning. This systems approach discussed in the results of the research further requires holistic climate strategies across business units.

5.2.1. Study limitations and future research recommendations

The results of this research should be interpreted with certain limitations in mind. These limitations were related to the interview sample size and its influence on the application of manual thematic analysis, the exclusion of executive members in interview selection, the application of a specific framework to companies which may not necessarily disclose information with such a framework in mind, and the period of assessment for this research.

While all efforts were made to secure interviews, the response rate remained relatively low (only 50% of samples companies had promising responses). This was further exacerbated by the SARS-Cov-2 (i.e COVID19) pandemic which began during the interview phase of the research. As a result, only seven out of the 18 companies were interviewed as other previously confirmed interviews no longer took place due to lack of response going forward. While the interviews conducted were quite insightful in the understanding of climate risk management, more interviews would have helped confirm and highlight the trends observed in my research. Rigorous thematic analysis relies on a substantial number of interviews and would require computer packages, but this research did not make use of this due to the limitation of sample size. The disadvantage to this was also that analyzing the relationship between codes in terms of sequencing and co-occurrence was challenging and subjective due to the reliability of the coding frame. Further, the sample size was not divisible (not all cell sizes were equal) and so while the researcher was able to discern patterns within the whole dataset, discerning patterns across sub-sectors was challenging. An increased interview sample size would have further prompted the use of a suitable qualitative analysis package which may have increased the reliability of the thematic analysis applied in the research. Thus, the coding frame in this study may not be as reliable and transparent as wished for.

Additionally, interviews were limited to sustainability managers due to the perceived ease of access to these vs ease of access to executive management, given the geographic footprint of most of the selected companies. The inclusion of executive management and board members could have potentially provided more insights into the extent of shifts in thinking about adopting a systems-approach towards climate risks and resilience.

The SES-resilience scoring framework in the research was designed for use in company documents more generally even though the reports were not written with this type of

assessment in mind. Noting this, the number of report types available per company per year had an impact on the scoring and thus had an impact on the interpretations of the results. This approach may have presented a limitation to the conclusions drawn as these conclusions were a function of the nature of the report and the information therein.

A further limitation arises from the period of assessment for this research. While the research findings of the improvement in social-ecological systems-resilience not being significant are not to be undermined, it is possible that three years (FY:2016- FY:2018) was too short a timeframe for assessment. Extending the timeframe to a longer period may help future research pick up significant progress, if present, as a result of more companies adopting TCFD recommendations and more updated reporting guidelines in their climate change disclosure.

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Appendices

Appendix A: Social-ecological-systems resilience scorecard adapted from CSIR & PwC (2016)

Principle		**State**			
	Principle indicators	**Below basic (0)**	**Basic (1)**	**Evolving (2)**	**Leading (3)**
Systems	Accountability	Organization shows zero accountability towards reducing its impact on the environment and contributing towards social responsibility	Organization shows accountability towards reducing its impact on the environment and contributing towards social responsibility as a compliance requirement and not as a result of real concern for the integrity of the system in which it exists	Organization shows accountability towards system integrity as a reaction to an identified need and not necessarily related to a program that implements the business strategy	Organization shows accountability towards system integrity through proactive formalized programs that implement the business strategy and positively influence organization performance. In addition, the business culture and value proposition of the organization embraces whole system thinking
	Value creation	N/A	Value creation is primarily defined as contributing towards growing the organization's financial capital	Value creation is defined by the sum of capitals and their different values. However, the relationship between the organization and the system in terms of these capitals is not well understood or unpacked. Thus, organization does not specifically acknowledge	Value creation is defined by the sum of capitals from the perspective that all capitals are well understood and interconnected within the system, and the organization specifically aims to create value for themselves as well as for society and the environment

				value creation as a mutually beneficial relationship between the organization, society, and the environment	
	Sharing	N/A	The fact that the organization shares social and ecological resources with other users in the system is not a priority in the organization's decision making (i.e not acknowledged) and thereby does not influence its value creation process	Organization acknowledges the sharing of social and ecological resources within the system it exists. Organization acknowledges the implication of resource sharing on its value creation process; however, it notes constraints preventing an effective collaboration with other users	The sharing of resources with other users within the system is a key consideration in the organization's value creation process and is thereby considered in the business strategy with an effective response planned to address constraints and opportunities
Risk and adaptation	Risk recognition	No climate related risks identified	Climate related risk landscape limited to immediate enterprise type risks to business	Climate related risk landscape includes immediate enterprise type risks and some social & ecological system risks	Climate related risk landscape has equal emphasis on immediate enterprise type risks and systemic risks which can affect system threshold
	Risk adaptation	No climate related risk mitigation measures addressed	Climate risk mitigation measures focus on response to immediate enterprise type risks	Climate mitigation measures address organizations adaptive capacity to immediate enterprise risks and	Innovative thinking applied towards building adaptive capacity and climate risk mitigation measures of both organization and

				social & ecological type risks	of the social-ecological system
Decoupling	Resource use	Less than two resource inputs monitored; and environmental impacts not monitored	Resource inputs and environmental impacts monitored primarily for complying with legal requirements	Resource efficiency / eco-efficiency achieved thus improvement in resource use and environmental impacts relative to production or to size of organization	Absolute decoupling achieved thus resource use and environmental impact reduced in absolute terms, year-on-year.
	Life cycle	No engagement with other users in the value chain regarding climate change and no responsibility taken for impacts of their products	Information on appropriate recycling options & safe disposal of products is provided to consumers, however no other responsibility taken for products impacts once they reach consumer	Responsibility taken for impacts of products throughout value chain up until disposal at end of their useful life, thus adopting a cradle-to-grave approach	Thinking transcends taking responsibility for impacts of products throughout value chain up until disposal at end of their useful life and considers possible up-cycling as part of circular economy
Well-being	Health & safety	The organization has no acknowledgment of climate related health and safety risks and does not provide any basic health and safety programmes for its employees	The organization has little to no acknowledgment of climate related health and safety risks and so it provides basic health and safety programmes in order to comply with legislation and/ or standard practice	The organization acknowledges climate related health and safety risks to its employees and thus provides health and safety programmes and has a formal well-being programme that focuses on the well-being of all employees	The organization acknowledges climate related health and safety risks to the broader community and thus provides health and safety programmes and has a formal well-being programme that seeks innovative ways of actively addressing not only employee well-being; but also, the well-being of employees'

					families and communities
	Employee satisfaction	Organization does not measure employee feedback and/ or satisfaction , especially on environmental related issues	Organization measures employee feedback and/ or satisfaction on environmental related issues but no evidence of responding to these	Measures are taken to address employee feedback and/or satisfaction , especially on environmental related issues, however these measures are isolated and do not form part of what the organization defines as value creation	Measures taken to address employee feedback and/or satisfaction on environmental related issues are a fundamental component of what organization defines as value creation. Measures enable employees to contribute to improving the local context
	Income disparities	N/A	Income disparities between top- and low-level employees are not monitored	Organization recognizes the need to address unfair income disparities between top- and low-level employees but there are limited changes observed	Organization is actively addressing unfair income disparities between top and lower-level employees and changes are successfully implemented over time
Restoration	Scope of investment	No mention of any investment in natural and/ or social capitals	Organization has limited investment in natural and/ or social capitals	Organization invests in restoring natural and social capitals with a focus on repairing environmental damage or employee/ community relations caused as a direct result of the organizations own operations (a reactive response)	Organization invests in restoring the social-ecological system within which it operates, with a focus on building both natural and social capital. Thus, investment provides for initiatives extending beyond the boundaries and operations of the organization and

					that benefit the capitals within the system more broadly
	Investment motivation	There is no mention of any investment in the natural and/ or social capital so no motivation for this either	There is limited investment in natural and/ or social capital which is mainly motivated by a concern with meeting regulatory requirements	Investment in natural and/or social capital is motivated primarily by a concern with building the organization's reputation and protecting market share	Investment in natural and/ or social capital is a key component of the organization's business strategy. The organization has measures in place that accounts for the benefits/ impacts to society; and activities are integrated into the value creation process of the organization
	Restoration partnerships	No mention of any restoration activities being conducted	Restoration activities are conducted in compliance with a directive or legal commitment	Restoration activities are initiated by the organization voluntarily, but are usually completed in isolation from other partners and networks	Restoration activities are initiated by the organization voluntarily and are usually done in collaboration with partners and networks. They are aimed at building skills, systems, value chains and livelihoods
Collaborative governance	Visionary governance	Organization's leadership does aspire or incorporate new around ideas around the governance and shared learning of environmental and/or climate change concerns and in fact sees no need to	Organization's leadership does incorporate new around ideas around the governance and shared learning of environmental and/or climate change concerns but there is some aspiration to incorporate this	Organization seeks to address new ideas around the governance and shared learning of environmental and/or climate change concerns, but it is still bound by traditional	There is evidence that the organization's leadership around environmental and/or climate change concerns is visionary and aspiring in their approach to governance and shared learning

				corporate governance parameters	
	Governance structure	No mention regarding the governance structure of environmental and/or climate change issues	Climate change governance in the organization operates as a top-down structure: decisions are filtered down from the bard and executive level and actioned by line and support staff, with limited upward feedback opportunities present	Climate change governance in the organization operates as a combined 'top down' and 'bottom up' structure: there is evidence that decision making is informed by data and feedback from all levels in the organization	Climate change governance in the organization reflects a culture of integrated thinking: the business strategy facilitates information sharing from all levels in the organization, and there is accountability and transparency in decision making
	Learning	No mention or evidence of the learning around environmental and/or climate change issues as these do not show up in the organization's material concerns	Learning around climate change is largely through the organization's observation of the behaviour and outcomes of other organizations and so there is adaptation using the best practice benchmarks available	Organization encourages a culture of learning around climate change and adapts to feedback from a broad range of sources including external stakeholders	Organization encourages a culture of learning around climate change and adapts to feedback from a very broad range of sources, including its own research. It also maintains formal knowledge sharing platforms with stakeholders
	Stakeholders	No mention of engaging with stakeholders on environmental issues, more so climate change concerns	Organization does not show evidence of being responsive to the needs and concerns of stakeholders	Stakeholder issues and concerns are considered in the organization's decision making although they do not have an active influence on the leadership and	Stakeholder issues and concerns are considered in the organization's decision making and there is evidence that stakeholders have an active influence on the leadership and

				governance of the organization	governance of the organization
Innovation and foresight	Planning horizon	No specific mention on the business planning around climate change	Business planning around climate change is primarily focused on the short-term (2-5 years) profitability of the organization	Business planning around climate change is primarily focused on the medium term (6-20 year) viability of the organization	Business planning around climate change is preferentially focused on the long-term (20 years and beyond) viability of the organization, acknowledges interdependence with the health and resilience of the system over time
	Sustainability innovation	No provisions in place for R&D that addresses climate change issues as these ae not specifically addressed in business planning	Currently no provisions in place for R&D that addresses climate change issues but there are plans to provide such support in future as climate change issues are being understood and addressed	Provisions are in place for R&D that supports climate change innovation which focusses on reducing impacts of the business and increasing robustness of the organization in the face of climate change	Provisions are in place for R&D and innovation directed towards achieving long-term business goals within the boundaries and capacity of the system, and focusing on strengthening systems resilience towards climate change
	Organizational culture	No culture of innovation for climate change resilience is established. No formal support given or encouragement of employees to engage in such innovation	A culture of innovation is being established, informal support and encouragement is given to employees through non-monetary (i.e recognition) rewards for climate change innovation	Employees are rewarded (including monetary rewards) for innovation when they improve organizational resilience to climate change	Employees are rewarded (including monetary rewards) for innovation that contributes not only to the success of organization but also to the resilience of the social-ecological system to climate change

Appendix B: Statistics tables indicating SES-score differences within each sector

Table 1: Statistics results indicating significant differences between SES-scores within the mining sector

Code	{1}	{2}	{3}	{4}	{5}	{6}
m.A		0.000173	***	0.000837	0.000173	0.000194
m.B	0.000173		0.000173	0.000180	0.000173	0.000173
m.C	***	0.000173		0.000585	0.000173	0.000208
m.D	0.000837	0.000180	0.000585		0.000173	0.000173
m.E	0.000173	0.000173	0.000173	0.000173		0.000173
m.F	0.000194	0.000173	0.000208	0.000173	0.000173	

*** - differences between these companies' SES-scores were not significant

Table 2: Statistics results indicating significant differences between SES-scores within the construction sector

Code	{1}	{2}	{3}	{4}	{5}	{6}
c.A		***	0.004184	0.021696	0.000340	0.006758
c.B	***		0.000249	0.000547	0.009376	***
c.C	0.004184	0.000249		***	0.000173	0.000176
c.D	0.021696	0.000547	***		0.000173	0.000190
c.E	0.000340	0.009376	0.000173	0.000173		***
c.F	0.006758	***	0.000176	0.000190	***	

*** - differences between these companies' SES-scores were not significant

Table 3: Statistics results indicating significant differences between SES-scores within the agriculture, forestry, and fisheries sector

Code	{1}	{2}	{3}	{4}	{5}	{6}
af.A		0.000173	0.000173	***	0.000173	0.000840
af.B	0.000173		***	0.000173	***	0.000173
af.C	0.000173	***		0.000173	0.012376	0.000177
af.D	***	0.000173	0.000173		0.000173	***
af.E	0.000173	***	0.012376	0.000173		0.000173
af.F	0.000840	0.000173	0.000177	***	0.000173	

*** - differences between these companies' SES-scores were not significant

Appendix C: Ethics clearance certificate

H190718 N
Mashiane Ethics Cle

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Research Office

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

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H19/07/18**
PROJECT TITLE	Assessing climate change vulnerability and resilience of JSE-listed companies
INVESTIGATOR(S)	Ms N Mashiane
SCHOOL/DEPARTMENT	Animal, Plant and Environmental Sciences/
DATE CONSIDERED	19 July 2019
DECISION OF THE COMMITTEE	Approved
EXPIRY DATE	28 August 2022

DATE 29 August 2019 **CHAIRPERSON** J-Knight
(Professor J Knight)

cc: Supervisor : Dr U Schwaibold

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 _____ Date ____/____/____

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES