



# Embedding environmental scenario analysis

into routine financial  
decision-making  
in South Africa

October 2018

## The Cambridge Institute for Sustainability Leadership Centre for Sustainable Finance

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# Executive summary

**In 2018 the World Economic Forum designated extreme weather events, natural disasters and failure of climate change mitigation and adaptation among the top five global risks in terms of likelihood and impact (WEF, 2018). Accordingly, the last five years have seen major global steps at the G20 level to ensure the financial system is taking due account of environmental risks and, as a consequence, capital is being allocated appropriately in support of sustainable economic development. South Africa, in particular, has demonstrated leadership in working to build and finance a climate-resilient economy.**

The United Nations Environment Programme (UNEP, 2016) has underlined the role of the South African financial sector as a leader and innovator in integrating environmental, social and governance (ESG) issues into financial decision-making. The Johannesburg Stock Exchange (JSE) was the first emerging market stock exchange to form a Socially Responsible Investment Index (SRI Index) in 2004. Accordingly, South Africa's financial firms need to keep pace with these developments and expose their strategy, risk and regulatory affairs teams to new areas of knowledge (from drought risk to the energy transition) in such a way that confidence can be built and new decisions made.

To facilitate this process in South Africa, the Deutsche Gesellschaft für Internationale Zusammenarbeit's (GIZ's) Emerging Markets Dialogue on Finance (EMDF) and the University of Cambridge Institute for Sustainability Leadership's (CISL's) Centre for Sustainable Finance joined forces with the National Treasury of South Africa on a project to promote the integration of environmental scenario analysis into practice in financial decision-making. A parallel project was carried out in México in co-operation with Instituto Tecnológico Autónomo de México (ITAM) and Banco de México. Specifically, the aim was to empower financial institutions across the banking, insurance and asset management sectors, and their respective regulators in both countries with insights that enable them to take demonstrable new actions to embed environmental scenario analysis into routine decision-making. The outcomes of the project include two tailor-made roadmaps for the South African and Mexican regulators and financial firms on how to develop environmental scenario analysis relevant to their own national contexts.

This analysis is based on a classification of environmental sources of financial risks (CISL, 2016), which is useful for understanding how environmental scenario analysis fits into the mainstream financial risk frameworks. Created as part of CISL's knowledge partnership with the G20 Green Finance Study Group, this framework details how environmental sources of risk can feed into mainstream financial risk frameworks.

Within this classification, a long-established typology of financial risks was used to categorise the ways in which financial institutions can be exposed to environmental sources of risk, covering market, credit, business and legal risk. Environmental sources of risk were classified into physical and transition sources. Physical sources denote risks which arise from the impact of climatic (ie extremes of weather) or geologic (ie seismic) events or widespread changes in air, land or marine ecosystem equilibria. Transition sources denote risks which arise from efforts to address environmental change, including but not limited to abrupt or disorderly introduction of public policies, technological changes, investor sentiment and disruptive business model innovation.

Based on the knowledge CISE has gathered about the approaches of various G20 members to understanding and incorporating environmental scenario analysis in their mainstream financial decision-making, this roadmap suggests four steps for incorporating environmental scenario analysis into every stage of the risk management process. The stages considered are Risk Identification (qualitative review of the sources of environmental risk that are relevant for financial institutions/firms); Risk Exposure (identification of sources of physical and transition risk); Risk Assessment (scenario analysis of identified sources of risk); and Risk Mitigation (selection of indicators to be used in everyday risk management tools and processes).

This analysis reviews the current literature on the data, scenarios and tools available as well as detailing the results of the in-depth conversations on environmental risk analysis practices with financial market participants in South Africa. Based on a variety of sources, the priority physical sources of risk in South Africa are of a climatic and ecosystem nature. It was not within the scope of the roadmap to prioritise these in terms of their probability and impact, however the top ones would include climatic sources of risk, namely climate warming, sea rise, droughts/flooding and windstorm; as well as ecosystem sources of risk, namely air and water pollution as well as ecosystem loss. South African stakeholders were aware of a number of physical sources of risk that could be material in their financial decision-making. Climatic sources are at the top of this list, with drought at the forefront, immediately followed by flooding. Other climatic sources of physical risk, potentially material to the financial firms, are wildfires, hailstorms, sea water temperature increases and flash flooding. Further, there was also awareness of ecosystem sources of risk, such as crop disease and ecosystem loss, in particular aquatic systems degradation.

While South Africa has been a leader in introducing sustainability into the financial system, it is also one of the world's most energy- and carbon-intensive economies (UNEP, 2016). Over a quarter of the JSE-listed equities are categorised as basic materials. South Africa's largest utility company, Eskom, relies on coal for 90 per cent of its electricity generation (Eskom, 2018) and is overstretched, leading to extended power shortages and blackouts. Therefore, given the poor national uptake of renewables, South Africa faces a particular challenge in transitioning away from energy-, carbon- and water-intensive pathways. This means that the South African transition might be hampered by stranding of assets and disruption from the incorporation of new risk management measures. The National Planning Commission in particular has highlighted a high risk of stranded assets in the South African coal industry and pointed to the need for co-ordinated action as part of just transition (NPC, 2018).

Based on the analysis of the national context, coupled with the knowledge CISE has gathered about the approaches of various G20 members to understanding and incorporating environmental scenario analysis in their mainstream financial decision-making, the report elucidates the main challenges faced by the South African financial system along with recommendations for addressing these challenges. The recommendations fall into three groups: recommendations for financial firms, recommendations for regulatory authorities and recommendations for the collaboration between the two.

**Recommendation 1.** Financial firms to develop methodologies and tools that enable incorporation of environmental scenario analysis into financial decision-making.

**Recommendation 2.** Financial firms to ensure that senior management is committed to implementing environmental risk analysis via scenario analysis.

Integrated environmental and social scenario analysis is a new concept for most firms. At the same time, global practice underlines the materiality and increasing scale, magnitude and likelihood of environmental sources of risk for individual financial firms and the financial system as a whole (CISE, 2016). These increases in complexity and likelihood of environmental sources of risk introduce challenges in forecasting the timing and exact exposure of financial firms. Therefore, tools such as environmental scenario analysis are integral for understanding, measuring and managing the financial risks stemming from these sources.

This means that financial firms need to develop environmental scenario analysis methodologies and tools to understand and manage these risks. Such innovation does not happen on its own – in order to flourish it needs to be prioritised and built into the organisational incentive system. Therefore, involvement of senior management is paramount for successful integration of methodologies such as environmental scenario analysis. A Board-level environmental risk champion, such as the Chief Risk Officer, could ensure that physical and transition sources of risk are measured and managed appropriately. Regulatory involvement will play a crucial role in focusing this attention.

To aid in this process, the report identifies several examples of good practice among financial firms, when they attempt to analyse and manage priority sources of risk. These range from the effect of windstorm on the market and credit risk of real estate and infrastructure debt portfolios to a tool to understand the impact of drought on credit risks. These are discussed in more detail in the 'Tools' section of the paper.

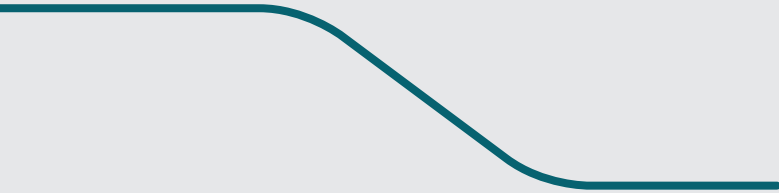
**Recommendation 3.** Financial regulatory authorities to introduce a clear position and agenda on the environmental sources of risk.

**Recommendation 4.** Financial regulatory authorities to signal that environmental scenario analysis is a mainstream issue by adding priority environmental sources of risk into the risk register for prudential supervisory activities.

**Recommendation 5.** Financial regulatory authorities to supplement this with regular in-person Board-level roundtables to discuss recent developments.

The involvement of regulatory authorities is key to successful integration of scenario analysis. The role of the regulator is to provide information, incentivise action and increase awareness, especially at the Board and senior management levels. The introduction of questions on environmental sources of risk into the prudential regulatory conversations is a powerful way of incentivising action and increasing awareness by the financial market participants. For example, the Netherlands has included environmental risks into the macro stability risk register, meaning that supervisors can ask financial firms a number of carbon risk-related questions in their supervision discussions (BOE, CISL, & Inquiry, 2017). Another way to incentivise action and increase awareness by the financial market participants is for the regulatory authority to develop a clear position on the relevance of environmental sources of risk to their respective regulatory mandate. This would decrease the risk of policy uncertainty and thereby reduce regulatory burden on financial firms. A good example of the current policy uncertainty is the introduction of the carbon tax. Although the proposal has been on the agenda for a number of years with a good coverage of GHG emissions (80 per cent), the specifics and the timeline of its implementation is as yet uncertain, meaning that most firms have not started preparing for it.

Finally, there are certain types of information, which can only be provided by the regulatory authorities. Financial market participants would, for example, welcome publication of best practices on integration of environmental scenario analysis, criteria to be used for choosing particular tools and models to align with it, as well as regulatory updates on key environmental sources of risk relevant to the South African context. Regular Board-level discussions on these issues led by the regulatory authorities with the involvement of academic and other types of experts, if required, would increase awareness of environmental sources risk among Board and senior management.



**Recommendation 6.** Convene a multi-stakeholder group (including industry practitioners, regulators and academic experts) to create a repository of existing risk data, scenarios and tools that industry could be using and provide recommendations that would address existing gaps, such as in the area of disclosure.

Building on the work done by the Sustainable Finance Working Group, such a working group would conduct the required consultation and construct a data, scenario and tool repository as well as advise on a disclosure framework that would be TCFD-compliant, relevant, reliable, meaningful, consistent, comparable and useful. This group could become an effective signalling mechanism of shared needs for new tools and disclosures. The recommendation to create a single South African data repository builds on the work conducted by the G20 Green Finance Study Group's publicly available environmental data work stream (Jun, Henderson, Gilbert, & Lin, 2017). The key rationale for the creation of the data repository is the reduction of the search costs and thus elimination of a barrier to innovation in the area of environmental risk analysis.

Substantial and meaningful disclosure will increase the provision of information to the market, thus enabling more sophisticated risk analysis and risk management to take place. South Africa already has integrated reporting requirements with mandatory greenhouse gas (GHG) reporting in certain cases. Further, larger players in the market already conduct voluntary disclosures according to existing frameworks, such as CDP and the United Nations Principles of Responsible Investment (UN PRI). However, current disclosure requirements within South Africa are not seen as sufficient to address climate-related challenges.


Currently, there is a reluctance within the financial system to the introduction of a new disclosure framework. Rather discussions centre around consolidation and adaptation of already available disclosure frameworks into a single consistent framework, which after a trial period would become mandatory across the South African financial system. It is important that this framework is the result of an industry-wide consultation that addresses the concerns of financial market participants.

Worldwide, the cost of 6°C global warming could lead to a present value loss of USD13.8 trillion (Economist Intelligence Unit, 2015). Locally, the slowdown of South Africa's 2015 GDP growth was driven by a severe drought (DEA, 2018). Against this backdrop, it is integral that South African financial firms and regulatory authorities take due account of material environmental sources of risk. However, there is a growing recognition that traditional approaches to incorporating environmental factors into risk management systems are insufficient in the face of the changing scale, likelihood and interconnectedness of environmental sources of risk (CISL, 2016). This calls for the use of environmental scenario analysis as a key tool to allow financial firms to analyse, measure and manage material sources of environmental risk. Putting environmental scenario analysis into practice would ensure that capital is appropriately allocated in support of financial stability and sustainable economic development that is consistent with the conservation and rational use of its natural capital and renewable energy resources. South Africa is well on the way in this journey, however it needs to take further steps to enable its financial firms and regulatory authorities to incorporate new areas of knowledge (from drought risk to the energy transition) and methodologies (such as environmental scenario analysis) into their daily financial decision-making in such a way that confidence can be built and better decisions made.



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# Introduction

## Project background

Managing risk is central to the effective functioning and stability of financial firms. The inability to analyse, measure and manage environmental sources of risk could pose a threat to the health of individual financial firms as well as the financial system as a whole. All capital is deployed based on expected 'risk-adjusted' returns; therefore, if environmental sources of risk are underestimated, the efficient allocation of capital within the financial system could be disrupted.

In recognition of this over the last three years, environmental sources of risk have been becoming more prominent on the global agenda. In 2018 the World Economic Forum has designated extreme weather events, natural disasters and failure of climate change mitigation and adaptation among the top five global risks in terms of likelihood and impact (WEF, 2018).

Impacts of dust bowls, hurricane activity, geological disasters such as earthquakes and volcanoes, heatwaves and droughts across a range of geographies are just some of the examples of how 'environmental' events can affect the soundness of financial firms as well as the performance of wider financial and economic systems. For example, the slowdown of South Africa's GDP growth to 1.3 per cent in 2015 was driven by a severe drought resulting in contraction of the agriculture industry by 8.4 per cent (the largest drop in production since 1995) (DEA, 2018). Further, if not managed, transition to a low carbon future can create financial risks. For instance, abrupt introduction of policies, breakthroughs in carbon technologies and increasing burden of liabilities for environmental damages according to the evolving interpretation of local laws can disrupt the functioning of the financial system.

The last five years have seen major global steps to ensure the financial system is taking due account of environmental risks and, as a consequence, capital is being allocated appropriately in support of sustainable economic development. South Africa, in particular, has demonstrated leadership in working to build and finance a climate-resilient economy. The United Nations Environment Programme (UNEP, 2016) has underlined the role of the South African financial sector as a leader and innovator in integrating environmental, social and governance (ESG) issues into financial decision-making.

In 2016 and 2017 during the Chinese and German presidency, G20 prioritised policy measures to improve environmental risk analysis in financial decision-making. In parallel, the Financial Stability Board's Taskforce on Climate-related Financial Disclosures (TCFD) published its final recommendations in 2017, mandating the use of scenario analysis for environmental risk analysis and risk management by

the companies. Both of these bodies of work have resulted in new emphasis on the use of forward-looking scenario analysis in financial decision-making. This is a welcome break from the past. And yet, one of the key challenges now is that financial institutions need to expose their strategy, risk and regulatory affairs teams to new areas of knowledge (from drought risk to energy transition) in such a way that confidence can be built and new decisions made.

To facilitate this process in South Africa, GIZ's Emerging Markets Dialogue on Finance (EMDF) and the University of Cambridge Institute for Sustainability Leadership's (CISL's) Centre for Sustainable Finance joined forces with the National Treasury of South Africa on a project to promote the integration of environmental scenario analysis into practice in financial decision-making. National Treasury's support of the project has been invaluable in bringing the industry on board. A parallel project was carried out in México in co-operation with the Instituto Tecnológico Autónomo de México (ITAM) and Banco de México. While every effort was made to understand and reflect the Mexican and South African context, CISL's Centre for Sustainable Finance core expertise lies in international practice, therefore the involvement of local partners has been instrumental in reflecting that global experience into a relevant and timely roadmap.

The aim of the project was to empower financial institutions and their respective regulators in two countries, South Africa and México, with insights that enable them to take demonstrable new actions to embed environmental scenario analysis into routine decision-making. The analysis is relevant to the entire financial sector including the banking, insurance and asset management industries. The project resulted in two tailor-made roadmaps for the South African and Mexican regulators and financial firms on how to develop environmental scenario analysis relevant to their own national contexts.

The project ran for a year from December 2017 to November 2018. In its first phase researchers from CISL's Centre for Sustainable Finance gathered information on the global trends in environmental scenario analysis as well as the South African and Mexican financial and regulatory context. In March and April 2018, two initial workshops were held in South Africa and México to assess the market's needs from the perspective of key financial institutions, such as regulators, industry associations and leading financial firms across the insurance, banking and investment management sectors.



Each workshop consisted of interactive sessions discussing the environmental scenario analysis and understanding the participants' experiences in this field. To structure the responses at the workshops, questionnaires were distributed to the participants. A total of 44 questionnaire responses were collected (24 in México and 20 in South Africa). The workshops were followed by a number of bilateral meetings in South Africa and México as well as remotely. All of the information gathered during the workshops and bilateral meetings was collated and combined with previous research. Further research was conducted to address questions raised during the country visits.

The result of this research was the drafting of two tailor-made roadmaps to reflect insights gained. Although South Africa and México have very different institutional and regulatory backgrounds, environmental challenges faced by these countries are similar. In terms of physical sources of risk, water risks feature prominently. Within transition sources of risk, both countries currently are highly dependent on fossil fuels. Further, social issues underline the need for a 'just' transition. The two roadmaps reflect those similarities.

## Environmental scenario analysis

There is a growing recognition that traditional approaches to incorporating environmental factors into risk management systems are insufficient in the face of environmental sources of risk, which now exist at new levels of scale, likelihood and interconnectedness (CISL, 2016). The traditional environmental risk analysis methods rely on large historical datasets, which may no longer reflect the environmental and economic reality. Due to the changing average probabilities of events as well as increased likelihood of low-probability, high-impact extremes, financial firms cannot rely on historic experience to predict future risks arising from environmental sources. For example, Holland and Bruyère (2014) note an increase in the global proportion of category 4–5 hurricanes, offset by a decrease in the proportion of category 1–2 hurricanes. Economist Intelligence Unit (2015) argues that the cost of 6°C global warming could lead to a present value loss worth USD 13.8 trillion, whereas keeping the warming under 2°C would cut such tail risks by three quarters (Economist Intelligence Unit, 2015).

The uncertainty in the variety of potential environmental and economic futures that financial firms need to understand and manage calls for the use of environmental scenarios – what may be termed 'environmental scenario analysis' – across key financial sectors such as banking, insurance and investment. They cover a spectrum of environmental issues, such as air pollution, natural hazards and water stress, as well as efforts to address them.

The project concentrates on understanding the application of scenario analysis to the assessment and management of environmental sources of risk in mainstream financial risk frameworks. Historically, scenario analysis has been used by decision-makers to assess the impacts of plausible, extreme futures. A scenario can be defined as "a script-like characterisation of a possible future presented in considerable detail, with special emphasis on causal connections, internal consistency, and concreteness" (Schoemaker, 1991). According to the TCFD (2017b) scenarios should be plausible, distinctive, consistent, relevant and challenging. The TCFD (2017b: 2) defines scenario analysis as a tool that "evaluates a range of hypothetical outcomes by considering a variety of alternative plausible future states (scenarios) under a given set of assumptions and constraints".

Scenario analysis has been used for years to understand and discuss the impact of a multitude of uncertain possible futures in the absence of reliable and detailed data sources (Schoemaker, 1995). CDP (2017b) has provided a technical note on the integration of scenario analysis into the CDP disclosures, noting six reasons to consider conducting climate-related scenario analysis. Among other reasons, CDP argues that scenario analysis can enhance strategic conversations about the future, help frame and assess the potential range of impacts from physical and transition sources of risk, as well as assist investors, policymakers, regulators and others to understand the robustness of organisational strategies. Further, the process of conducting scenario analysis can be as useful, if not more so, as the outputs of scenario analysis. Based on this usefulness, scenario analysis is being adopted as a tool of choice by a variety of

industry and regulatory bodies, such as the TCFD, for understanding climate risks inherent in the corporate and financial systems (TCFD, 2017a). Therefore, within this roadmap, scenario analysis has been chosen as an appropriate tool to address/quantify physical and transition sources of risk for financial firms.

A classification of environmental sources of financial risk (CISL, 2016) is useful for understanding how environmental scenario analysis fits into the mainstream financial risk frameworks (please see Figure 1). Created as part of CISL’s knowledge partnership with the G20 Green Finance Study Group, this framework details how environmental sources of risk can feed into mainstream financial risk frameworks.

		Financial risks			
		Business	Credit	Market	Legal
Environmental sources	Physical				
	- Climatic				
	- Geologic				
	- Ecosystems				
	Transition				
	- Policy				
	- Technology				
	- Sentiment				

**Figure 1. Environmental sources of financial risk**

Within this classification a long-established typology of financial risks was used to categorise the ways in which financial institutions can be exposed to environmental sources of risk, covering business, credit, market and legal risk.

1. **Business risk** refers to the possibility that changes in circumstances undermine the viability of business plans and business models. Operational risk is the risk of losses due to “physical catastrophe, technical failure, and human error in the operation of a firm, including fraud, failure of management, and process errors” (Christoffersen, 2003). For simplicity, in this research ‘business risk’ and ‘operational risk’ were combined into one category, labelled ‘business risk’.
2. **Credit risk** is comprised of issuer and counterparty risk. Issuer risk is the possibility that an issuer/borrower is not able to fulfil its obligations due to its default. Counterparty risk comprises the risk that a counterparty defaults and is not able to fulfil its obligations (Christoffersen, 2003). Underwriting risk is the risk of insured losses being higher than expected. In property and casualty insurance products, significant components of such risk are the reserve and premium risks. In life and health insurance products, biometric and customer behaviour risks are important (Bennett, 2004). For simplicity, ‘underwriting risks’ that are faced by insurers and ‘counterparty risks’ are collated into the category of ‘credit risk’.
3. **Market risk** refers to the “risk of losses in on- and off-balance-sheet positions arising from movements in market prices” (Basel Committee on Banking Supervision, 1996).
4. **Legal risk** is the risk of significant legal consequences that flow from actions attributable to business (Moorhead & Vaughan, 2016). These are the risks that may arise when parties suffer losses related to environmental change, or their failure to manage appropriately their contribution to it.

There is a range of ways to conceptualise environmental sources of risk (eg Mercer’s ‘TRIP’ framework (Mercer, 2015) or the framework developed by the University of Oxford’s Sustainable Finance Programme (Caldecott & McDaniels, 2014)). The roots of the typology used in CISL’s framework lie in the Bank of England’s Prudential Regulation Authority (PRA) 2015 report ‘The impact of climate change on the UK insurance sector’ (PRA, 2015), which has been widely built upon since.

1. **Physical.** Risks which arise from the impact of climatic (ie extremes of weather) or geologic (ie seismic) events or widespread changes in ecosystem equilibria, such as soil quality or marine ecology. These sub-categories are informed by the Cambridge Centre for Risk Studies ‘Taxonomy of Macro-threats’ (Coburn et al., 2014). As the Financial Stability Board notes, they can be event-driven (‘acute’) or longer-term in nature (‘chronic’).
2. **Transition.** Risks which arise from efforts to address environmental change, including but not limited to abrupt or disorderly introduction of public policies, technological changes, investor sentiment and disruptive business model innovation.

In order to further clarify how physical and transition sources of risk drive financial risks, there are some illustrative examples of how environmental sources of risk drive different financial risks, which were initially conceptualised for the G20 Green Finance Study Group (CISL, 2016).

### Physical sources of...

**...Business risk:** As part of modern contingency planning, financial institutions of all kinds around the world are accustomed to preparing for the impact of extreme weather events like flooding on their operations. With global financial centres like New York, London and Shanghai all potentially exposed to flooding from storm surges, this seems entirely appropriate. In the longer term, climate and public health scientists warn of the impact of rising average temperature levels on labour productivity, with one risk analytics company warning that heat stress threatens to cut labour productivity in south-east Asia by 25 per cent within 30 years (Verisk Maplecroft, 2015).

**...Credit risk:** One of the cornerstones of market initiatives like the Equator Principles for project finance or market practices like ‘ESG integration’ in the institutional investment industry is the recognition that physical risks can give rise to issuer or counterparty risk. The impact of drought on the probability of default of a water-intensive company is just one example.

**...Market risk:** Causing a direct loss of USD43 billion (12 per cent of GDP), the floods that hit Thailand in the second half of 2011 were classed as by far the most expensive natural catastrophe in the country’s history. Thailand’s own economy shrank by 2.5 per cent in the fourth quarter of 2011 compared with the previous quarter, when growth still stood at +1.6 per cent. Flooding in Thailand’s industrial areas affected Japanese corporations’ production facilities, including numerous key electronic component manufacturers (Beilharz, Rauch, & Wallner, 2013). By way of example, production of around 25 per cent of the world’s computer hard-drive component requirements came to a standstill, leading to hard drive pricing jumps of 20–40 per cent (Ploy Ten & Chang-Ran, 2011). Six months after the floods prices remained above the pre-flood levels, leading some analysts to suggest that they had become the new normal (Haraguchi & Lall, 2015).

**...Legal risk:** Whether through Professional Indemnity, Directors and Officers or other forms of third-party liability cover, insurers in particular are potentially exposed to claims against their insureds for their failure to adequately foresee or respond to physical extreme events. Depending on the jurisdiction, banks and investors may also be exposed to such risks by legislation that imposes joint and several liability on them through their financing relationships.

### Transition sources of...

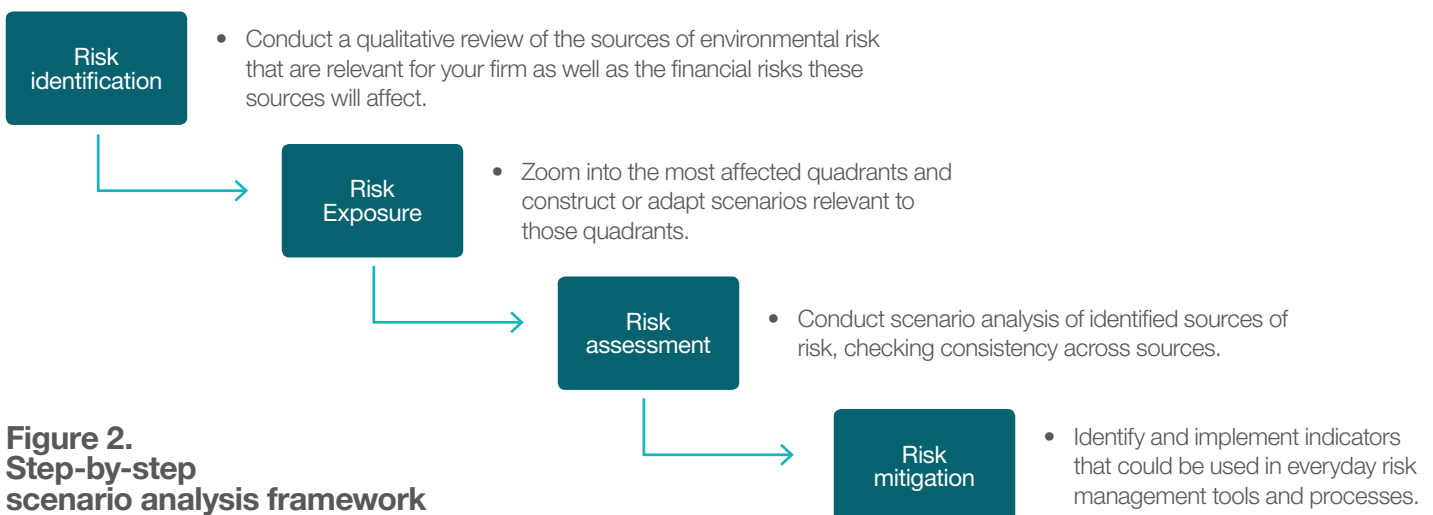
...**Business risk:** One of the risks being analysed by banks and investors around the world is how the transition away from a high-emission energy system could lead to material falls in demand for fossil fuels, potentially impacting pure play producers the hardest and calling into question their business model. For financial institutions that are particularly overweight in such sectors, this might expose them to a requirement to change strategic priorities. Equally, there is a growing trend of asset owners wishing to decarbonise their portfolios; asset managers without credible service offerings to meet such rising demand will increasingly face strategic headwinds.

...**Credit risk:** Banks and investors are increasingly looking at the impact of carbon- and energy-regulation on the financial performance of their energy-intensive clients and investee companies. Insurance companies may also experience such risks on the asset side of their balance sheets.

...**Market risk:** Unexpected breakthroughs in technology known to be central to the development of an affordable clean energy system at scale could have the potential to have abrupt impacts on investor sentiment and energy commodity markets. Such a scenario would affect all financial institutions, given the systemic impact of the energy system on the wider economy.

...**Legal risk:** In many developing economies, inadequate implementation of environmental regulations has driven financial regulators to mandate financial institutions to adhere to such regulations, which are enforced through, for example, lender liability regimes.

The majority of the cases covered by the G20 Green Finance Study Group environmental risk analysis input papers in 2016 and 2017 (BOE et al., 2017; CISL, 2016) have used scenario analysis in some form. CISL (2016) has seen that scenario analysis is being used at every stage of the risk management process: risk exposure, risk identification, risk assessment and risk mitigation. To build on the G20 work, this roadmap suggests a simple step-by-step framework, which can fit into the risk management waterfall (Figure 2).



**Figure 2.**  
Step-by-step  
scenario analysis framework

1. Using the G20 Green Finance Study Group (GFSG) classification, conduct a qualitative review of the sources of environmental risk that are relevant for your organisation as well as the financial risks these sources will affect.
2. Zoom into the most affected quadrants and construct (or depending on availability of data, adapt) scenarios relevant to those quadrants.
3. Based on these scenarios, conduct scenario analysis of a particular quadrant. Check what effect this scenario analysis will have on the other quadrants of the classification.
4. Identify indicators that could be used in everyday risk management tools and processes and implement them into the organisational risk management systems.

To aid in the use of this step-by-step framework, this roadmap will review the up-to-date literature on the data, scenarios and tools available. However, to make it more applicable to the national context of South Africa, first it will address the national financial and regulatory background, as well as priority sources of financial risk.

# Environmental sources of risk and the South African financial system

## National strategies and policies in South Africa

Despite its emerging market label, South Africa has a well-developed financial sector. Accounting for over 20 per cent of the economy, it is the country's largest sector (Statssa, 2018). Since reintegration into the global economy in 1994, South Africa's financial sector has kept pace with international standards, while government, the financial sector and civil society in South Africa have engaged in a national debate about its role and responsibilities to continuously enhance corporate governance and the financial system's inclusion of environmental risks.

In 2013, the International Monetary Fund (IMF) acknowledged South Africa as a global example for financial sector regulatory reform given its rapid adoption of Basel III and other reforms (IMF, 2013). Much of South Africa's progress in financial standards has been driven by the need to address persistent socio-economic issues and to demonstrate world-class governance to external investors. To complement this South Africa has made commendable strides in addressing environmental issues and environmental risk.

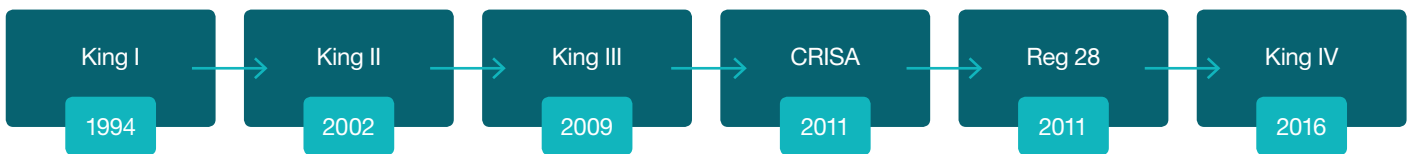
A recent report highlighted that "the financial sector in South Africa has been a leader and an innovator in integrating environmental, social and governance (ESG) issues into its practices" (UNEP, 2016). Many of the principles of the enhanced regulatory system call on the sector to recognise the economic opportunity from greener technologies and industries, and thoughtfully consider the risks and damage from unsustainable practices.

South Africa has undertaken several iterations of consultative processes with industry and civil society, resulting in three key regulatory devices to enhance the financial sector's inclusion of environmental risks and sustainability: the King Code, Regulation 28 and the Code for Responsible Investing in South Africa (CRISA). While there are no specific regulations for the banking sector, there are certain industry initiatives ongoing. The recent National Environment Act, and the upcoming National Sustainable Finance Strategy will also contribute to a more environmentally-risk-conscious financial sector.

## King Code

The King Code regulates corporate governance. The King Committee has completed four iterations: King I (1994) King II (2002), King III (2009) and King IV (Institute of Directors Southern Africa, 2016). The King Code sets out broad principles for ethical, responsible corporate governance primarily targeting the Board and directors, audit committees, risk management units, stakeholder engagement and reporting and disclosure. All listed companies on the Johannesburg Stock Exchange (JSE) are required to report, despite the Code's non-legislative status. If companies do not conform to the principles set out in the Code, they are required to explain their deviations (known as "comply or explain"). The Code highlights that the leaders of corporations should direct the firm to achieve sustainable economic, social and environmental performance. The Code views the corporation as a juristic person under the South African constitution and highlights that as a part of its corporate citizenship it should operate in a sustainable manner (Smart & Creelman, 2013). The Code has experienced evolution as it relates to economic, social and environmental impact standards.

In 2002, when the Earth Summit was held in Johannesburg, King II revision included new sections on sustainability, the role of the corporate Board and risk management. By 2009, however, it was acknowledged that sustainability should not have been included as a stand-alone chapter. Thus, in the King III report, sustainability was integrated throughout the Code, and disclosure requirements streamlined reporting on sustainability aspects through all principles (eg risk). In addition, it suggested that companies also develop stand-alone sustainability reports according to the Global Reporting Initiative's Sustainability Reporting Guidelines. The most recent iteration, King IV, asks companies to innovate and develop their own philosophy to secure long-term value creation.



### King IV

While King III requests companies to act in a sustainable manner and take responsible decisions within the confines of their existing structures and ecosystems, King IV requests companies to think about systemic changes in order to shift “short-term capital markets to long-term, sustainable capital markets” (Institute of Directors Southern Africa, 2016). Importantly, King IV asks the Board to consider long-term value creation and measured environmental risks associated with sustainable development.

**Principle 4** “The board should appreciate that the fund’s core purpose, its risks and opportunities, strategy, business model, performance and sustainable development are all inseparable elements of the value creation process”

Recommended practices under Principle 4 ask the Board to develop short-, medium- and long-term strategies in light of environmental, social and governance factors and the “risks, opportunities and other significant matters connected to the triple context in which the organization operates”.

It recognises, and asks firms to recognise, that “Financial performance alone can no longer serve as proxy for holistic value creation”. It establishes that firms should consider multi-faceted and interconnected risks such as climate change and understand the limitations of current accounting and profit recognition systems, which do not accurately take into consideration the value of natural capital.

The code of corporate governance has served as a foundation for several acts, and many of the principles have been incorporated into laws including the Companies Act of South Africa of 2008, the Public Finance Management Act and the Promotion of Access to Information Act. It also underpins South Africa’s commitments to the United Nations Global Compact and the Principles for Responsible Investment, the OECD Guidelines for Multinational Companies, and Global Reporting Initiative’s G3 Guidelines.

### Code for Responsible Investing in South Africa (CRISA)

The Code for Responsible Investing in South Africa (CRISA) was launched in July 2011 as a voluntary, institutional, investor-led initiative. The Code seeks to guide institutional investors and their service providers in developing and implementing sustainable, responsible and long-term investment strategies. Much like the King Code, CRISA has five key principles, the main one being Principle 1.

**Principle 1** An institutional investor should incorporate sustainability considerations, including environmental, social and governance, into its investment analysis and investment activities as part of the delivery of superior risk-adjusted returns to the ultimate beneficiaries.

CRISA provides a set of suggested standards on how the institutional investor should execute investment analysis and investment activities, and exercise rights.

An institutional investor should develop a policy describing how it incorporates sustainability considerations, including ESG, into its investment analysis and activities. The policy should include, but not necessarily be limited to, an assessment of the tangible and intangible assets of a company as well as the quality of the company’s integrated reporting on the long-term sustainability of the company’s strategy and operations. If integrated reporting has not been applied, due enquiry should be made on the reasons for this. An institutional investor should also ensure implementation of the policy on sustainability considerations, including ESG, and establish processes to monitor compliance with the policy (CRISA, 2011).

CRISA highlights that such an approach would be in the long-term interest of ultimate beneficiaries and cognisant of the environmental and socio-economic context. CRISA guidance also aids institutional investors in fulfilling their Regulation 28 obligations.

Given the broad and influential membership of CRISA, it is an important initiative for advancing the integration of ESG practices in South Africa. However, it needs further resources to set up a permanent secretariat and maintain continuity of its activities (PRI, Generation Foundation, & UNEP Finance Initiative, 2017).

Within the institutional investment space, according to an EY survey there are positive signs that ESG issues are influencing the investment process (Ahee & Schulschenk, 2013). The survey summarised the results from 40 respondents from the Association for Savings and Investment South Africa and Principal Officers Association of South Africa. The results note that 84 per cent of the South African institutional investors consider ESG issues, 12 per cent are always influenced by ESG issues in investment decisions and 60 per cent of respondents will pay a premium to invest in a company with sound ESG performance. The small sample and self-selection of respondents would suggest caution when relying on these statistics. However, it is interesting that the respondents noted CRISA, the United Nations Principles of Responsible Investment (PRI) and financial returns as the main motivations for engaging with ESG factors.

### Regulation 28

Regulation 28 under Section 36 of the Pension Funds Act was amended to include ESG factors into the South African approach to financial prudence. For trustees to fulfil their fiduciary duties, they must give “appropriate consideration [to] any factor which may materially affect the sustainable long-term performance of a fund’s assets, including factors of an environmental, social and governance character” (FSB). It leaves open for explanation how the fund has implemented this approach. Regulation 28 aims to protect individuals’ savings from improper or poor diversification. It requires that the funds report on asset allocations quarterly (FSCA, 2011).

Regulation 28 asks asset managers to understand the underlying nature of the assets it selects by conducting due diligence before making commitments to invest. They must also consider a change in the risk profile of the asset over time, giving due consideration to the environmental social and governance characteristics of the investment. It advocates for education of trustees with respect to ESG standards, and ensures that adequate risk-adjusted returns are suitable for the member’s profile, particularly in considering the long-term nature of the risk-return profile.

### National Sustainable Finance Strategy

In January 2017, the National Treasury brought together a Working Group of financial sector regulatory agencies and industry associations to develop a sustainable finance framework. Members include the National Treasury as Chair, the South African Reserve Bank, Financial Services Board, Banking Association South Africa (BASA), Council of Retirement Funds for South Africa (Batseta), Association for Savings and Investment South Africa (ASISA) and the South African Insurance Association (SAIA).

The Working Group seeks to:

1. Define sustainable finance for a South African context.
2. Incorporate perspectives from all parts of the financial sector, including banking, pension funds, insurance, asset management and capital markets.
3. Describe the global and national drivers for sustainable finance, as well as existing industry initiatives.
4. Map supply and demand for, as well as barriers to, sustainable finance.
5. Provide recommendations on a national strategic approach and the role of regulatory agencies and industry stakeholders (Sheoraj).

In addition, a review of the Financial Sector Regulatory Framework will seek to enhance climate-related disclosures, reporting and monitoring to support decisions (Sheoraj).

**Progress, but more to be done**

These approaches to managing environmental risk have been developed in collaboration with industry and have, therefore, assisted financial firms in understanding and fulfilling international requirements. Dialogue with industry has also demonstrated that the 'principles-based' approach is preferred, arguing that the diversity and evolving nature and understanding of sustainability, ESG risk and long-term value creation require flexible approaches embodied in the 'apply and explain' approach (UNEP, 2016). The professionals also identified gaps and barriers in the financial system itself, such as development of models to quantify environmental and social risks systematically, a clearer framework for lender liability and reforming regulations for unlisted assets (UNEP, 2016).

Notwithstanding the significant progress, many in the financial sector argue that more could be done to make the financial system more robust. A number of reports, as well as the interviews conducted within this project, identify the lack of a single regulatory approach on sustainable finance as a potential roadblock to implementation of sustainable finance policies. While both the King Code and CRISA are substantive initiatives, they are also voluntary. Incorporating these codes within the financial regulatory framework would drive their impact on the financial community. First steps towards this single regulatory framework have been taken with the establishment of the National Sustainable Finance Working Group, however more remains to be done.

**South African regulatory bodies**

Overseen by the Minister of Finance, the National Treasury is responsible for policy creation for private and public-sector investment and as it relates to environmental-risk management. The South African Reserve Bank (SARB) is responsible for developing appropriate monetary policy and overseeing the banking sector. It promotes overall stability, including monitoring vulnerability of the financial system to external and internal shocks, collecting data on capital requirements, asset quality and asset mix, and the liquidity of the market. It undertakes stress-testing and scenario analysis to assess risk of financial instability in line with Basel Committee Principles (SARB, 2018a).

On 21 August 2017, the Financial Sector Regulation Act (FSR) was signed into law. It established that as of April 2018 South Africa would adopt a 'Twin Peaks' system. The Twin Peaks architecture is designed to "strengthen South Africa's approach to consumer protection and create a more resilient and stable financial system" (UNEP, 2016). The Financial Services Board (FSB-SA) is an independent institution, established by statute to oversee the South African non-banking financial services industry (including retirement funds, short- and long-term insurance, companies, funeral insurance, schemes, collective investment schemes and financial advisors and brokers). Twin Peaks implementation will allow for the creation

of an additional regulator, the 'Prudential Authority'. It seeks to rationalise and align supervisory powers and functions, and lay the foundation for the exchange of information related to systemic risk between the FSB-SA, the SARB and the National Treasury. Once created, FSB-SA will be refocused to market conduct embodied in the 'Financial Sector Conduct Authority'. The Prudential Authority will be responsible for regulating banks, insurers, co-operative financial institutions, financial conglomerates and certain market infrastructures (SARB, 2018b).

There are 17 locally controlled banks registered in South Africa (BASA, 2018b). The largest four commercial banks apply the Equator Principles and have their own internal standards for determining, assessing and managing ESG risks for project finance transactions valued from USD10 million (UNEP, 2016).

The JSE is a self-regulating organisation that sets listing standards and disclosure obligations for listed equities. The JSE is currently ranked the 19th largest stock exchange in the world by market capitalisation and the largest exchange in the African continent (JSE, 2018a). It was the first emerging market as well as the first stock exchange globally to introduce a sustainability index measuring companies on indicators related to ESG practices (JSE, 2018c).



## National level mechanisms in South Africa

The South African investment industry has endorsed and implements a range of investing for impact strategies that incorporate environmental risk management, such as using positive or negative screens based on social or environmental criteria. With over USD360 billion in assets under management allocated to ESG integration investing for impact strategy, South Africa leads the continent in environmental screening (GSB, 2017).

### The banking sector

Banking professionals highlighted that implementing the Equator Principles has increased their ability to identify ESG risks, incorporating their evaluation financially as part of a standardised credit assessment process. Commercial bankers from two of the largest commercial banks confirmed in interviews, conducted by UNEP Inquiry and the Global Green Growth Institute, that, in principle, they do not finance projects where a borrower does not meet designated social and environmental policies and/or have the resources or technical knowledge to implement the Equator Principles. However, they cautioned that often borrowers are compliant in certain aspects and not others, and in such circumstances the banks work with borrowers to comply with the Equator Principles in the lagging areas (UNEP, 2016).

Commercial bankers and an industry association also implement the National Environmental Management Act (NEMA), requiring environmental authorisation to be obtained before certain activities are undertaken, and evidence suggests this has drawn the attention of financiers to ESG risks (UNEP, 2016).

The Banking Association South Africa (BASA) established a Sustainable Finance Committee to promote understanding and best practice nationally within the sector. Amongst other initiatives, the Sustainable Finance Committee has developed 'Principles for Managing Environmental and Social Risk' (BASA, 2018a). The Principles recognise the role that financial institutions can play in the protection, promotion and fulfilment of social, economic and environmental rights in South Africa by conducting their operations, business, lending and investing practices in a sustainable manner as well as reporting on them. The Principles set the minimum standards for evaluation of environmental and social risk, increased transparency, and greater engagement with stakeholders. BASA members commit themselves to these Principles.

### Johannesburg Stock Exchange

The Johannesburg Stock Exchange prioritises sustainability and environmental and social risks in its risk management oversight. The JSE was the first emerging market stock exchange to form a Socially Responsible Investment Index (SRI Index) in 2004 as a tool for investors to identify companies incorporating sustainability practices into their business activities, and its strong commitment to risk management oversight of its listed equities is notable (JSE, 2018b).

### Sustainable Returns for Pensions and Society project

In 2011, the Council of Retirement Funds for South Africa (Batseta) launched the Sustainable Returns for Pensions and Society project. With support from industry stakeholders and the International Finance Corporation (IFC), it set out to empower South African retirement funds to comply with the amended Regulation 28 and newly published CRISA code. In September 2013 it released 'Responsible Investment and Ownership – A Guide for Pension Funds in South Africa'. In consultation with the National Treasury and the Financial Services Board (FSB), the Guide included recommended 'Action Steps' for pension funds to put in place policies and systems for responsible investing.

The 'Action Plan' identifies the fund's potential exposure to ESG-related risks and opportunities in its equities portfolio. It suggests a review of the fund's most important holdings by company and/or sector, to conduct a forward-looking analysis of future sustainability pressures and trends relevant to the fund's asset-liability management and to estimate and benchmark the carbon intensity of the portfolio (Batseta, 2013).

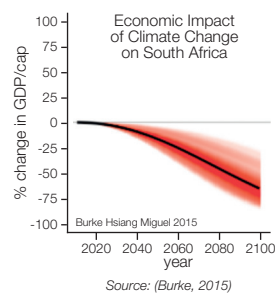
Additionally, the Government Employees Pension Fund and the Public Investment Corporation require asset managers they engage to demonstrate competence in ESG investing (UNEP, 2016).

# Priority environmental risks for the country

## Physical sources of risk

Over the period of 1931–2015, South Africa has seen some significant climate warming (DEA, 2018). In the western parts of the country, the observed rate of warming has been 2°C per century, twice the rate of global warming. This is associated with increased numbers of hot days and decreased numbers of cold nights. There is an increase in rainfall over the central southern interior and a decrease over the northern parts of the Limpopo Province (DEA, 2018). In terms of natural disasters, South Africa is exposed to droughts, flooding, extreme storms and fires (DEA, 2018).

A 2015 Stanford University study evaluated the impacts of the Representative Concentration Pathway (RCP) 8.5 emissions trajectory (which corresponds to an increase by 3.7° of median temperature between 2081 and 2100) on South Africa's GDP from 2015 to 2100 (Burke, 2015). The study had projected impacts of climate change by combining three estimates. The first estimate was of future temperature change. The second of how GDP growth rates correspond to temperature (based on 50 years of historical data). And the third of future change in population and GDP/capita absent climate change, based on estimates of shared socioeconomic pathways (SSP), in particular using SSP3 and SSP5 as they are consistent with the RCP8.5 emissions trajectory. The second estimate is used to calculate a historical response function to understand the effect of a particular temperature change on GDP growth. This response function is then combined with the first and third estimates to project the effect of particular temperature change on the future GDP. The study found that there is a 97 per cent probability that more than 20 per cent of GDP will be lost due to climate change in South Africa by 2100.



Lack of fresh water sources, air pollution and environmental damage top the list of environmental risk and concerns for business (Allianz, 2017). Deforestation, soil degradation, water pollution, oil spills, and coal mining pollution and related environmental damage are also high due to the large agricultural sector operating in the country, the large number of oil tankers passing through rough waters near South Africa's ports, and the coal-intensity of its energy system, respectively.

In 2017, drought featured as the number one reported risk by companies, in line with previous reporting years (CDP, 2017a). Water is used in the direct operations of many companies in this sector and is critical in their supply chains. Given the importance of water risks in South Africa, the National Business Initiative (NBI) has collaborated with CDP on the CDP water project in South Africa. In 2016 the questionnaire was sent to 66 South African companies in order to understand their water risk, drive performance and make the necessary shifts to achieve a more water resilient future (CDP, 2017a). CDP's water security programme motivates companies to disclose and reduce their environmental impacts by using the power of investors and customers. The data CDP collects helps influential decision makers to reduce risk, capitalise on opportunities and drive action towards a more sustainable world (CDP, 2018). Responding to the CDP water questionnaire allows companies to identify their water risk exposure and implement appropriate governance and management actions. In 2017, 41 South African companies responded to the questionnaire. Out of these 44 per cent were classified as showing leadership in the area of understanding, oversight and management of water (CDP, 2017a). Further, 93 per cent of respondents have Board oversight for water, 91 per cent have water management integrated into business strategy and 91 per cent have a water policy in place that sets out goals and guidelines for action.

## Based on this overview, the priority physical sources of risk in South Africa are of a climatic and ecosystem nature.

The significant and painfully recent water shortages in the Western Cape provide a critical reminder that access to water in South Africa is a source of significant risk for businesses and economic operations. Identified as the worst drought in at least 100 years, dam levels reduced to roughly 35 per cent of capacity ahead of the dry season (CDP, 2017a). The full extent of the economic impact of the recent shortage is not yet quantified, while the Intergovernmental Panel on Climate Change predicts that South Africa will become drier in decades to come. One quarter of river ecosystems are critically endangered and pressures on limited water resources are high. While progress has been made to improve access to safe water, sanitation and waste management require further investment to improve access and quality of services (OECD, 2013).

Within this project, the questionnaire respondents have also identified drought as the most relevant physical source of risk to the financial community. It affects the financial system in a number of ways. In Mossel Bay, the drought is causing people to lose their jobs in water-intensive industries, which induces migration into the cities and affects the distribution of bank branches. Within the insurance industry, drought and water shortages are not usually insured perils (with the exception of commercial farming, and then coverage is not universal), so there are challenges in indemnifying clients. This presents a potential new business opportunity for the insurance industry.

While South Africa gets drier it will also get hotter. Under the low mitigation scenario, for the period of 2080–99, over the entire country more than 4°C temperature increases are likely, whereas large parts of the western, central and northern areas might see increases of more than 6°C (DEA, 2018). Due to the high certainty in projections of increasing mean temperatures, an increase in the number of very hot days is clearly a major component of future extreme event management and adaptation. For emissions scenario RCP8.5, one of the four greenhouse gas concentrations trajectories adopted by the Intergovernmental Panel on Climate Change (IPCC) consistent with average 3.7°C mean warming by 2100, the number of very hot days is projected to increase to as high as 120 days. This nearly doubles the current scenario in the Northern Cape, which experiences currently only around 60 days a year. Even under the lower emissions RCP4.5 scenario, consistent with 1.8°C mean warming by 2100, some models project increases in this variable as high as 80 days a year by the end of the century (DEA, 2016). This will have significant

impacts on the agricultural and power generation sectors. In agriculture, such large shifts in temperature may change planting seasons or even crop types, while the electricity sector will be faced with spikes in demand that have not been experienced before.

In the agricultural sector, crops sensitive to temperature may have shown early responses to the effects of climate change, and producers have started addressing these by, for example, using shade netting and evaporative cooling, or shifting to alternative crops (DEA, 2016). Savannas, important for grazing and the subsistence harvest of numerous resources, may be radically reduced, leading to large losses of productive value (Turpie, Winkler, Spalding-Fecher, & Midgley, 2002). In contrast, the productivity of rangelands may increase due to a CO<sub>2</sub> fertilisation effect (Turpie et al., 2002). Forests, small but locally valuable in terms of commercial production of timber and non-timber products, stand to be entirely lost (Turpie et al., 2002).

In terms of the fishing industry, estuaries west of the Transkei region are threatened with significant reductions in water flow. Based on a reanalysis of estuarine fishery production data, it is estimated that the national estuarine catch may be reduced by as much as 35 per cent. Very little can be said about offshore marine fisheries at this stage, but inshore fisheries are likely to be affected by the change in estuarine functioning, with an expected loss of about 18 per cent of fishery value. (Turpie et al., 2002). Further, the African Development Bank reports that rising ocean temperatures and ocean acidification will radically alter aquatic ecosystems, jeopardising fisheries and aquaculture in Gabon, Namibia and South Africa.

With regard to rainfall and its variability, South Africa has a range of seasonal rainfall regimes, and predicting specific changes is difficult. Large-scale circulation changes indicate that extreme winter flooding events may occur less frequently over the southern parts of South Africa in response to a poleward displacement of the frontal systems that bring winter rainfall. Tropical cyclone tracks are projected to shift northward in the summer rainfall area, bringing more flood events to northern Mozambique and fewer to the Limpopo province in South Africa (DEA, 2016). Investors should continue to consider this uncertainty and the impacts it might have on urban systems such as storm drainage and transportation.

Ecosystems are showing first signs of potential physical sources of risk. Coral reef bleaching in the tropical coastal waters of northern KwaZulu-Natal is increasing, and the geographic ranges combined with timing of migration in migrating wild birds and coastal marine fish species are shifting – all of which could have impacts for traditional tourism hubs (DEA, 2016). These changes might affect specific economic activities, eg the sensitivity of South Africa's large vineyard region to small changes in ecosystems and soil composition. Finally, the impacts of climate change on human health are considered, concentrating on the increased incidence of malaria, the proportion of deaths being expected to increase coupled with the increased treatment costs and the loss of earnings of the affected or their carers (Turpie et al., 2002).

Based on this overview, the priority physical sources of risk in South Africa are of a climatic and ecosystem nature. It was not within the scope of this analysis to range these in terms of their probability and

impact, however the top ones would include climatic sources of risk, namely climate warming, sea rise, droughts/flooding and windstorm; as well as ecosystem sources of risk, namely air and water pollution and ecosystem loss.

Based on the questionnaires distributed, the financial community is aware of physical sources of risk within the system. Water is at the top of this list, with drought at the forefront, immediately followed by flooding. Other sources of physical risk, potentially material to the financial firms, are wildfires, crop diseases, hailstorms, seawater temperature increases and ecosystem loss, in particular aquatic systems degradation.

## Transition sources of risk

Transition sources of risk can stem from policy, technology and sentiment shifts. However, there seems to be an assumption that the most prevalent driver for transition sources of risk is the introduction of new climate policy. According to new research, that is no longer the case. Mercure et al. (2018) use an integrated global economy–environment simulation model to understand the macroeconomic impact of stranded fossil fuel assets (SFFA). They argue that some fossil fuel assets will become stranded as a result of an already ongoing technological trajectory, irrespective of whether or not new climate policies are adopted. The losses will amplify if climate policies targeted at 2°C mean warming are implemented. The overall loss from SFFA may amount to USD1–4 trillion, however there are distributional effects. These mean that net importers of fossil fuels will benefit, while net exporters could see their fossil fuel industries almost shut down (Mercure et al., 2018). For South Africa the approximate GDP loss due to SFFA would be USD177 billion (under the 10 per cent discounting assumption with a time horizon of 2035).

While South Africa has been a leader in introducing sustainability into the financial system, it is also one of the world's most energy- and carbon-intensive economies (UNEP, 2016). Over a quarter of the Johannesburg Stock Exchange listed equities are categorised as basic materials. This includes mining, minerals, and forestry enterprises. South Africa's largest utility company, Eskom, relies on coal for 90 per cent of its electricity generation (Eskom, 2018) and is overstretched leading to extended power shortages and blackouts on a regular basis. In the literature, this is known as the dominance of the socio-political regime by the 'mineral-energy complex' (Fine & Rustonjee, 1996; Mohamed, 2010).

The mineral-energy complex describes a coalition of interests that govern energy production, extractive industries as well as their up- and downstream partners in the manufacturing sector (Swilling, Kaviti Musango, & Wakeford, 2015). Therefore, given the poor national uptake of renewables, South Africa faces a particular challenge in transitioning away from energy-, carbon- and water-intensive pathways. This means that the South African transition might be hampered by stranding of assets and disruption from the incorporation of new risk management measures.

In the context of transition, poverty, inequality, social investment and unemployment, arising from structural changes in the energy industries in particular, present challenges. In this regard a stream of work on just transitions, transitions that consider the social aspects rather than looking at purely physical environmental issues, has been highlighting the difficulties that countries such as México and South Africa face (Robins, Brunsting, & Wood, 2018). Just transition is rising up the policy agenda in South Africa. The National Planning Commission in particular has highlighted a high risk of stranded assets in the South African coal industry and pointed to the need for co-ordinated action as part of just transition (NPC, 2018).

Within the policy sphere, the National Treasury has been leading the conversations on the transition to a low carbon economy. While a balance between industry needs and sustainability considerations should be struck, and the collaborative process of stakeholder engagement has served this end well thus far, there are concerns that progress has been slow precisely because of the selection of the 'apply and explain' principle over a compulsory regulation.

On the other hand, the financial system can only take so much at once. Since 2013, the financial sector had to contend with multiple regulatory reforms including Basel III and anti-money-laundering regulations. Further, regulators and industry professionals have predictably prioritised the implementation of international regulatory standards.

South Africa thus far has done a good job of carefully negotiating and sequencing its reforms, however there is a risk that under new administration or under uncertain circumstances this thoughtful approach could be lost. Further, some industry professionals note that the system is fatigued by the pace and complexity of regulatory changes (UNEP, 2016). This sentiment was also expressed in the bilateral conversations conducted during this project. The Financial Stability Board (FSB, 2013) describes the regulatory system as “complex, involving multiple government agencies, advisory and oversight committees and self-regulatory organizations”. It also identifies poor co-ordination and overlapping mandates as a real problem facing regulation in South Africa. Twin Peaks legislation may go some way to addressing this issue.

Despite significant advancement in South Africa’s regulations regarding environmental risk, implementing these approaches does not appear to have significantly affected the allocation of capital as South Africa remains a highly carbon-intensive economy. Some in the industry have noted that the preoccupation with regulatory changes has diverted attention away from true, self-led implementation that would shift capital flows (UNEP, 2016).

Difficulties in co-ordinating between commercial banks and Development Finance Institutions (DFIs) are also likely to persist. DFIs attempt to provide proof-of-concept funding for riskier projects but in reality have hurdles for their own risk tolerance levels, which can result in competition between DFIs and commercial banks for more secure investments (NBI, 2013).

The banking sector and the insurance industry are both dominated by a few major players (FSB, 2013). This presents three rather specific transition challenges. First, the structural concentration means that these players will significantly influence the process, thus their willingness and ability to implement additional environmental risk management measures will to a large extent determine the uptake of these measures and their efficacy. Secondly, a lack of diversity in the system potentially decreases an opportunity to have mixed approaches to incorporating environmental risks and developing innovative mechanisms. Finally, there are spill-over risks if any one of these key players experiences instability.

Further, the four largest South African banks make use of the Equator Principles and half of the banks confirmed that they do not finance projects where the borrower does not meet the principles. However, project finance at around USD10 million is a small proportion of the big four banks’ total lending, and in at least one instance was stated to comprise just 2 per cent of the total loan portfolio (UNEP, 2016). This indicates that a large portion of the banks’ lending has not undergone extensive screening, which might present significant structural challenges for the banks.

Lender liability exists where the costs of environmental incidences can be recovered from the lenders. Lender liability is a significant possibility stemming from the National Environmental Management Act (NEMA) and although commercial banks have acknowledged support the principle of lender liability, reservations persist. It would present an opportunity for banks to incorporate environmental costs into their credit models and processes, but it may also reduce credit availability.

Significant practical challenges remain; nearly every professional interviewed by the United Nations Environment Programme Finance Initiative (UNEP FI) referred to integrated reports as being “form over substance”. This has and will leave investors without access to standardised quantitative ESG information. Without a go-to ESG rating agency, investors find the burden on their own systems to be overwhelming (UNEP, 2016). A dominant theme across UNEP FI review was that the most significant bottleneck hindering green economic transformation was a lack of bankable projects. Many interviewees argued that too few good-quality green economy projects have an acceptable risk-return profile (UNEP, 2016); increasing transaction costs processing projects (in addition to growing capital constraints) will not make this profile any more attractive.

# Key considerations in integrating environmental scenario analysis into financial decision-making

**In the following section, a selection of key considerations for building environmental scenario analysis into financial decision-making will be presented. These considerations address three prerequisites for a successful usage/application of scenario analysis: data sources, available scenarios, tools and methodologies as well as thoughts on integrating these into mainstream financial risk analysis. While the roadmap will reflect much of the guidance available today, the TCFD Knowledge Hub ([www.tcfdhub.org](http://www.tcfdhub.org)) also provides a good compilation of resources on scenario analysis.**

## Data sources

The availability of consistent, comparable and reliable data is one of the key challenges in scenario analysis. However, there are more sources of publicly available environmental data than is frequently assumed, for example Sanderson et al. (2017) provide a useful summary of sources in the annex. Relevant data can be classified into physical asset-level data (facility-level data), firm-level data, value chain-level data, industrial/sectoral data and regional/national/global data (Jun et al., 2017).

Physical asset-level data is the environmental information on physical assets, such as GHG, wastewater or other types of emissions. One classification (Zdii, UNEP Inquiry, & CDC Climat, 2015) splits climate-related physical assets data into carbon data, green/brown metrics and qualitative data/scores (Thoma et al., 2016). Thoma et al. (2016) list asset-level database providers for transition sources of risk in energy-relevant sectors, for example Plantfacts for the steel industry or Wood Mackenzie for the coal industry.

Dupre et al. (2016) provide a useful summary of carbon footprinting data sources, green/brown metrics data sources and climate ESG data sources. In a number of geographies, facility-level data is collected by national environmental authorities as well as non-governmental organisations (NGOs). For example, the US Environmental Protection Agency (EPA) has a FLIGHT (Facility Level Information on GreenHouse gases Tool) available for GHG emissions from 41 categories of reporters (Jun et al., 2017). The Institute of Public and Environmental Affairs (IPE) in Beijing, China provides environmental quality information, emissions data and pollution source supervision records of certain provinces and cities in China (Jun et al., 2017). Other national environment agencies, such as the European Environment Agency and the Australian Department of the Environment and Energy, gather and provide physical asset-level data. A particular challenge, currently being investigated, in using facility-level data is the linkage between physical asset data and financial asset data, more specifically correct mapping of ownership structures.

Firm-level and value-chain data is usually available through corporate disclosures, environmental agencies and third-party data providers, such as Bloomberg, S&P Global Market Intelligence and others. With more and more organisations and national regulatory authorities subscribing to and supporting the TCFD recommendations (CISL, 2018b), the availability of firm-level data and value-chain data is set to increase over the next three to five years. Already the list of companies performing and publicly reporting on scenario analysis includes BHP Billiton, ConocoPhillips, Enel, Glencore, Royal Dutch Shell and Statoil to name a few (Raynaud & Roettmer, 2018).

Industrial/sectoral data is data on industrial averages or on standards for environmental performance, such as emission per unit of production, provided by government agencies or academic organisations (Jun et al., 2017). For example Moodys (2015) analysis has provided a credit risk heatmap and sector-level risk results for equities in top-down portfolio-level models.

Regional/national/global data is the macro data that helps construct environmental scenarios for assessing transition and physical sources of risk. The roadmap will examine the issues inherent in global data when addressing physical and transition scenarios.

## Scenarios for understanding physical and transition sources of risk

Transition scenario literature is quite extensive. The two publicly available and widely accepted scenario sources are the International Energy Agency (IEA) and the Integrated Assessment Models (Colas, Khaykin, Pyanet, & Westheim, 2018). The International Energy Agency provides over 100 carbon transition pathway scenarios (Acclimatise, 2017; Mazzacurati, Firth, & Venturini, 2018; TCFD & BoE, 2017). CICERO (2018) has produced a basic scenario guide, demystifying the various types of climate scenarios currently available and comparing the IPCC and the IEA scenarios.

The choice of scenario used depends on the type of analysis to be undertaken, as some scenarios are more suited to certain types of analysis. For example, the IEA World Energy Outlook scenarios go to 2040 and focus on markets, so they are suitable for the medium-term analyses, whereas the IEA Energy Technology Perspectives go out to 2060 and focus on energy technologies, meaning that they could be used to look at technology-based transitions over the long term. When conducting scenario analysis it is good practice to compare a 2°C scenario to a 4–5°C scenario. In IEA terms, that would equate to looking at the IEA World Energy Outlook Sustainable Development scenario (consistent with the Paris Agreement ambition of reaching 2°C warming) as well as the IEA World Energy Outlook Current Policies scenario (consistent with no climate policy and resultant warming of 4–5°C). Given that Department for Environmental Affairs (DEA, 2018) predicts that under low mitigation the warming in South Africa is likely to exceed 4°C and reach as high as 6°C in parts of the country, it would equate to looking at the IEA World Energy Outlook Current Policies scenario. In IEA terms, that would equate to looking at the IEA World Energy Outlook. Further, under high mitigation (RCP4.5), the temperature increases would still reach 2.5–4°C. In practice that means a 2°C transition scenario in South Africa would need to incorporate the possibility of physical sources of risk that are likely to manifest at 2.5–4°C.

There is, of course, a gap between climate scenarios and financial risk assessment, therefore several reports have attempted to adapt climate scenarios for financial analysis. Colas et al. (2018) make some suggestions, for example summarising model outputs as a set of focused risk drivers. 2dii and The CO Firm (2017) provide a number of cross-sector and sector-based indicators, which can be used by financial firms in constructing bespoke or adapting traditional climate scenarios to their portfolios. Thoma et al. (2016) list further resources, which can be useful in such adaptation.

The amount of work on scenarios for physical sources of risk is more limited and differs based on the classification used. For example, IPCC defines extreme climate change events as heat stress, extreme precipitation, drought, cyclones and sea-level rise (IPCC, 2013). Mazzacurati et al. (2018) provide a sensitivity matrix of a particular industry to various types of physical sources of risk, which could provide a helpful guide in understanding the impact of physical sources of risk on particular portfolios.

Probabilistic models, used widely by the insurance industry, provide a valid starting point for understanding physical sources of risk in the financial portfolios. Most of the current analyses of physical sources of risk, such as the analysis of the impact of climate change on sovereign ratings conducted by S&P Global Ratings (2015), combine probabilistic modelling with economic analysis. In their recommendations for advancing TCFD guidance on physical climate risks and opportunities, Mazzacurati et al. (2018) suggest basing physical scenarios on current and desired greenhouse gas pathways combined with nationally determined contributions. For short- and medium-term physical sources of risk, they look to probabilistic modelling to assess first-order impacts and overlaying scenario analysis for understanding second-order impacts. They suggest using scenario analysis for understanding both first- and second-order impacts of long-term physical sources of risk (Mazzacurati et al., 2018).

An increasingly important source of physical risks in South Africa, as highlighted by the literature and by our discussions, is water availability. This year, Cape Town has famously suffered from water shortages. In terms of hydrological complexity, South Africa is on the border between water stress and water security, meaning that it is not the worst affected country, however it is close to entering water stress (Fischer, Hizsnyik, Tramberend, & Wiberg, 2015). Hydrological complexity is an indicator that assesses total renewable water resources per capital, intensity of water use, runoff variability and dependency on external water resources. A helpful resource for enabling firms in analysing and managing water risks is the Tramberend et al. (2015) overview of global water scenarios. Given the importance of agriculture in the South African economy, there is a particular need for development of climate risk scenarios for the agriculture sector. As demonstrated by the DEA (2018) assessment of risks and vulnerabilities of the agriculture and forestry sectors to climate change, some steps have already been taken in this space. There is also a lack of more generic commodity scenarios for market risk purposes.

One of the most important discussions on the use of scenarios for understanding climate risks is the debate about the benefits of standardised scenarios vs bespoke scenarios. The standardised approach allows for comparability between firms, whereas the bespoke approach provides for a more detailed picture of the risk within a particular firm. Standardised scenarios are attractive as it is perceived that they are easier and quicker to use in comparison to developing bespoke scenarios, however this might prove deceptive as even a standardised scenario will need to be adapted to the organisational models and tools. In comparison, bespoke scenarios allow for a more nuanced picture to be built, which would fit into the existing organisational processes.

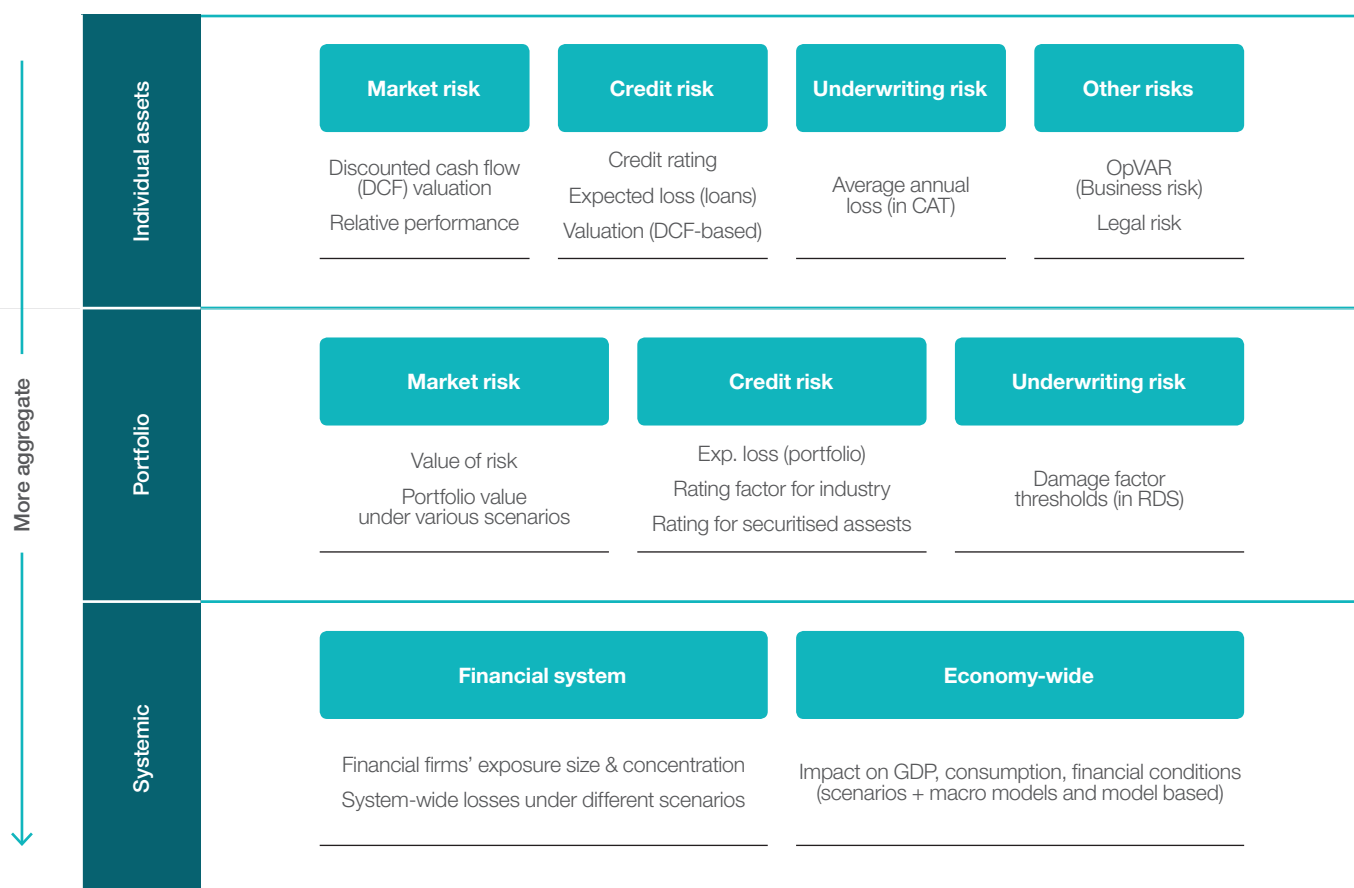
A comparison to regulatory and proprietary stress testing employed within the banking sector might prove informative in this debate. Within the traditional stress testing exercises, banks perform proprietary stress testing to bespoke scenarios to understand the impact of a particular scenario on their balance sheets, as well as regulatory stress testing to allow the regulators and the markets to compare between various financial firms. In the same way, within environmental scenario analysis, a combination of standardised and bespoke scenarios can be used to suit different end users and different goals. This corresponds to the results of the questionnaires distributed in the course of the project. Within the questionnaires, there is support for a combined approach, with the caveat that development of standardised scenarios is closely aligned with the local and industry context and is a result of consultation with the financial industry.

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**One of the key questions raised by the integration of environmental risk analysis into mainstream financial frameworks is which department is responsible for environmental scenario analysis.**

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**Figure 3. Categorisation of environmental risk tools (BOE et al., 2017)**

### Tools

One of the key questions raised by the integration of environmental risk analysis into mainstream financial frameworks is which department is responsible for environmental scenario analysis. Over the last several years, sustainability functions have been migrating from the central investor relations and PR functions into the mainstream risk, finance and business functions. Inevitably, environmental knowledge contained in the sustainability functions needs to be integrated with the knowledge and expertise of mainstream credit, market, legal and business analysts. The migration of sustainability functions into the mainstream business functions will aid the knowledge intermingling process and enable mainstream risk and finance analysts to incorporate environmental indicators into the mainstream tools, thereby ensuring that environmental sources of risk are priced into every financial transaction.

Integration of environmental scenario analysis into financial decision-making can and should be done via mainstream tools already used in financial decision-making. Some of the tools that are amenable to such an integration can be seen above (please see Figure 3).

Awareness about the types of tools that can be used to perform or to align with environmental scenario analysis is growing in South Africa. Discussions at the workshops and in bilateral meetings revealed some examples of tools that are seen as useful in the South African context. These vary depending on the source of environmental risk and the type of financial risk. The use of the Equator Principles and IFC methodology for screening for environmental impacts is prevalent among larger institutions. In terms of physical sources of risk, a good example is the WWF Water Risk Filter tool (WWF, 2018). Further, there are a number of tools used by the insurance industry to model catastrophe risk, which can be used in combination with economic models to understand the impact of physical sources of risk on financial portfolios. In terms of client engagement, client checklists and enterprise risk management frameworks are used to understand environmental sources of risk at the client level. The business process risk management framework as approved by the South African Reserve Bank is another example.

Within South Africa, interesting work is being done on integration of environmental scenario analysis into mainstream risk frameworks. While we have not been able to find examples of recent work in the public domain to profile it within the roadmap, we have seen some evidence of progress within the workshops conducted. One

particular example highlights the impact of rising water temperatures and the migration of fish further away from the coast on fisheries, and therefore on the risks and opportunities this presents to the banking sector in South Africa. There is also some interesting work ongoing on the incorporation of environmental risk assessments into banking credit risk assessment processes. Additionally, there is work within the insurance and investment management industry on understanding the impact of particular environmental scenarios on the operations and business continuity of the firm in question.

In order to demonstrate some examples of leading practice of environmental scenario analysis being conducted around the world, nine cases are presented. The selection of case studies was designed to demonstrate a variety of evolving approaches utilised by different financial sectors to understand the impact of environmental sources of risk on financial risks. The case studies are neither an exhaustive list of current practice, nor necessarily an indication of best practice. Rather, they are a selection designed to reflect the diversity of experiences evident across markets of interest to the G20. The purpose of these is to provide a useful platform for South African financial institutions to build on when constructing their own environmental scenario analyses.

Case number	Sector	Environmental source of risk	Financial risk
1.	Investment management	Transition: policy and technology	Market
2.	Banking	Transition: policy and technology	Credit
3.	Insurance	Transition: policy and technology	Market and credit
4.	Financial	Transition: policy, technology and sentiment	Legal
5.	Investment management	Transition: policy and technology	Market
6.	Investment management	Physical: climatic, geologic, ecosystem	Market and credit
7.	Insurance and investment management	Physical: climatic	Market and credit
8.	Banking	Physical: climatic	Credit
9.	Banking	Physical: climatic	Credit

**Table 1. Overview of the cases**

More specifically, cases provide some examples of financial firms analysing and attempting to manage priority sources of risk that are relevant to the South African context, such as windstorms, droughts, climate warming and air pollution. Within this analysis, in case 7, AXA looks at the effect of windstorms on the market and credit risk of their real estate and infrastructure debt portfolio. Case 8 puts forward

a tool to understand the impact of drought on credit risk. Case 9 describes the impact of global warming on the agricultural portfolio of Itaú Unibanco. CISL (2016) describes the Industrial and Commercial Bank of China's (ICBC's) efforts in quantifying the cost of incoming air pollution regulations on their portfolio of cement and thermal power clients.

## Case 1.

*Transition sources of risk for equity valuation of electric utilities (Brunke & Raynaud, 2018)*

<b>Organisation:</b>	Kepler Cheuvreux and The CO Firm
<b>Sector:</b>	Investment management
<b>Environmental source of risk:</b>	Transition: policy and technology
<b>Financial risk:</b>	Market risk

### Main approach

As part of the ET Risk Project, during which a research consortium came together to provide research and tools to assess financial risks and opportunities of transition to a low carbon economy, Kepler Cheuvreux and The CO Firm have jointly analysed the transition sources of risk for the electric utilities sector. The report has described the changing energy landscape for electric utilities as well as the associated financial impact. The changes in the landscape include the decreases in CO<sub>2</sub> emissions, the introduction of CO<sub>2</sub> certificate prices, the increasing share of renewables in energy generation as well as average global temperature increase. In the report they have laid out two potential climate transition scenarios as well as two adaptive pathways for companies' portfolio development. Based on these scenarios they have calculated company-specific impact on financial KPIs (ie EBIT, EBITDA and depreciation) for Enel, Engie, EDF and the global utilities sector. They have then conducted global and company-specific deep dives into the financial impacts, technological portfolio development and the robustness of earnings, as well as provided an EBITDA heatmap for country and technology combinations going out to 2020, 2030 and 2050. They have also provided some suggestions on the integration of such an analysis into investment decision-making.

### Integration into mainstream risk assessments

The main mechanism for integration of such an analysis would be via equity valuation. In this regard, two questions can be posed to ensure integration of the results into the financial decision-making: (1) what would be the target price of a company under a 2°C scenario and (2) whether this target price can be used to integrate transition risk into current valuation models. In order to answer these questions, the authors suggest that integration of transition scenario results into financial modelling can be done via looking at the long-term growth potential of a country, sector or company and either extending the period, over which cashflows are modelled year on year, or changing the growth rate used. Another way would be to use the effect of transition pathways on risk profile (variability of cashflows). Due to availability of data, the report details the analysis of the first option and provides some guidance on how to conduct the analysis of the second option.

### Challenges of the approach

The report details using the results of a set number of climate scenarios on the financial performance of the companies in question. However, to drive capital allocation, financial analysts need to make a choice on the probabilities of such scenarios coming to fruition. One potential solution for this challenge would be deriving a probability distribution of key parameters and then using a Monte Carlo analysis to understand under which conditions company valuations might be affected the most.

The report has described the changing energy landscape for electric utilities as well as the associated financial impact.

## Case 2.

*Transition sources of risk for credit portfolio of utilities (Colas et al., 2018)*

<b>Organisation:</b>	Barclays as part of 16-bank UNEP Finance Initiative on TCFD disclosures
<b>Sector:</b>	Banking
<b>Environmental source of risk:</b>	Transition: policy and technology
<b>Financial risk:</b>	Credit risk

### Main approach

Barclays applied the transition risk assessment method, developed by the group, to calculate the climate-adjusted probability of default for electric utilities credit portfolios in the USA and Europe. It has assessed 35 companies, each across four potential scenarios, resulting in 80 stress tests on US entities and 60 stress tests on European entities. The REMIND 2°C scenario, developed for the CD-LINKS project, was used as the transition scenario. Based on exposure to climate risk drivers, the electric utilities credit portfolio was segmented into four homogenous groups, and the sensitivity of each group to risk factor pathways was evaluated. Then credit risk officers assessed how the transition scenario will impact the credit standing of the companies in question. Five representative cases were chosen and subjected to a static (assuming no capex requirements) and an adaptive (assuming overnight capex requirements) stress test. These stress tests assessed financial performance through impact on earnings, cashflows and balance sheets. Four stressed through the cycle probabilities of default were calculated: static 2030, adaptive 2030, static 2040 and adaptive 2040. The average between static and adaptive was used for every year, and the resulting Probability of Default (PD) was used to calibrate the entire portfolio. Under the 2040 2°C scenario the climate-stressed exposure at default weighted average portfolio PD is 2.2x greater in the US and 2.3x greater in Europe relative to the baseline.

### Integration into mainstream risk assessments

This methodology can be used to assist early identification of entities 'at risk' under a particular scenario. It is a pilot study that can be further developed methodologically and applied to various portfolio sectors to understand the susceptibility of those sectors to transition scenarios. There are a variety of options for mainstreaming this type of analysis. The first option would be to conduct such stress tests on a regular basis, with the results contributing to the discussions with the companies on possible risk mitigation measures and opportunities in the sector, as well as forming a consistent sector strategy. Another would be to identify transition risk indicators that could be incorporated into the standard model in order to reflect some of this risk in the credit rating of the company in question. One of the benefits of this exercise is the fostering of cross-team collaboration and expertise exchange in the area of environmental sources of risk.

### Challenges of the approach

Data and methodological challenges remain. In terms of data, the required credit portfolio metrics had to be extracted from the systems. Firm-level disclosure of data such as, among others, current generation mix and nuclear capacity, could improve the overall quality of analysis.

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Barclays applied the transition risk assessment method, developed by the group, to calculate the climate-adjusted probability of default for electric utilities credit portfolios in the USA and Europe.

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## Case 3.

*Navigating the transition framework (CISL, 2018a)*

<b>Organisation:</b>	ClimateWise Insurance Council
<b>Sector:</b>	Insurance
<b>Environmental source of risk:</b>	Transition: policy and technology
<b>Financial risk:</b>	Market and credit risk

### Main approach

The ClimateWise Insurance Council, in collaboration with ERM, has put together a primer on identifying transition risks and opportunities inherent in infrastructure investment portfolios. The framework helps investors and regulators manage risks and capture emerging opportunities from the low carbon transition. The framework includes a step-by-step guide, a methodology, open-source high-level tools, and case studies to help investors understand variations in transition risk across portfolios and within various asset types. The framework is based on financial driver analysis and transition scenario analysis. Three scenarios are considered – business as usual (consistent with 3.7°C warming), nationally determined contributions within the Paris Agreement (consistent with 2.7°C warming) and the path to 2°C. Three steps are suggested: assessing the breadth of asset types impacted by the transition risk and opportunities, defining potential impacts at the asset level and incorporating these impacts into the financial models. Three offerings are provided to enable financial firms to go through each step. For the first step, an infrastructure risk exposure matrix provides an overview of transition exposures across a breadth of asset classes under two scenarios – the nationally determined contributions within the Paris Agreement and the 2°C scenario out to 2020, 2030 and 2040. In the second step, asset impact identification methodology is described to assess the impact of transition scenarios on individual infrastructure assets. Finally, within the third step a financial modelling analysis guide helps firms to incorporate the results into their financial models.

### Integration into mainstream risk assessments

Within the third step the framework provides a guide to incorporating the results of the assessment into financial modelling. This is done using the outputs from the Infrastructure Risk Exposure Matrix, Asset Impact Identification Methodology and the relevant scenario datasets. The framework uses a German gas distribution company to demonstrate how this would be done. In step 3 (a), financial drivers need to be interpolated into the model. For the gas distribution company, there are three key financial drivers – pipeline utilisation, carbon price and the costly emission reduction requirements – that need to be interpolated into the financial model to account for potential transition risk impacts. For each driver, the potential risk impact can be estimated annually using the Infrastructure Risk Exposure Matrix methodology and refining it to the specific asset level based on the Asset Impact Identification Methodology. In step 3(b), financial materiality of transition risks and opportunities needs to be assessed by tracking the impact of financial drivers on a variety of the asset's financial metrics, and considering exit strategies where risk is high, or developing investment options to improve asset resilience.

### Challenges of the approach

The selection of asset types, geographies (US, Europe and India) and time horizons was driven by the alignment with and relevance to the insurance investment portfolios. Further work can expand to cover other infrastructure types as well as widen its geographical application and reach.

The ClimateWise Insurance Council, in collaboration with ERM, has put together a primer on identifying transition risks and opportunities inherent in infrastructure investment portfolios.

## Case 4.

*Risky business – climate change and professional liability for auditors (ClientEarth, 2017)*

<b>Organisation:</b>	ClientEarth
<b>Sector:</b>	Financial – relevant to directors and audit companies
<b>Environmental source of risk:</b>	Transition: policy, technology and sentiment
<b>Financial risk:</b>	Legal risk

### Main approach

Reflecting the unique nature of legal risks, this case is a step away from the discussions in the cases above. In this report, ClientEarth argues that directors and auditors already have legal duties with regard to understanding and reporting climate risk. They note that company directors must consider, manage and report climate risks. Those who fail to do so face potential litigation, regulatory intervention and shareholder pressure. Auditors need to understand the implications of climate risks within the current accounting treatments and audit standards. The report provides a hypothetical example of Pump It Up – a multinational company in oil and gas production and development. The company's 2017 annual report does not refer to climate risk and neither does the auditor's report, however it does disclose the impact of a decline in oil and gas prices and changes in regulatory and fiscal environments as principal risks. Transition risk forces the oil and gas industry to stall by 2022 and Pump It Up goes into bankruptcy. In the light of this bankruptcy, liquidators commence proceedings against the directors for breaching their director duties. Directors' potential liability is covered by their Directors and Officers insurance and insurers step in to defend the claim. In order to limit their exposure, insurers add the auditors into the claim and argue that auditors are liable for failing to consider climate risk in breach of their legal duties of skill and care. While this is a hypothetical example, the report also highlights recent fines, levied on auditors by the Financial Reporting Council in relation to failing to express insufficient auditor scepticism in the areas of significant risk.

### Integration into mainstream risk assessments

This report points to the need to consider legal risk implications of particular scenarios on the financial firms involved. This should be part of the third step of the risk assessment and management process.

In this report, ClientEarth argues that directors and auditors already have legal duties with regard to understanding and reporting climate risk.

## Case 5.

*Out of the fog: quantifying the alignment of Swiss pension funds and insurances with the Paris Agreement (Thoma, Murray, Hayne, & Hagedorn, 2017)*

<b>Organisation:</b>	2dii for Swiss Federal Office for the Environment (FOEN) and the State Secretariat for International Financial Matters (SIF)
<b>Sector:</b>	Investment management
<b>Environmental source of risk:</b>	Transition: policy and technology
<b>Financial risk:</b>	Market risk

### Main approach

This case is an example of a national regulatory agency initiating an analysis of the alignment of Swiss pension fund and insurance portfolios with a 2°C climate goal. The participation in this pilot analysis was voluntary and free. The focus of the analysis, performed by 2dii, was on the listed equity and corporate bonds portfolios. Seventy-nine investors, covering around two thirds of the listed equity and corporate bonds portfolios, held by Swiss pension funds and insurance companies, participated in the analysis of the alignment of these portfolios with the 2°C scenario as well as assessment of transition risks for the portfolios. The participating firms received reports on their individual results and an anonymised summary report was made public. The project used an open-source Paris Agreement Capital Transition Assessment (PACTA) model, which is available online, to understand alignment of the portfolios to the 2°C climate scenario. The model covered energy, electric power, transportation, cement and steel sectors and used the IEA 2°C scenarios. Collectively, the analysed portfolios (with the exception of fossil fuels, where investment in expanding production has decreased) are consistent with a 6°C pathway. This alignment opens portfolios to the risk of an abrupt transition. Around one third of corporate bond portfolios have more than 20 per cent of the funds exposed to transition risks. A top-down sector analysis for equity portfolios comes to similar conclusions.

### Integration into mainstream risk assessments

A number of regulatory agencies across G20 member states are currently contemplating the introduction of climate stress tests. This pilot project is an example of a stepping stone towards climate stress testing of a particular national financial system. It provides the regulatory agencies and the public with an anonymised assessment of the level of risk inherent in the system, while at the same time providing detailed feedback to participating institutions, allowing them to make better informed decisions about the need for potential risk mitigation strategies.

### Challenges of the approach

There are a number of processual and data challenges associated with this approach. Real estate and infrastructure portfolios were excluded from the analysis due to gaps in data coverage of these portfolios. In terms of process, the analysis relies on voluntary participation of the financial firms in question. Therefore there is a possibility that the overall numbers are not generalisable to the whole financial system.

This case is an example of a national regulatory agency initiating an analysis of the alignment of Swiss pension fund and insurance portfolios with a 2°C climate goal.

## Case 6.

*Shades of climate risk. Categorising climate risks for investors (Clapp, Francke Lund, Aamaas, & Lannoo, 2017)*

<b>Organisation:</b>	CICERO Climate Finance
<b>Sector:</b>	Investment management
<b>Environmental source of risk:</b>	Physical: climatic, geologic, ecosystem
<b>Financial risk:</b>	Market and credit risk

### Main approach

In this report, CICERO Climate Finance has categorised physical sources of risk by timeframe, probability and region as well as provided an analysis of information gaps for investors. Further, in the report they make a commitment to updating the data and continuing to provide sources of information on physical sources of risk for investors. The availability of consistent and continuously updated data is a challenge, so this commitment is welcome. The report takes a regional view and categorises the sources of physical risk, observed impacts, projected impacts towards 2050 (for a range of scenarios between 2°C and business as usual), and examples of impacted sectors. Further, it provides a heatmap of the severity of these sources of risk. For example for Africa it underlines the rise of sea level and its effects on tourism, fisheries, transportation, industry and infrastructure.

### Integration into mainstream risk assessments

The report provides a useful starting point for assessment of physical sources of risk for financial firms and high-level understanding of potential sources of risk that are relevant for a particular firm. Further, an updatable list of sources can provide a useful starting reference library.

### Challenges of the approach

The geographical segmentation of the report is at the region level, which while providing a high-level view makes it challenging to conduct a detailed and robust data analysis. In the future, it would be useful if the geographical segmentation was done at a country level.

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In this report, CICERO Climate Finance has categorised physical sources of risk by timeframe, probability and region as well as provided an analysis of information gaps for investors.

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## Case 7.

AXA's climate risk disclosures (AXA Group, 2016)

<b>Organisation:</b>	AXA
<b>Sector:</b>	Insurance and investment management
<b>Environmental source of risk:</b>	Physical: climatic
<b>Financial risk:</b>	Market and credit risk

### Main approach

In this report, AXA Group presents its approach, which was recognised as a good example of environmental risk disclosure by the French Ministry of the Environment, to analysing the effects of transition and physical sources of risk on their portfolio. Given the wealth of transition risk cases, this case will concentrate on the impact of physical sources of risk. Here, AXA has analysed physical sources of risk present in its EUR12.6 billion real estate portfolio and EUR3 billion infrastructure debt portfolio. The methodology used natural catastrophe models to assess the impact of windstorms (as the most common catastrophic event in Europe) on 100 per cent of the infrastructure debt portfolio and 41 per cent of the real estate property portfolio. Having geolocated each asset in the portfolio, AXA used an internal natural catastrophe model to determine potential damage rates for European-specific sites. The analysis concluded that in the case of a 1-in-100 windstorm, the cumulated loss of two portfolios would be c. EUR15 million. The average annual loss is calculated at EUR0.8 million. Looking through the lifecycle of the investments (average of c. 30 years), the cumulative annual losses would be EUR24 million.

### Integration into mainstream risk assessments

In addition to conducting ESG assessments across asset classes, since 2015 AXA has been putting particular focus on climate risk management and carbon-related factors. There are a number of initiatives that are either informed by or the result of climate risk management. These are divestment from coal, carbon footprinting, energy transition scenario analysis for article 173, and internal ESG impact report data.

### Challenges of the approach

For the infrastructure portfolio, an assumption had to be made that each asset was fully owned by AXA, which is not the case. In the future, to determine real impact, risk could be differentiated according to the ratio of debt to total asset ownership. Further analysis would refine geocoding information and improve building-specific information to improve average destruction rates. The intention is to extend the analysis to flood risk, which would likely increase estimated annual damages by 30 per cent.

Here, AXA has analysed physical sources of risk present in its EUR12.6 billion real estate portfolio and EUR3 billion infrastructure debt portfolio.

## Case 8.

*Drought stress testing tool (Carter & Moss, 2017)*

<b>Organisations:</b>	The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH in partnership with the Natural Capital Finance Alliance, Risk Management Solutions and ten financial institutions from Brazil, China, México, Switzerland and the United States
<b>Sector:</b>	Banking
<b>Environmental source of risk:</b>	Physical risk: climatic
<b>Financial risk:</b>	Credit risk

### Main approach

The tool provides an analytical framework and model that enables banks to evaluate the potential effects droughts have on the performance of individual loans as well as the overall corporate loan portfolio. The framework draws on insights from traditional catastrophe risk models developed by the insurance industry. A set of five drought scenarios was developed for each pilot country, showing the impact of drought geographically and over time. The participating financial institutions utilised the tool to assess the impact of these scenarios on their own loan portfolios.

To assess how the drought would affect an individual company's probability of default, the model looks at how drought could directly and indirectly affect a company using both a vulnerability model and a standard macroeconomic model. By applying a series of impact factors across a company's operations, the tool calculates how drought conditions could affect the business, both by reducing output and thus decreasing revenue and by increasing operating costs, eg through a rise in electricity prices. Based on the impact, the tool determines the total expected loss for a loan portfolio for each scenario. The framework used in the drought tool is highly flexible and could be adapted to assess default risk for other ESG issues, including other natural catastrophes such as hurricanes, earthquakes and flood, legislative risk and carbon risk

### Integration into mainstream risk assessments

The tool was designed in a way that it can be integrated into banks' existing stress testing methodologies.

### Challenges of the approach

The greatest bottlenecks for financial institutions in applying the tool tend to be a lack of in-house capacity and data. The tool provides the most complete view of drought impact when information on the financial statements and location of operating sites is available for the companies to which financial institutions are lending money. Many credit-modelling teams do not have this information, but that does not mean they cannot benefit from the tool. By using 'archetype' data (included within the tool) to supplement their own data, they can still get an idea of the impact of drought on the companies in their portfolios. As the amount and quality of data available to them improves, so the insight derived from the tool will increase.

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The tool provides an analytical framework and model that enables banks to evaluate the potential effects droughts have on the performance of individual loans as well as the overall corporate loan portfolio.

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## Case 9.

*Physical sources of risk for credit portfolio of agriculture clients (UNEP Finance Initiative & Acclimatise, 2018)*

<b>Organisation:</b>	Itaú Unibanco as part of a 16-bank UNEP Finance Initiative on TCFD disclosures
<b>Sector:</b>	Banking
<b>Environmental source of risk:</b>	Physical: climatic
<b>Financial risk:</b>	Credit risk

### Main approach

Itaú Unibanco applied the physical risk assessment method, developed by the group, to measure and assess physical risk associated with climate change in the agriculture sector. Within this case, it was assumed that the agriculture sector is impacted via incremental changes in temperature, precipitation patterns and other variables that change gradually over the years (incremental climate change) as well as by the changes in frequency and intensity of extreme events (extreme events). For this second type of impact, five types of events were selected for the pilot: windstorms, drought, extreme heat, floods and wildfires. In practice, due to the particular portfolio in question, windstorms were not considered in the case, and the impact of floods and wildfires was not seen to be material – the most impact came via droughts.

The tool developed consisted of four steps. The first one was the establishment of climate scenario, where two scenarios were chosen (2°C and 4°C) with the horizon of 2025 and 2045. In practice the results only disclose the impact of the 4°C scenario with the 2045 horizon. The second step was to verify how production, price and cost indicators would react to incremental and extreme source of risk. The third step would evaluate the credit quality of a sample of companies affected by these indicators. In the final steps the results of the sample would be extrapolated to the entire portfolio.

Itaú Unibanco selected a portfolio of 130 rural producer clients in Brazil in the bank's corporate sector, with a risk of R\$4 billion, concentrated in short-term operations. The portfolio was split into two groups: with better and worse credit quality. Fourteen clients (ten from good credit quality and four from a group with financial difficulties) were chosen as the sample. Most of the clients within the sample would have negative revenue implications from incremental climate change risk (from -16 per cent to -2 per cent relative to the baseline revenues) with one showing a 22 per cent positive revenue growth in the scenario. Extreme events resulted in mostly negative revenue changes (with a smaller magnitude of from -3.5 per cent to +3.5 per cent) and minimal cost changes (around 1 per cent) relative to the baseline. These changes were then transferred to a credit rating impact, where five of the 14 clients would have seen a negative and medium qualitative rating impact, with the rest showing

neutral rating impact. The results were then extrapolated to the rest of the portfolio, with the conclusion drawn that the portfolio has a low downgrade potential in the agriculture sector. This conclusion seems at odds with the results of the sample, where 35 per cent of the clients demonstrated medium negative rating impacts. This may be due to the extrapolation technique used.

### Integration into mainstream risk assessments

In order to conduct the pilot case study, Itaú Unibanco has brought together the socio-environmental risk area, the sustainability group, the portfolio management group, the credit risk group as well as the commercial group, responsible for the agricultural sector. Therefore the pilot has provided an opportunity for knowledge exchange between various groups within the bank. The methodology enables the quantification of physical risk within the mainstream risk management systems, which would allow the bank to start adequate long-term planning for risk management resource requirements in this area. The bank found that with adequate resources and commitment it was not challenging to incorporate the methodology into the mainstream activities of the bank.

### Challenges of the approach

The first challenge of understanding the reach of the pilot case is that only one of the four possible scenario/horizon combinations has been made public. Therefore it is hard to draw conclusions on what both scenarios would have meant in the short term (2025) and what a 2°C scenario would have meant in the long term. There were a number of limitations to the approach. Firstly, there is the lack of data on geographical distribution of the clients, necessitating certain assumptions to be made. Secondly, methodology did not consider the impact of physical sources of risk on client investment. Thirdly, the pilot used a direct extrapolation technique for the rest of the portfolio – a more robust distribution technique across the portfolio may be helpful. Fourthly, the impacts from incremental and extreme event parts were added, not taking into consideration the impact of both taking place at the same time. Finally, there is still a great degree of divergence of impact data – better data would, of course, allow for calculation of more precise results.

# Challenges and roadmap for the future

**Based on the analysis of the national context, coupled with the knowledge CISL has gathered about the approaches of various G20 members to understanding and incorporating environmental scenario analysis in their mainstream financial decision-making, this section elucidates the main challenges faced by the South African financial system along with recommendations for addressing these challenges.**

The recommendations fall into three groups: recommendations for financial firms, recommendations for regulatory authorities and recommendations for the collaboration between the two.

**Recommendation 1.** Financial firms to develop methodologies and tools that enable incorporation of environmental scenario analysis into financial decision-making.

**Recommendation 2.** Financial firms to ensure that senior management is committed to implementing environmental risk analysis via scenario analysis.

Integrated environmental and social scenario analysis is a new concept for most firms. At the same time, global practice underlines the materiality and increasing scale, magnitude and likelihood of environmental sources of risk for individual financial firms and the financial system as a whole (CISL, 2016). These increases in complexity and likelihood of environmental sources of risk introduce challenges in forecasting the timing and exact exposure of financial firms. Therefore, tools such as environmental scenario analysis are integral for understanding, measuring and managing the financial risks stemming from these sources. In the words of one of the workshop participants, integration challenges are about “effectively integrating environmental risks into the inner workings of the business in ways that effectively translate into behavioural change, and reduce risk, but while ensuring that the company remains profitable”. Three conditions enable integrated scenario analysis: a solid business case, adequate tools and models as well as expertise in using and adapting these tools to suit new requirements.

Financial firms need to recognise that innovation in tools and methodologies is required to understand and manage these risks. Such innovation does not happen on its own – in order to flourish it needs to be built into the organisational incentive system. Therefore, a productive way to foster the development of environmental scenario analysis within the mainstream risk functions would be to align employee incentives with the development of relevant and innovative environmental scenario analysis methodologies that genuinely add value to institutional decision-making (on both the risk and opportunity side), through behavioural economics, internal or external partnerships.

An example of such a partnership would be for insurance companies to share their knowledge and modelling expertise on physical sources of risk with banks. In turn, banks can share their expertise on modelling macroeconomic shifts of the type required for understanding transition sources of risk with insurance companies. Such a partnership would widen the horizons and deepen the expertise of environmental sources of risk in both parties.

A productive point of departure for this incorporation would be the consideration of financial risks stemming from priority environmental sources of risk for South Africa. In terms of physical sources of risk, these include climatic sources of risk, namely climate warming, sea rise, droughts/flooding and windstorm; as well as ecosystem sources of risk, namely air and water pollution and ecosystem loss. In terms of transition sources of risk, these include particular challenges South Africa faces in transitioning away from energy-, carbon- and water-intensive pathways due to its heavy reliance on fossil fuels, which increases the likelihood of stranded assets, as well as the poor uptake of renewables. Further, poverty, inequality, unemployment and social investment are particular challenges. Risk management and sustainability teams could collaborate on the development of scenario analyses that would identify, analyse, measure and manage these risks, and risk management teams could then ensure that relevant risk indicators are incorporated into mainstream risk tools.

Further, management attention is the deciding factor for incorporation of environmental scenario analysis into mainstream financial decision-making. Therefore, involvement of senior management is paramount for successful integration of environmental scenario analysis. A Board-level environmental risk champion, such as the Chief Risk Officer, could ensure that physical and transition sources of risk are measured and managed appropriately. Regulatory involvement will play a role in focusing this attention.

**Recommendation 3.** Financial regulatory authorities to introduce a clear position and agenda on the environmental sources of risk.

**Recommendation 4.** Financial regulatory authorities to signal that environmental scenario analysis is a mainstream issue by adding priority environmental sources of risk into the risk register for prudential supervisory activities.

**Recommendation 5.** Financial regulatory authorities to supplement this with regular in-person Board-level roundtables to discuss recent developments.

The involvement of regulatory authorities is key to successful integration of scenario analysis. During our workshops and within our questionnaires we have solicited feedback from the financial market participants on the form this regulatory involvement should take. There is a debate in the industry about the benefits of self-regulation vs regulation vs a dual system. Some in the financial sector would prefer the regulators to issue new requirements, and others believe that the industry only requires an incentive to move towards a more effective environmental risk analysis. There is an argument that additional regulatory requirements carry unintended consequences. Further, often the issue is not the lack of legislation but rather the implementation and policing of existing regulations. The consensus is that the role of the regulator is at least to provide information, incentivise action and increase awareness, especially at the Board and senior management levels.

The introduction of questions on environmental sources of risk into the prudential regulatory conversations is a powerful way of incentivising action and increasing awareness by the financial market participants. This is the route taken by some leading regulatory authorities in this context. For example, the Netherlands has included environmental risks into the macro stability risk register, meaning that supervisors can ask financial firms a number of carbon risk-related questions in their supervision discussions (BOE et al., 2017). As environmental risk analysis is a new field, such discussions benefit both the financial firms in question and the regulatory authorities increasing the flow of information within the financial system.

Another way to incentivise action and increase awareness by the financial market participants is for the regulatory authority to develop a clear position on the relevance of environmental sources of risk to their respective regulatory mandate. This would decrease the risk of policy uncertainty and thereby reduce regulatory burden on financial firms. A good example of the current policy uncertainty is the introduction of the carbon tax. Although the proposal has been on the agenda for a number of years with a good coverage of GHG emissions (80 per cent), the specifics and the timeline of its implementation are as yet uncertain, meaning that most firms have not started preparing for it.

Finally, there are certain types of information which can only be provided by the regulatory authorities. Financial market participants would, for example, welcome publication of best practices on integration of environmental scenario analysis, criteria to be used for choosing particular tools and models to align with it, as well as regulatory updates on key environmental sources of risk relevant to the South African context. Regular Board-level discussions on these issues led by the regulatory authorities with the involvement of academic and other types of experts, if required, would increase awareness of environmental sources of risk among the Board and senior management.

**Recommendation 6.** Convene a multi-stakeholder group (including industry practitioners, regulators and academic experts) to create repository of existing risk data, scenarios and tools that industry could be using and provide recommendations that would address existing gaps, such as in the area of disclosure.

Building on the work done by the Sustainable Finance Working Group, such a working group would conduct the required consultation and construct a data, scenario and tool repository as well as advise on a disclosure framework that would be TCFD-compliant, relevant, reliable, meaningful, consistent, comparable and useful. This group could become an effective signalling mechanism of shared needs for new tools and disclosures.

Provision of data that is reliable, relevant to the South African national context, consistent and constantly updatable is essential to the integration of environmental scenario analysis. It is the issue mentioned the most in conversations with financial industry participants. Although, as demonstrated in the 'Data sources' section, there are a number of various publicly (and commercially) available datasets for environmental scenario analysis, in practice they are disparate, frequently not relevant to the South African context and suffer from lack of consistency. Here a broad set of risk data will be relevant as well as very specific data pertinent to the South African context and specific risks inherent in this context. The recommendation to create a single South African data repository builds on the work conducted by the G20 Green Finance Study Group's publicly available environmental data work stream (Jun et al., 2017). The key rationale for the creation of the data repository is the reduction of the search costs and thus elimination of a barrier to innovation in the area of environmental risk analysis.

The changing political and regulatory environment in South Africa has restricted the attention directed at physical and transition sources of risk. As detailed above there are concerns about the heavy reliance on the fossil fuel industries for the energy requirements of the country and the potential stranding risks that can develop. Further, within South Africa there is a heavy focus on the social issues, such as losses of jobs within the fossil fuel industries and the shift of those jobs to the renewable industries. A more detailed exploration of South Africa specific transition and physical scenarios would direct attention to environmental and social risks of the transition and help financial firms adapt standard climate scenarios to fit financial analysis needs. Provision of standardised reference scenarios can be constraining in terms of the development of proprietary bespoke environmental scenario analysis, therefore this process needs to be carefully managed.

Substantial and meaningful disclosure will increase the provision of information to the market, thus enabling more sophisticated risk analysis and risk management to take place. South Africa already has integrated reporting requirements with mandatory GHG reporting in certain cases. Further, larger players in the market already conduct voluntary disclosures according to existing frameworks, such as CDP and UN PRI. However, current disclosure requirements within South Africa are not seen as sufficient to address climate-related challenges.

TCFD is the most relevant global climate risk disclosure initiative. A recent report (CISL, 2018b) notes that the majority of G20 members are engaging with the TCFD recommendations in some form. Most of that engagement takes the shape of political and regulatory discussions, however some G20 members have progressed to setting up working groups with direct involvement of the private sector. Further, more and more organisations worldwide are subscribing to the TCFD framework for climate risk disclosures in mainstream financial filings. Existing disclosure initiatives, such as CDP (2017b) for example, are working on aligning their disclosure requirements to the TCFD recommendations. In this regard, it would be beneficial for a South African disclosure framework to be aligned with TCFD requirements.

Currently, there is a reluctance within the financial system to the introduction of a new disclosure framework. Rather discussions centre around consolidation and adaptation of already available disclosure frameworks into a single consistent framework, which after a trial period would become mandatory across the South African financial system. It is important that this framework is the result of an industry-wide consultation that addresses the concerns of financial market participants. Further, to be meaningful it needs to address fears that the market holds about how disclosed information would be used by the regulatory authorities. It would eliminate unnecessary duplication of reporting, thus decreasing the burden of reporting to disparate initiatives with disparate requirements. This disclosure framework would also eliminate first mover disadvantage.

Before we conclude, there is a particular challenge that was unexpected in our research. We could see some work on integrating environmental scenario analysis taking place in the banking and insurance sector, but substantially less work could be found in the investment management sector in South Africa. This is curious, not least because as demonstrated by a number of cases, globally quite a lot of work is being done to address these issues. Of course, this could be due to the selection of financial market participants that we have engaged with. Nevertheless, this is something to consider in future research in this area.

# Conclusion

Worldwide, the cost of 6°C global warming could lead to a present value loss of USD13.8 trillion. Locally, the slowdown of South Africa's 2015 GDP growth was driven by a severe drought (DEA, 2018). Against this backdrop, it is integral that South African financial firms and regulatory authorities take due account of material environmental sources of risk. However, there is a growing recognition that traditional approaches to incorporating environmental factors into risk management systems are insufficient in the face of the changing scale, likelihood and interconnectedness of environmental sources of risk (CISL, 2016). This calls for the use of environmental scenario analysis as a key tool to allow financial firms to analyse, measure and manage material sources of environmental risk. Putting environmental scenario analysis in practice would ensure that capital is appropriately allocated in support of financial stability and sustainable economic development that is consistent with the conservation and rational use of its natural capital and renewable energy resources.

South Africa is well on the way in this journey, however it needs to take further steps to enable its financial firms and regulatory authorities to incorporate new areas of knowledge (from drought risk to the energy transition) and methodologies (such as environmental scenario analysis) into their daily financial decision-making in such a way that confidence can be built and better decisions made.

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