



Embedding environmental scenario analysis

into routine financial
decision-making
in México

October 2018

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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. México, in particular, has demonstrated leadership in working to build and finance a climate-resilient economy.

As early as the 1990s it had set up a fund for natural disasters, FONDEN, as a mechanism to support the rapid rehabilitation of federal and state infrastructure as well as people affected by adverse natural events (World Bank, 2012). México was the first emerging country to submit its climate action plan ahead of the 2015 Paris Agreement. Banco de México is among eight central banks and supervisors, who established a Network of Central Banks and Supervisors for Greening the Financial System (NGFS) in December 2017. Accordingly, México'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 México, 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 Instituto Tecnológico Autónomo de México (ITAM) and Banco de México on a project to promote the integration of environmental scenario analysis into practice in financial decision-making. A parallel project was carried out in South Africa in co-operation with the South African National Treasury. 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 CISL 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 markets participants in México. Based on a variety of sources, the priority physical sources of risk in México are of a climatic, geologic 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 five would include geologic sources of risk, namely earthquakes; climatic sources of risk, namely windstorms, droughts and global warming; as well as ecosystem sources of risk, namely air pollution. Mexican stakeholders were aware of a number of physical sources of risk that could be material in their financial decision-making. Two physical sources attracting the most concern are the warming of the climate and impact of earthquakes on financial assets.

There are two interconnected issues that underline transition sources of risk within the Mexican economy. The first one is that the regulatory framework that would motivate companies to develop, implement and finance technologies that can reduce carbon emissions is insufficiently developed. The national development plan needs to take a more comprehensive approach for consideration of the transition to a low carbon economy. The second one is the difficulties in compliance with and enforcement of existing regulations. In particular, policy risks and uncertainty regarding the sticking power of policy objectives complicate the transition (Holmes, Orozco, & Paniagua Borrego, 2017).

Information on the incorporation of environmental risk analysis practices in the Mexican financial system is scarce. One source of information is the UNEP FI 2012 survey of Latin American Financial Institutions, covering 85 institutions, of which 14 were from México (UNEP Finance Initiative, 2012). A vast majority, 89 per cent, of surveyed institutions claim to have a sustainability strategy in place; however, only 53 per cent confirmed including environmental and social aspects in their risk assessment methodologies. A recent Ecobanking report surveyed 80 financial institutions, of which 51 per cent were in Central America and México (Ecobanking, 2016). Although 84 per cent confirmed looking into environmental and social risks of their portfolio, only 54 per cent had implemented a formal social and environmental risk analysis system, with mixed levels of monitoring taking place. Still, there was no mention of the use of scenarios in environmental risk assessment methodologies in either of the surveys.

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, the report elucidates the main challenges faced by the Mexican 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.

One of the major challenges in the introduction of environmental scenario analysis within the financial sector in México is the lack of awareness of environmental sources of risks and tools required to assess and manage them. Within the financial sector there is a lack of understanding that environmental sources of risk are material for business and therefore absence of sponsorship at the senior level. This means that, inevitably, financial risk managers are not familiar with sustainability concepts and, sustainability risk managers are just starting to familiarise themselves with basic components of risk analysis and management.

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.

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. Environmental authorities and the National Statistics Institute (INEGI) to proactively disclose environmental sources of risk data relevant and material for the financial system.

Recommendation 4. Financial regulators to develop, through the work of a high-level advisory group on sustainable finance, a deeper understanding of environmental sources of risk for the financial sector. Based on this understanding, regulators to introduce a clear position and agenda on environmental sources of risk.

Recommendation 5. Financial regulators to signal that environmental scenario analysis is a mainstream issue by adding priority environmental sources of risk to the country into the risk register for prudential supervisory activities.

Recommendation 6. Financial regulators to supplement this with regular in-person Board-level roundtables to discuss recent developments.

One route to addressing the lack of attention to environmental sources of risk within the financial sector is via the involvement of regulatory authorities. Such involvement is key to successful integration of scenario analysis within mainstream financial decision-making. 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 markets participants is for the regulatory authority to develop a clear position on the relevance of environmental sources of risk to their respective regulatory mandate. 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 for Mexican 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.

As this study shows, Mexican environmental authorities have produced a series of data on environmental risks that is relevant and useful for financial institutions. Nonetheless, this data still seems to be unknown or not relevant to financial institutions. A more proactive approach on the part of environmental authorities and the National Statistics Institute to make the information available and applicable to financial institutions, as well as to participate in multidisciplinary discussions with the financial industry on the subject of environmental opportunities would be welcome. México's forthcoming 6th Assessment report at the Intergovernmental Panel on Climate Change (IPCC) offers a good opportunity for this type of dialogue.

Recommendation 7. Convene a multi-stakeholder group (including industry practitioners, financial and environmental regulators and academic experts) to foster dialogue about environmental scenario analysis, construct a roadmap to implementation and explore creating a repository of risk data, scenarios and tools for environmental risk analysis.

Further challenges to the introduction of environmental scenario analysis are the lack of consistent data, unfamiliarity with climate scenarios and absence of mainstream tools needed to measure and manage the financial risks stemming from environmental sources of risk. Setting out a strategic framework for environmental risk analysis in México requires the introduction of a clear national position and agenda on the environmental sources of risk and sustainable finance more broadly. In order to achieve this, a number of G20 countries have introduced sustainable finance working groups, which include a combination of regulators, industry professionals and academics.

In México, this working group could build on the work of the Consultative Committee on Green Finance, which already brings industry professionals together in the area of green finance. The working group could look into harmonising definitions and guidelines for assessing environmental risk, as well as understanding whether there is a need for additional regulatory requirements for environmental risk analysis and management. It would also conduct the required consultation and construct a data, scenario and tool repository for environmental risk management. Finally, it could advise on a disclosure framework that would be Task Force on Climate-related Financial Disclosures (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.

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. TCFD is the most relevant global climate risk disclosure initiative. 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 Mexican financial system.

Worldwide, the cost of 6°C global warming could lead to a present value loss of USD3.8 trillion. In México, the average annual cost of natural disasters has been rising steeply (National Risk Atlas, 2018). Against this backdrop, it is vital that Mexican 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. México has already embarked on this journey, however it should 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) in 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 five years, environmental sources of risk have been becoming more prominent on the global agenda. 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).

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. The average annual cost of natural disasters (cyclones, floods and storms) has been rising steeply in México, from 9.73 billion pesos over 2000–05 to 23.63 billion pesos over 2010–15 (National Risk Atlas, 2018). According to the Organisation for Economic Co-operation and Development (OECD) the cost of air pollution in México amounts to 2.9 per cent of GDP (Roy & Braathen, 2017). Further, if not managed, transition to a low carbon future can create financial risks. For instance, the 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. México, in particular, has demonstrated leadership in working to build and finance a climate-resilient economy. As early as the 1990s, it had set up a fund for natural disasters, FONDEN, as a mechanism to support victims and the rapid rehabilitation of federal and state infrastructure affected by adverse natural events (World Bank, 2012). México was the first emerging country to submit its climate action plan ahead of the 2015 Paris Agreement. Banco de México is among eight central banks and supervisors, who established a Network of Central Banks and Supervisors for Greening the Financial System (NGFS) in December 2017.

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 México 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 Instituto Tecnológico Autónomo de México (ITAM) and Banco de México on a project to promote the integration of environmental scenario analysis into practice in financial decision-making. In particular, ITAM has acted as a source of local knowledge, facilitated the workshops as well as provided valuable input into and commentary on the report. Banco de México support of the project has been invaluable in bringing the industry on board. A parallel project was carried out in South Africa in co-operation with the South African National Treasury. 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 Mexico 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 sector.

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 Mexico and 20 in South Africa). The workshops were followed by a number of bilateral meetings in South Africa and Mexico 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 Mexico 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 US\$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 TCFD (2017b) scenarios should be plausible, distinctive, consistent, relevant and challenging. 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 (2017) 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 potential range of impacts from physical and transition sources of risk, as well as assist investors, policy makers, 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).

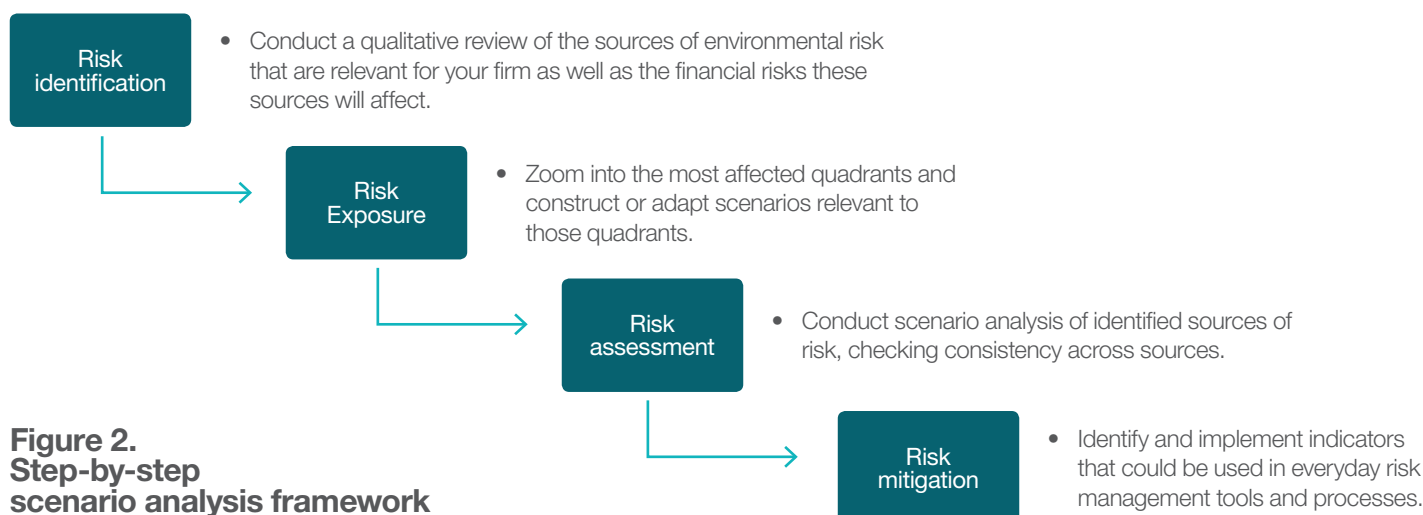


Figure 2.
Step-by-step
scenario analysis framework

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 México, first it will address the national financial and regulatory background, as well as priority sources of financial risk.



Environmental sources of risk and the Mexican financial system

México has demonstrated leadership in working to build and finance a climate-resilient economy, however robust integration of environmental scenario analysis into routine decision-making is required.

In its 2016 report, the International Monetary Fund highlighted key risks to México's financial system. It states that key risks were "external and include a United States (U.S.) growth slowdown, lower oil prices, and volatility in global financial markets" (IMF, 2016). Volatility in the global financial markets is increasingly being discussed through a lens of environmental risk as Environmental, Social and Governance (ESG) concerns and climate-related risks rise to the top of the list of risks facing the global financial system.

Public information on the incorporation of environmental risk analysis practices in the Mexican financial system is still scarce. One source of information is the UNEP FI 2012 survey of Latin American Financial Institutions, covering 85 institutions in 19 countries, of which 14 were from México (UNEP Finance Initiative, 2012). A vast majority, 89 per cent, of surveyed institutions claim to have a sustainability strategy in place; however, only 53 per cent confirmed including environmental and social aspects in their risk assessment methodologies. The focus of the sustainability strategy was rather on the organisational supply chain and ecoefficiency strategies. Lack of understanding of the subject is the main obstacle to integrate sustainability in their institutional strategy and to implement environmental risk analysis methodologies, according to 78 per cent of institutions. Training of staff is implemented in 78 per cent of respondent institutions, covering mainly environmental risk analysis methodologies, internal ecoefficiency and product innovation for sustainable development. At the time of the survey, only 31 per cent of respondents had signed the Equator Principles. There was no mention of the use of scenarios in their environmental risk assessment methodologies.

In 2016, Ecobanking published a more recent survey and a sustainability performance index for financial firms (Ecobanking, 2016). The survey analysed governance structures, operational and risk analysis strategies, social responsibility approaches and sustainability reports. The report surveyed 80 financial institutions

(private banks, development banks and some unregulated institutions), of which 51 per cent were in Central America and México. Three quarters of surveyed institutions claimed to have a social and environment policy in place. Although 84 per cent confirmed looking into environmental and social risks of their portfolio, only 54 per cent had implemented a formal social and environmental risk analysis system, with mixed levels of monitoring taking place. Finally, 57 per cent of the surveyed institutions had in place specific financial products for social and environmental investments.

In the last two years several development banks have implemented or committed to introduce an 'Environmental and Social Risk Management System' (ESRMS) based on the Equator Principles developed by Findeter, a Colombian development bank, with help from Inter-American Development Bank in 2015 (Findeter, 2015). ESRMS blends with the traditional credit granting processes of banks so that banks' additional cost of these processes is reduced. ESRMS allows the identification of potential environmental and social risks during the credit evaluation process and leads to risk mitigation actions. In doing so, development banks have been quickly reacting to soft but clear signals on the part of financial authorities, increasing awareness of physical and transition risks as well as the demands by multilateral financial institutions that frequently require development banks to have in place methodologies to identify, assess and mitigate environment and social risks.

For Mexican institutional investors, environmental and social risk analysis is also increasingly relevant. The UN Sustainable Development Goals (2015) and the Paris Accord on Climate Change (Paris Agreement on Climate Change, 2015) have raised awareness of environmental and social risks, and spurred the adoption of ESG risk analysis and even a discussion of changes to fiduciary duties.

National strategies and policies

The National Development Plan (NDP), presented by the federal government, set out criteria for state and municipal planning. For the first time, the 2007–12 NDP explicitly covered climate change among an environmental sustainability axis (México, 2012).

In 2012, México was the second country in the world to introduce a Climate Change Law, which paved the way for the introduction of a Carbon Tax in 2014. The Energy Transition Law sets out a policy framework for achieving energy system transformation (Holmes et al., 2017). The Energy Transition Law mandated that the minimum share of clean energy in electricity generation should be 25 per cent by 2018, 30 per cent by 2021 and 35 per cent by 2024 (Holmes et al., 2017).

México's Carbon Tax covers just 40 per cent of greenhouse gas (GHG) emissions (low compared to other early adopters, such as Chile at 55 per cent, South Africa at 80 per cent and Japan at 70 per cent) and the price is USD3.50/tonne of CO₂ which makes it

the lowest of all adopters. Nonetheless, that México is among the 15 early adopters is a significant sign of its level of awareness and integration of the transition risks posed by climate change to the financial system (Farid et al., 2016).

Similarly, both the Ejercicio de Mercado de Carbono (EMC) and MÉXICO2 contribute to reducing climate-related transition risk by ensuring that companies are familiar with and beginning to trade carbon credits (Altamirano & Martinez, 2017). The EMC is an exercise in a carbon market simulation (no real emissions will be traded) to help companies get familiar with the way carbon trading works, while MÉXICO2 is a voluntary exchange that provides carbon credits to companies that develop environmentally friendly projects in the country. The Advisory Council for Sustainable Finance, led by MÉXICO2, was formalised in 2016, and is responsible for the annual Sustainable Finance summit.

Regulatory bodies

The Mexican financial system has undergone significant changes over the past three decades. México nationalised its banking system in 1982, privatised it in 1992, and permitted majority foreign investment in 1994 (IFLR, 2005).

The Mexican Central Bank and National Banking and Securities Commission were established in 1925 and 1924 respectively. The National Bank and Securities Commission is a long-standing, decentralised agency of the Ministry of Finance and Public Credit created in 1924, which oversees inspections of financial intermediaries, the issuance of general accounting principles, and prudential regulation like credit and risk management procedures. The Institute for the Protection of Bank Savings was only created in 1999 to provide security for banking depositors. These measures will lessen injury in the event that environmental risks catalyse an impact on the financial system, but they do not mitigate environmental risks.

Despite an active regulatory environment, none of the Financial Sector Assessments (2001–06) or Financial System Reports (2006–16) made publicly available by the Banco de México contain any reference to environmental or climate-related risks (Banxico, 2017). This suggests that significant structural blind spots may exist regarding environmental risk for the Mexican Financial System despite ad hoc advancements outlined in the next section.

As early as 2006, México became the first transition country to transfer part of its public sector natural catastrophe risk to the international reinsurance and capital markets (Cardenas, Hochrainer, Mechler, Pflug, & Linnerooth-Bayer, 2007).

National level mechanisms

Central Bank and the Securities and Exchange Commission (CNBV) have implemented stress tests on the Mexican financial system. To date the officially implemented tests have lacked broad incorporation of environmental risks and their potential impact on the balance sheets of institutions.

As early as 2006, México became the first transition country to transfer part of its public sector natural catastrophe risk to the international reinsurance and capital markets (Cardenas, Hochrainer, Mechler, Pflug, & Linnerooth-Bayer, 2007). The Mexican government, in collaboration with the academic community, made use of the International Institute for Applied Systems Analysis (IIASA) catastrophe simulation model (CATSIM). By modifying a range of assumptions, the government was able to test various options available to them. México's subsequent purchase of a mix of reinsurance and catastrophe bonds demonstrates the sovereign's capacities to assess and implement national risk management measures.

Subsequently in 2007, México hosted an Environmental and Social Risk Analysis training for the Latin America region. The training workshop sought to assist financial analysts to identify and assess environmental and social risk in credit lending and investment. Academics from CLACDS/INCAE Business School provided methodologies for identification, evaluation and management of environmental and social risks. Finally, the Banco Nacional de Obras y Servicios Públicos (BANOBRAS) provided an overview of their environmental and social risk management processes. A second round of advanced environmental and social risk training was undertaken in 2011.

"We feel proud to be the first green bank of México and join a community of over 200 institutions and three dozen members in Latin America with one common interest: to identify the best sustainable practices for financial operations," said CIBanco's Chairman of the Board of Directors, Jorge Rangel de Alba, as México's flagship green bank entered the UNEP FI community in mid-March by signing the UNEP FI Statement on Sustainable Development.

In January 2015, new regulations for compliance with Pillar II of Basel II requirements included the recommendation for financial institutions to develop scenarios that are specific to their operations. This recommendation is not mandatory and most banks continue to use standard scenarios, which do not consider environmental risks. However, as trainings such as the environmental and social trainings outlined above become more widely appreciated and familiar to the Mexican financial system, a greater uptake of scenario analysis that includes environmental risk for the organisation's specific operations relevant to the Basel II requirements is likely.

In January 2018, the government announced a change in regulations for pension funds, which increased the limits for equity investments, defined more flexibility and discretion of pension funds on investment decisions, and included a new requirement to implement environmental and social governance criteria for investments. Also, a specific requirement to assess potential exposure to natural disasters of potential investments was defined (CONSAR, 2018).

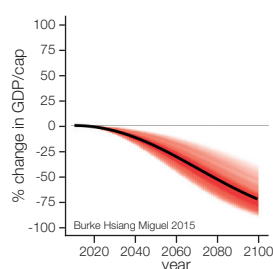
In summary, México has demonstrated leadership in working to build and finance a climate-resilient economy. It was the first emerging country to submit its climate action plan ahead of the 2015 Paris Agreement. Its financial system regulation and regulatory bodies continue to implement improvements, it has adopted a carbon tax and a policy framework for achieving the energy transition, and was an early participant in several high-level environmental and social risk assessment measures. Despite these positive attributes, as is the case in many developed and emerging countries, México's financial system lacks robust integration of environmental risk management measures.

México has demonstrated leadership in working to build and finance a climate-resilient economy. It was the first emerging country to submit its climate action plan ahead of the 2015 Paris Agreement.

Priority environmental risks for México

Physical sources of risk

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 México'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 with a 90 per cent probability more than 50 per cent of GDP will be lost due to climate change in México by 2100.



The National Institute of Statistics and Geography (INEGI) has estimated the costs for the depletion of natural resources and environmental degradation to be equivalent to 4.6 per cent of the Mexican GDP in 2016 (INEGI, 2018). As seen in Table 1, the majority of these come from air pollution.

Type of cost	Percentage
Natural resource depletion	13.6
Hydrocarbons	8.5
Forestry	1.3
Groundwater	3.9
Environmental degradation	86.4
Air pollution	64.5
Water pollution	4.9
Solid waste	7.1
Soil degradation	9.8

Table 1.
Costs of depletion of natural resources and environmental pollution (INEGI, 2018)

According to Comisión Económica para América Latina (CEPAL), México is vulnerable to a variety of natural disasters (Schroeder & Cabrera, 2007).

According to Comisión Económica para América Latina (CEPAL), México is vulnerable to a variety of natural disasters (Schroeder & Cabrera, 2007). Among them are earthquakes, hurricanes, volcanic eruptions, floods, etc. CEPAL identifies earthquakes as a priority physical source of risk (Schroeder & Cabrera, 2007). México identified specific environmental vulnerabilities in its First and Second Communication, NC1/NC2 to the United Nations Framework Convention on Climate Change (UNFCCC). Many of these are irreversible. These impacts include continuous increase in the sea surface temperature of the Gulf of México, continuous sea level increase affecting coastal areas in inland basins, intensification of hurricanes, changes in water precipitation cycles, net decreases in water run-offs and others (GSP, 2017). Particularly fragile to climate impacts are water resources, forestry, agriculture, coastal zones and specific wetlands. Drought and desertification also pose risks for the country. Based on impact, the two priority physical sources of risk identified in the NC5 (México, 2012) are droughts and tropical cyclones. In 2011, the drought caused losses greater than 15 billion pesos. Further, the lack of water affected more than 2,350 communities, with approximately 2 million inhabitants in total (México, 2012).

Tourism, an important economic sector for México (9 per cent of the GDP in 2016), is also at risk from environmental factors (Recaséns,

2014; USAID, 2017a), and managing environmental risk as well as maintaining and improving the natural attractions of the country will be crucial to maintaining its tourism revenue base. Marine ecosystems are at risk of climate change, poor management and recent oil spills. Moreover, the tourism industry faces knock-on effects from any decarbonisation transition the aviation industry will face.

With regard to agriculture, extreme temperatures and erratic rainfall will have major impacts on agricultural productivity, for both crops and livestock. Agriculture has accounted for 80 per cent of weather-related financial losses in the country since 1990 (SAGARPA & Organización de las Naciones Unidas Para la Alimentación y la Agricultura, 2014; USAID, 2017a).

México's exposure to climate and other environmental impacts is not evenly spread throughout the country. Monterroso and Conde (2015) find that northern states are affected by a higher recurrence of environmental risks, mainly climatic, such as droughts and frosts. The southeast is the region where heavy rains and floods occur. The central and western states have a lower recurrence of two or more extreme events, although the severity of past events has been significant.

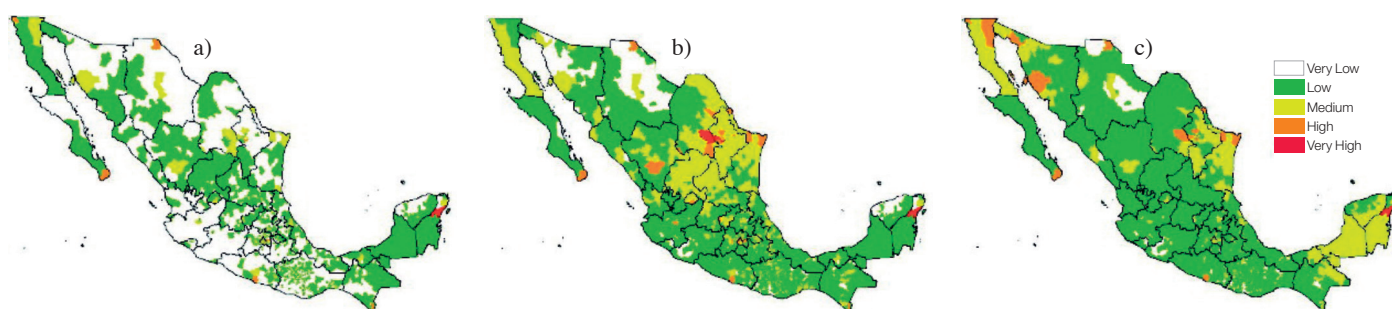


Figure 3.
Climate hazard exposure classes (Monterroso & Conde, 2015)

Climate-resilient infrastructure is particularly critical to México given that 71 per cent of its economy is vulnerable to climate-related disasters (World Bank, 2017). Ageing transportation, power and water infrastructure in coastal areas is vulnerable to flooding and strong winds associated with hurricanes. Impacts on basic infrastructure have knock-on effects for a majority of industries including transportation lines, manufacturing and agriculture.

Based on this overview, the priority physical sources of risk in México are of a climatic and geologic nature. It was not within the scope of this analysis to range these in terms of their probability and impact, however the top five would include geologic sources of risk, namely earthquakes; climatic sources of risk, namely windstorms, droughts and climate warming; as well as ecosystem sources of risk, namely air pollution.

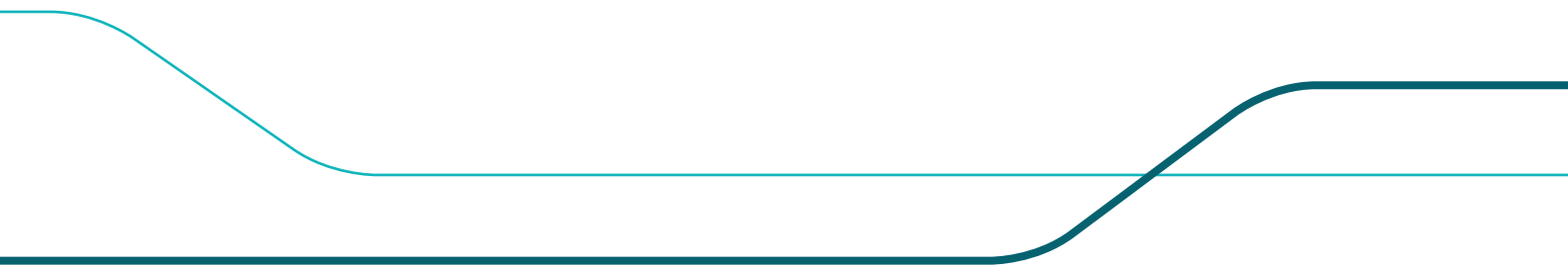
Transition sources of risk

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). The paper does not provide details for México, however it does approximate GDP loss for Latin American countries (not including Brazil) to be USD300 billion (under the 10 per cent discounting assumption with a time horizon of 2035). This underlines the point that vulnerability to transition sources of risk could be derived from developments in other markets that are significant trading partners of México, for example the USA.

In the stakeholder workshop held in April 2018 in México City, and in the bilateral conversations, participants were aware of a number of physical sources of risk that could be material in their financial decision-making. Two physical sources of risk attracting the most concern are climatic (overall rise in temperature) and geologic (impact of earthquakes on financial assets). Given that hydropower is the largest renewable energy source in México, which accounts for 17 per cent of total installed capacity (IHA, 2018), increased occurrence of earthquakes may present a material source of risk to the energy supply. Other climatic sources of risk, such as windstorms, flooding, drought, water scarcity and fires followed closely behind. There was also awareness of the ecosystem sources of risk such as air and water pollution, and disruption of the ecosystem as a whole. Some of these perils amplify each other, for example hurricanes are often followed by floods.

To facilitate a transition to a low carbon economy, as part of its Nationally Determined Contributions to the Paris Agreement, México has made a pledge to reduce its greenhouse gas emissions by 22 per cent by 2030, with an additional target of 36 per cent reduction contingent on a global carbon price agreement, access to finance and technology transfer (Holmes et al., 2017). Estimates of costs required to meet nationally determined contributions vary. The National Institute of Ecology and Climate Change (INECC) estimates costs to be USD126 billion between 2016 and 2030 (INECC, 2018b), while International Finance Corporation (IFC) argues that the estimate will be closer to USD791 billion for the same period. Different modelling and scenarios lead to the huge gap, however both estimate that the power sector accounts for half of the total costs (Holmes et al., 2017).

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).



Based on this overview, the top five priority physical sources of risk would include geologic sources of risk, namely earthquakes; climatic sources of risk, namely windstorms, droughts and climate warming; as well as ecosystem sources of risk, namely air pollution.

In its current form, the national energy mix in México is not conducive to a managed transition. The energy sector accounts for 70 per cent of total GHG emissions (USAID, 2017b). Decarbonisation of the power sector is also essential to deliver low carbon strategies in other sectors, notably transport. A key transition risk is the structure of automobile production, which is currently heavily based on fossil fuels. As above, reorientation of the industry towards renewable sources will require re-skilling of the labour force and may result in higher unemployment among certain types of workers. One particular leverage point here is the possibility of quickly changing consumer/public attitudes towards the level of acceptable air quality standards.

Further, it is uncertain whether México can achieve its commitments in either emission reduction or clean energy. INECC has recommended particular mitigation routes for each sector (INECC, 2018b). However, a recent study by WWF (2017) argues that México is three years behind achieving its goals as the electricity sector has yet to show a sharp reduction in emissions, and it is unlikely that the closure of virtually all conventional thermal power plants will be achieved by 2019 and 2020.

There are two interconnected issues that underline transition sources of risk within the Mexican economy. The first one is that the regulatory framework that would motivate companies to develop, implement and finance technologies that can reduce carbon emissions is insufficiently developed. Of all the GHG emission sources (transport, electricity generation, commercial, oil and gas, industry, agriculture and cattle raising, land use change and urban waste) only electricity generation has a solid institutional and policy framework to mitigate GHG emissions. The national development plan needs to take a more comprehensive approach for consideration of the transition to a low carbon economy. One way forward here is the introduction of an environmental risk disclosure framework, which would provide incentives for firms to understand and manage these risks.

The second one is the difficulties in compliance with and enforcement of existing regulations. This is underlined by Holmes et al. (2017) analysis, which argues that policy risks and uncertainty regarding the sticking power of policy objectives complicate the transition. They add that lack of operational data and historical precedents for low carbon projects, lack of familiarity with innovative technologies and environmental risk management measures as well as limited expertise and ability to appropriately price environmental risk are the key transition risks facing the implementation of environmental risk management and the introduction of low carbon policies in México (Holmes et al., 2017).

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) 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

Physical asset-level data is the environmental information on physical assets, such as GHG, wastewater or other types of emissions. One classification (2dii, 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.

(Jun, Henderson, Gilbert, & Lin, 2017). Once operational, it is hoped that the climate vulnerability atlas will provide some valuable data sources for México (INECC, 2018a).

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 organizations (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 Intergovernmental Panel on Climate Change (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). In México, it would be particularly important to look at the impact of 3.5–5°C scenarios as well as a 2°C as these are the global warming bounds of the fifth IPCC assessment on Central America/México (IPCC, 2014).

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 (Stocker et al., 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 México, as highlighted by the literature and by our discussions, is water availability. Large regions in México face water stress. However, as a whole, in terms of hydrological complexity, México is on the border between water stress and water security (Fischer, Hizsnyik, Tramberend, & Wiberg, 2015). A helpful resource for enabling financial firms in analysing and managing water risks is Tramberend et al. (2015) overview of global water scenarios. Given the importance of agriculture in the Mexican economy, there is a particular need for development of agricultural scenarios that address climate risks. There is also a lack of more generic commodity scenarios for market risk purposes.

Another source of risk is of a geological nature, namely earthquakes. Here the work, conducted by CEPAL (Schroeder & Cabrera, 2007) on understanding various physical sources of risk can be helpful. In their analysis they provide a scenario of a large earthquake with the epicentre off the coast of Guerrero. The scenario closely resembles the earthquake that took place in September 2018. The comparison of the scenario suggested by CEPAL with the actual historical event might provide an informative picture in understanding the impact and financial risks of an earthquake of that magnitude.

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 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.

In México the overwhelming preference expressed during conversations is for the use of standardised scenarios, or at the very least start with the use of standardised scenarios and then once expertise develops progress towards bespoke scenarios. This could be because financial firms do not yet have technical capabilities to build bespoke scenarios. The caveat, however, is that development of standardised scenarios is closely aligned with the local and industry context and is a result of consultation with the financial industry.

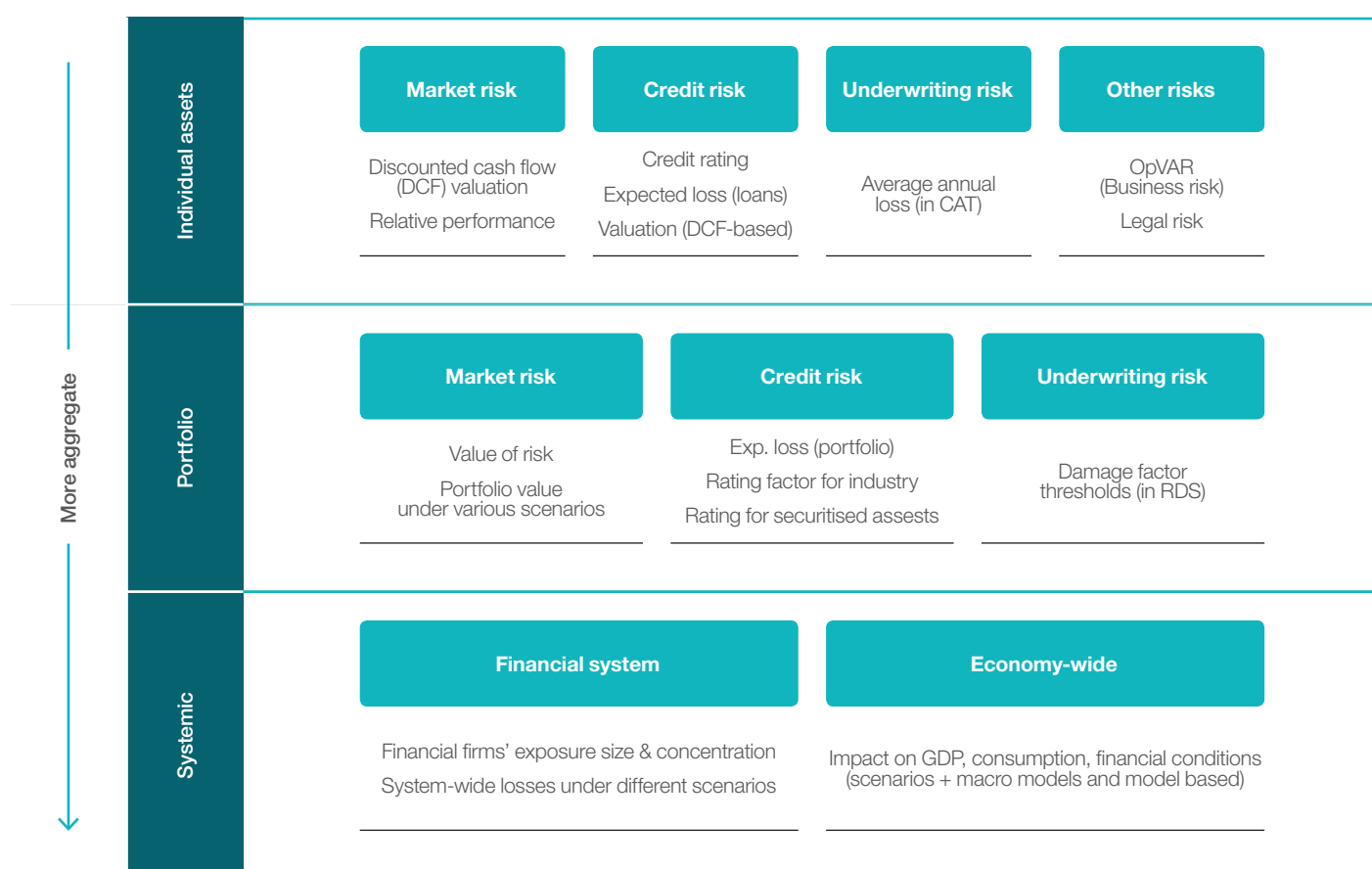


Figure 4.
Categorisation of environmental risk tools (BOE et al., 2017)

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 below (please see Figure 4).

The awareness about the types of tools that can be used to perform or to align with environmental scenario analysis is growing in México. Discussions at the workshops and in bilateral meetings revealed some examples of tools that are seen as useful in the Mexican context. These vary depending on the source of environmental risk and the type of financial risk. The use of Equator principles and IFC methodology for screening for environmental impacts is prevalent among larger institutions. In our conversations, it emerged that one pension fund is using the climateXcellence model, as well as integrated assessment models. Several development banks and some commercial banks have been adopting ESRMS. In terms of physical sources of risk, a number of firms are using data and models from the National Autonomous University of México (UNAM) developed earthquake database (UNAM, 2018).

Within México, interesting work is being done on the 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 physical sources of risk, such as windstorms, on the tourism industry. However, the availability of insurance on the portfolios presents a moral hazard, as although financiers recognise that prices and availability cannot be guaranteed, there is an assumption that the insurance industry will take the impact of any physical sources of risk. There is also some interesting work ongoing on the incorporation of environmental risk assessments into banking credit risk assessment processes. One institution in particular is developing a tool that will help credit officers assess environmental impacts according to geographies.

In August 2018, the INECC launched the Atlas of vulnerability to climate change, a tool that will map the risk areas, segmenting impacts on population, infrastructure, productive activities and natural capital. This is a dynamic tool that will allow local governments and society in general to assess the vulnerability to climate change of specific territories (georeferenced). The platform was expected to be operational in September 2018. INECC provides an example of the platform (INECC, 2018a).

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 Mexican financial institutions to build on when constructing their own environmental scenario analyses.

In order to demonstrate some examples of leading practice of environmental scenario analysis being conducted around the world, nine cases are presented. The purpose of these is to provide a useful platform for Mexican 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 sector	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 2. 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 Mexican context. 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. The authors were not able to find a case of a financial firm looking at the impact of an earthquake, however here some work

by CEPAL (Schroeder & Cabrera, 2007) and UNAM (2018) might be instructive. More specifically, CEPAL (Schroeder and Cabrera, 2007) provides a scenario of a large earthquake with the epicentre off the coast of Guerrero. The scenario closely resembles the earthquake that took place in September 2018. The comparison of the scenario suggested by CEPAL with the actual historical event might provide an informative picture in understanding the impact and financial risks of an earthquake of that magnitude. The UNAM (2018) earthquake database could be helpful in this endeavour.

Case 1.

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

Organisation:	Kepler Cheuvreux and The CO-Firm
Sector:	Investment management
Environmental source of risk:	Transition: policy and technology
Financial risk:	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 CO2 emissions, the introduction of CO2 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)

Organisation:	Barclays as part of 16-bank UNEP Finance initiative on TCFD disclosures
Sector:	Banking
Environmental source of risk:	Transition: policy and technology
Financial risk:	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.

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

Case 3.

Navigating the transition framework (CISL, 2018a)

Organisation:	ClimateWise Insurance Council
Sector:	Insurance
Environmental source of risk:	Transition: policy and technology
Financial risk:	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)

Organisation:	ClientEarth
Sector:	Financial – relevant to directors and audit companies
Environmental source of risk:	Transition: policy, technology and sentiment
Financial risk:	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)

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

Organisation:	CICERO Climate Finance
Sector:	Investment management
Environmental source of risk:	Physical: climatic, geologic, ecosystem
Financial risk:	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.

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.

Case 7.

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

Organisation:	AXA
Sector:	Insurance and investment management
Environmental source of risk:	Physical: climatic
Financial risk:	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)

Organisations:	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
Sector:	Banking
Environmental source of risk:	Physical risk: climatic
Financial risk:	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 environmental, social and governance 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.

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.

Case 9.

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

Organisation:	Itaú Unibanco as part of a 16-bank UNEP Finance initiative on TCFD disclosures
Sector:	Banking
Environmental source of risk:	Physical: climatic
Financial risk:	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 socioenvironmental 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 Mexican 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.

One of the challenges in the introduction of environmental scenario analysis within the financial sector in México is the lack of awareness of environmental sources of risk and tools required to assess and manage them. Within the financial sector there is a lack of understanding that environmental sources of risk are material for business and therefore absence of sponsorship at the senior level. This means that, inevitably, financial risk managers are not familiar with sustainability concepts, and sustainability risk managers are just starting to familiarise themselves with basic components of risk analysis and management. To address this challenge a programme of raising awareness and building capacity on environmental risk analysis is required. Given that the financial sector serves as an intermediary to the corporate world, building the capacity among the financiers will allow them to spread the expertise to their corporate clients, therefore raising the level of awareness and capabilities of the economy as a whole.

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 either 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 México. In terms of physical sources of risk, these include climate warming, earthquakes, windstorms, flooding, drought, water scarcity, and water and air pollution. In terms of transition sources of risk, these include particular challenges México faces in the 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. Environmental authorities and the National Statistics Institute (INEGI) to proactively disclose environmental sources of risk data relevant and material for the financial system.

Recommendation 4. Financial regulators to develop, through the work of a high-level advisory group on sustainable finance, a deeper understanding of environmental sources of risk for the financial sector. Based on this understanding, regulators to introduce a clear position and agenda on environmental sources of risk.

Recommendation 5. Financial regulators to signal that environmental scenario analysis is a mainstream issue by adding priority environmental sources of risk to the country into the risk register for prudential supervisory activities.

Recommendation 6. Financial regulators to supplement this with regular in-person Board-level roundtables to discuss recent developments.

One route to addressing the lack of attention to environmental sources of risk within the financial sector is via the involvement of regulatory authorities. The involvement of regulatory authorities is key to successful integration of scenario analysis within mainstream financial decision-making. During our workshops and within our questionnaires we have solicited feedback from the financial markets 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 markets 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. In the absence of a clear regulatory mandate, financial firms may postpone investment in capacity building in the area of environmental risk analysis. One clear example here is the current policy uncertainty around the introduction of the carbon tax in South Africa. Although the proposal has been on the agenda for a number of years, 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 that can only be provided by the regulatory authorities. Financial market participants would, for example, welcome the 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 Mexican 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 7. Convene a multi-stakeholder group (including industry practitioners, financial and environmental regulators and academic experts) to foster dialogue about environmental scenario analysis, construct a roadmap to implementation and explore creating a repository of risk data, scenarios and tools for environmental risk analysis.

Further challenges to the introduction of environmental scenario analysis are the lack of consistent data, unfamiliarity with climate scenarios and absence of mainstream tools needed to measure and manage the financial risks stemming from environmental sources of risk. Setting out a strategic framework for environmental risk analysis in México requires the introduction of a clear national position and agenda on the environmental sources of risk and sustainable finance more broadly. In order to achieve this, a number of G20 countries have introduced sustainable finance working groups, which include a combination of regulators, industry professionals and academics.

In México, this working group could build on the work of the Consultative Committee on Green Finance, which already brings industry professionals together in the area of green finance. The working group would include industry practitioners, financial and environmental regulators and academic experts. The working group could look into harmonising definitions and guidelines for assessing environmental risk, as well as understanding whether there is a need for additional regulatory requirements for environmental risk analysis and management. It would also foster dialogue between environmental data suppliers and environmental data users in the financial sector aimed at creating a repository of existing risk data, scenarios and tools for environmental risk management. Finally, it could 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 provision of data that is reliable, relevant to the Mexican 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 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 Mexican 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 Mexican context and specific risks inherent in this context. The recommendation to create a single Mexican 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.

A more detailed exploration of México 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. In México, the largest players in the market already conduct voluntary disclosures according to existing frameworks, such as CDP and UN PRI. However, current disclosure requirements within México 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 (2017) for example, are working on aligning their disclosure requirements to the TCFD recommendations. In this regard, it would be beneficial for a Mexican 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 Mexican financial system. There was a strong preference for a mandatory framework during the workshops and bilateral discussions, as the participants did not see the experience of introducing a voluntary framework of ESG analysis and disclosure for pension funds to be particularly successful. 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.

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 México. 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. In México, the average annual cost of natural disasters has been rising steeply (National Risk Atlas, 2018). Against this backdrop, it is integral that Mexican 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.

México has already embarked on 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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