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European Bank
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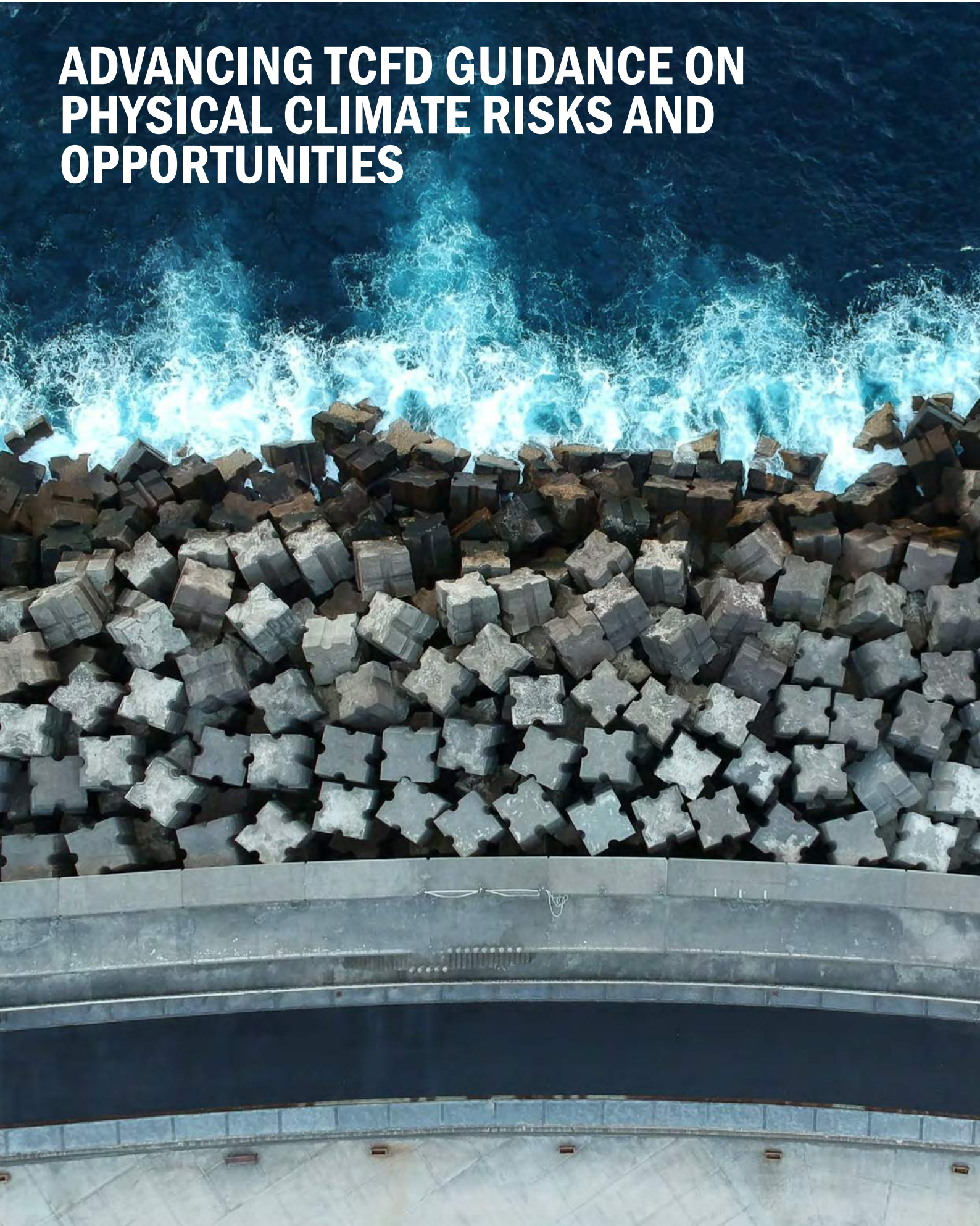
Global Centre of Excellence on
Climate
Adaptation

ADVANCING TCFD GUIDANCE ON PHYSICAL CLIMATE RISKS AND OPPORTUNITIES



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Lead authors: Emilie Mazzacurati (emazzacurati@427mt.com), John Firth (j.firth@acclimatise.uk.com) and Sara Venturini (s.venturini@acclimatise.uk.com).

Contributing authors: Four Twenty Seven: Natalie Ambrosio, Frank Freitas, Lindsay Ross; Acclimatise: Caroline Fouvet, Robin Hamaker-Taylor.

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Executive summary

The final recommendations of the Task Force on Climate-related Financial Disclosures (TCFD), released at the G20 summit in the summer of 2017, recommended that metrics on physical climate risks and opportunities should be included in financial disclosures but did not provide concrete guidance on what the appropriate metrics would be.

To address this challenge and support the emergence of standards for the disclosure of physical climate risks and opportunities, the European Bank for Reconstruction and Development (EBRD) and the Global Centre for Excellence on Climate Adaptation (GCECA) launched a targeted initiative to work with innovative thinkers in the financial and corporate sectors. The goal of this initiative was to identify the greatest needs for guidance and research and to lay the foundations for a common conceptual framework and a standard set of metrics for reporting physical climate risks and opportunities.

The EBRD-GCECA project focused on disclosure metrics specifically for corporations. Industry-led working groups with participants from the financial sector and corporations met over the first half of 2018 to discuss and consider key research questions:

- Working group 1: Metrics for physical climate risk management and disclosures
- Working group 2: Metrics for climate resilience opportunities
- Working group 3: Climate intelligence for business strategy and financial planning.

The working group discussions informed the development of a set of recommendations, presented in this report. These recommendations, primarily targeted at corporations, are intended to inform and support early efforts to adopt the TCFD recommendations.

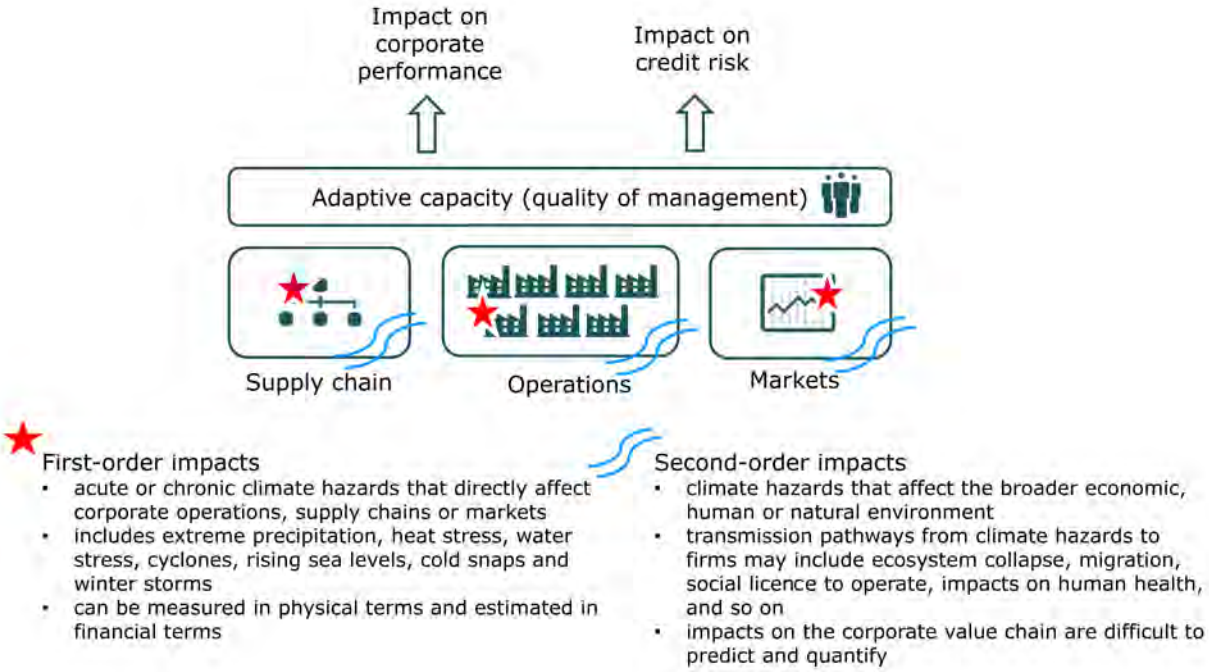
Disclosing physical climate risks

The TCFD recommendations identify climate-related physical risks as being one of the two main types of risks that financial and non-financial corporations should disclose, including both acute (event-driven) and chronic risks (those due to longer-term shifts in climate patterns). Climate change may affect all and any part of a company's financials, including expenditures, revenues, assets and liabilities, capital and financing. The TCFD recommends that organisations disclose information about governance, strategy and risk management, as well as metrics used to assess risks.

Identifying physical climate risks

A corporation's vulnerability to climate impacts goes well beyond the physical exposure of its facilities. It includes supply chains, distribution networks, customers and markets. Furthermore, a company's resilience to physical climate impacts depends on its risk management and business plans, as well as its governance.

Figure ES-1. How climate change affects corporate value chains



From the perspective of a corporation, we distinguish between first-order and second-order impacts. First-order impacts are direct hazards from climate change, both acute and chronic, that can be measured in physical terms (degrees Celsius, millimetres of rain, sea temperature, acres burned, and so on) and that affect specific regions or locations, often within a discrete timeframe (days, weeks, years). These hazards are relevant for all economic and human activities.

Second-order impacts include all impacts of climate change on economic, human and ecosystems beyond the boundaries of the corporation. These may include changes in the availability of natural resources, agricultural productivity, and the geographic distribution of species, disruption to transport, changes to global trade routes, migration, and macroeconomic indicators such as GDP, employment and interest rates. Unlike direct climate hazards, second-order impacts are difficult to predict and even harder to mitigate through traditional approaches to risk management.

The impacts of climate change on corporate value chains depend on where the company operates and what impacts may affect relevant locations, but they also depend on the company's activities. Corporations whose production processes consume high volumes of water, for example, may be particularly sensitive to changes in drought and the availability of water. Similarly, corporations with high-energy consumption or significant use of outdoor labour will experience greater challenges as average temperatures rise, affecting both energy costs and labour productivity.

Recommendation 1: Assess exposure to all first-order physical climate impacts

Corporations should consider all first-order impacts when undertaking a physical climate risk assessment: heat stress, extreme rainfall, drought, cyclones, sea-level rise and wildfires. Corporations should also consider in their physical climate risk assessments additional climate hazards relevant to their industries, such as ocean acidification for fisheries. Exposure to climate hazards should be assessed at the local scale (for example, flood risk to a land parcel, extreme rainfall and heat in a city), using the most recent climate data and literature.

Recommendation 2: Assess physical climate risks over the duration of an asset's lifetime or over the lifetime of a financial instrument

This paper recommends that a physical climate risk assessment should include projections for a 5- to 20-year timeframe, with a focus on 'tail risks'. Impacts beyond a 20-year timeframe should be assessed using scenario analysis to account for the uncertainty in climate policy and for the cascading impacts of climate change.

Firms should consider physical climate impacts over the following timeframes:

1. Assess changes in asset performance over the past 5-10 years (or longer) that are attributable to extreme weather events or to climate variability, in order to detect possible impacts from climate change.
2. Assess potential impacts over the expected lifetime of the asset and/or over the lifetime of the investment or loan.

Table ES-1. Timeframe and recommended approach to assessing physical climate risks

	Recommended timeframe	Approach for first-order impacts	Approach for second-order impacts
Short term	3-5 years	Probabilistic	Scenario analysis
Medium term	5-20 years	Probabilistic	Scenario analysis
Long term	20+ years	Scenario analysis	Scenario analysis

Recommendation 3: Disclose locations that are critical to value chains

This report recommends that corporations provide more detailed information on the location of their critical operations, suppliers and market, at least at the country level, as part of segment reporting and thereby enable investors and creditors to conduct analysis on exposure to risk in their portfolio.

For all physical climate risk disclosures, the focus should be on material risks. Corporations should disclose whether physical climate risks have been assessed at the asset level and disclose specific risks that are material at the group level, rather than making detailed facility-level information the default. The focus on materiality will ensure that disclosures are relevant and proportionate.

Recommendation 4: Provide detailed information on the financial impacts of recent extreme weather events

Firms should provide in their financial filings detailed information on the historical impacts of extreme weather events, including metrics on days of business interruptions and associated costs, costs of repairs or upgrades, fixed-asset impairment, supply chain disruptions and lost revenues.

Recommendation 5: Disclose the impacts of weather variability on value chains

Corporations with moderate or high sensitivity to variability in temperature and precipitation should identify and disclose whether and how changes in temperature and precipitation have materially affected their performance.

Recommendation 6: Perform forward-looking assessments of physical climate risks

Assessing future physical climate risks is extremely challenging. The combination of uncertainty over climate impacts, the timing of these impacts, business consequences and the effectiveness of risk management efforts will require additional work from companies if they are to gain a sophisticated understanding of what lies ahead. Corporations should disclose 1) their assessment of the types of physical climate risks to which they may be exposed in the future due to the geographic exposure of their facilities and 2) the estimated financial impacts from the risks they have identified as being material.

Metrics for projected impacts may include a combination of:

- the number of sites and business lines exposed to relevant climate impacts
- the projected changes in production, revenues, operational expenditure or capital expenditure due to climate change
- value-at-risk from probabilistic estimates (for example, 1:100 or 1:200) of extreme weather event disruption to operations or production, key suppliers, customers or markets
- annual average losses from projected climate impacts.

Recommendation 7: Describe risk management processes for physical climate change impacts

Corporations should describe their processes for identifying, assessing and managing the physical climate risks, as noted by the TCFD. For these physical impacts, aspects of particular interest to financial institutions and banks include risk management processes, insurance coverage, planned facility moves or retrofits, corporate climate resilience strategy, and engagement with local authorities to build climate resilience locally.

Disclosing physical climate opportunities

The TCFD also encourages corporations to disclose opportunities related to the impacts of a changing climate. This recommendation is critical to ensuring that businesses and financial institutions continue to thrive in a changing environment. It is also vital for promoting the healthy development of climate resilience products and services that cater to new market needs for climate resilience.

Identifying physical climate opportunities

The TCFD defines “climate-related opportunity” as “the potential positive impacts related to climate change on an organisation,” and notes that opportunities “will vary depending on the region, market and industry in which an organisation operates.” This report identifies three broad types of opportunities related to physical climate change impacts:

1. Opportunities related to managing existing physical climate risks
2. Opportunities to respond to new emerging physical climate risks
3. Opportunities to adapt to market shifts driven by physical climate impacts and cater to any resulting new market needs.

This framework invites firms to consider short-term and long-term opportunities alike, and opportunities to improve internal processes (efficiency, risk management), as well as opportunities to grow into new markets as the impacts of climate change become prevalent.

Climate resilience investment opportunities can also be broken down into ‘horizontal’ and ‘vertical’ solutions. Horizontal solutions include products and services for physical climate risk analytics and climate resilience that are relevant to all public and private organisations looking to manage physical climate risks and build climate resilience. Vertical solutions are products and solutions that cater to specific business sectors that actively manage business risks and have unique needs.

Disclosing opportunities that may arise from climate change raises challenges with regard to the disclosure of forward-looking information. Corporations may be sensitive about disclosing to investors and competitors quantitative or qualitative forward-looking information about market analyses and anticipated market conditions.

Recommendation 8: Identify opportunities based on managing physical climate risks and related market shifts

Corporations and financial institutions should strive to identify opportunities in managing existing physical climate risks and responding to emerging risks.

Corporations should also assess the potential changes in their value chains as a result of physical climate change impacts, and explore potential market shifts as customer needs change. They should target their products and services to cater to growing demand for climate resilience solutions.

Recommendation 9: Assess physical climate opportunities over timeframes relevant to business planning

Corporations should define the appropriate timescales in which to report physical climate opportunities in consultation with their investors. The preferred timescales will vary by sector. Opportunities in response to managing existing physical climate risks that affect recent and current accounts and the next year's accounts should be reported as part of core financials. Those opportunities arising from responding to emerging physical climate risks should be included in core financials where the impact is expected to affect current management accounts and future short-term trading as well as statements issued to investors on market conditions. Opportunities arising from market shifts linked to physical climate change impacts are unlikely to be reported quantitatively and are more appropriate for disclosure in general reporting on future business expectations.

Recommendation 10: Disclose physical climate opportunities for business at the segment level; for critical facilities, disclose climate resilience benefits at the facility level

Physical climate opportunities may be disclosed at different levels to best serve firms and investors. Opportunities due to shifting market demand or new products should be reported at the segment level, in line with risk disclosures. Benefits from managing existing or emerging risks may be disclosed at the segment level (for process or supply-chain improvements, for example). For critical facilities, it may be advantageous for firms to disclose significant climate resilience upgrades or strategic improvements at the facility level, to showcase good stewardship and provide confidence that critical facilities are protected.

Recommendation 11: Disclose benefits from climate resilience investments using the same metrics as for the disclosure of physical climate risks

Corporations should acknowledge the importance of accurately accounting for the opportunity effects on their core financials arising from actions to manage current risks and respond to emerging risks. These metrics may include avoided negative impacts on revenues, operating expenses, capital expenses, supply chain costs, value-at-risk, or projected annual average losses. Recent work by multilateral development banks on metrics for climate resilience results may provide a starting point but will require further development and modification. Whenever possible, companies should disclose public co-benefits from their climate resilience investments. These benefits may be disclosed qualitatively or quantitatively.

Recommendation 12: Include physical climate opportunities for business in qualitative disclosures

The disclosure of physical climate opportunities involving market shifts and new products and services can be achieved by qualitative disclosures of the lifecycle of new commercial opportunities. The disclosures may include information on the development stage of endeavours, sector, the size of potential markets, and the length of time until commercial viability.

Scenario analysis for physical climate risks and opportunities

With regard to climate intelligence for business strategy and financial planning, the TCFD recommendations strongly advocate the development and use of scenarios when analysing climate risks and opportunities. In this context, scenario analysis is intended as a tool to address challenges and acquire key information.

Scenarios are understood to provide a narrative, either qualitative or quantitative, which "describes a path of development leading to a particular outcome." The types of scenario that could ideally be considered for scenario analysis are 'context exploring' scenarios ('views of the world') modelled on the approach of Shell, which allow organisations to understand risks and capture opportunities.

The development of physical climate risk scenarios has lagged in comparison to carbon transition scenarios; comprehensive hypothetical scenarios have not yet been developed or established for scenario analysis of these risks. Sector-level climate impact studies, which use climate model outputs, and integrated assessment models (IAMs) can be used to explore risks at the sector, system and spatial levels over time. However, the use of IAMs for climate impact analysis has been far less systematic and limited to a few sectors (such as impacts on agriculture, water and coastal zones from sea level rise).

Recommendation 13: Consider current and desired GHG concentration pathways and related warming projections as a basis for scenario analysis of physical climate risks and opportunities

The bases for evaluating physical climate risks are Intergovernmental Panel on Climate Change (IPCC) climate scenarios that show how increases in global mean temperatures are driven by concentrations of greenhouse gas (GHG) emissions in the atmosphere.

Corporations should not be concerned with developing new climate scenarios themselves. Instead, as a basis for their scenario analysis of physical risk, they should consider at least two main types of existing climate scenarios:

- Current GHG pathway: National climate policies currently in place around the world are projected to reduce baseline emissions, which would result in warming of about 3.4 °C above pre-industrial levels.[1]
- Desired ('aspirational') GHG pathway: These are the scenarios compatible with limiting warming to below 1.5 °C by 2100 (with a probability of ≥50 per cent), and to below 2 °C in the 21st century (with a probability of about 80 per cent).

Recommendation 14: Integrate scenario analysis of physical climate risks and opportunities into existing planning processes to ensure strategic, flexible and resilient businesses and investments

The main reason to undertake scenario analysis is to obtain a comprehensive assessment from firms of their risks and opportunities. Firms should achieve this by exploring different possibilities of what might happen in the future, despite uncertainty and by integrating climate change considerations into their existing business strategies and financial planning.

For corporations and financial institutions, the direct value added by undertaking scenario analysis is that they will be able to align their business strategies with potential outcomes, which will make them more robust. In this sense, the real value of scenario analysis is the ability to ensure strategic, flexible and resilient businesses and investments, and is not the process of disclosure in itself.

Climate scenarios and output should be integrated into existing business and investment planning of corporations. Some firms – particularly large companies in specific industries – already produce scenarios as part of their business-planning and risk-management processes. In an ideal situation, companies and investors alike would develop scenarios and undertake scenario analysis of physical climate risks.

Recommendation 15: Avoid standardised scenario analysis in order to have a more comprehensive range of outcomes

Firms should look at more than one scenario and multiple climate models in order to have a more comprehensive range of potential outcomes. Although a degree of comparability is desirable, it is also recommended that corporations develop their own scenarios, which should be highly contextual, and based on the views and values of individual corporations.

There is more than one way to conduct scenario analysis. It may be done as a standalone workshop or as a longer-term planning process undertaken on a regular basis by a single company. In all its various forms, the aim of scenario analysis is to make more robust long-term plans by systematically analysing risks in possible future states.

Second-order impacts of climate change are well suited for inclusion in scenario analysis because they are impossible to predict with precision, but must be considered due to their wide-ranging and potentially catastrophic effects. Typical examples of macroeconomic impacts to be considered in scenario analysis include climate impacts on economic growth, global trade flows and human migration.

Recommendation 16: Consider data from a wide variety of sources and scales when developing scenario analysis of physical climate risks

In order to construct plausible scenarios of physical climate risks and opportunities, firms should consider inputs from a wide variety of sources and levels of detail. These include scientific data (not only on climate change), macroeconomic data, socio-economic data, data on political economics and policy, corporate data, 'vision' and market analysis data, 'big data', and so on. It should be noted that climate change is just one of the drivers that influences scenario analysis as intended in this report.

Recommendation 17: Take account of scientific uncertainty inherent in climate data and in scenario analysis of physical climate risks and opportunities

Corporations and financial institutions are very well accustomed to making decisions within a large spectrum of uncertainty. In the same way, they should consider and manage the uncertainty that surrounds climate data and climate science for scenario analysis. Scientific uncertainty should be taken into account and made explicit when assessing climate-related financial risks and opportunities.

Recommendation 18: Disclose qualitative information that is relevant to the company and its investors

The ultimate objective in disclosing the use of scenarios is to build investor confidence that a company is meaningfully engaged on the topic of climate change, that it is looking at a broad range of outcomes and is responsive and proactive, rather than defensive and reactive. In this context, firms should disclose information on their physical climate risks and opportunities in the way that is most appropriate to them, as well as to their investors, and to the type of information disclosed or its format (quantitative or qualitative).

Conclusion

Efforts to formalise and standardise the assessment and disclosure of physical climate risks and opportunities are still in their infancy. As science and business continue to progress in their understanding of climate impacts, the recommendations made in this report will evolve over time, informed by emerging practices and the continuous efforts of corporations, financial institutions, credit rating agencies, industry groups, think-tanks, regulators and governments.

Further challenges and research questions remain to be addressed across the three topics, including issues surrounding the materiality of risks, methodologies for quantifying the disclosure of risks, management practices, forward-looking statements, as well as guidance and standardisation for scenario analysis. For all of

these topics, broader cross-cutting challenges may also emerge, for example, with regard to ongoing policy and regulatory developments for climate disclosures.

Climate disclosures will remain a topic of active research and discussion, and this report aims to support the emergence of market practices that bring transparency to markets and help build climate resilience in firms and financial institutions.

Table ES-2. Summary of recommendations for disclosing physical climate risks and opportunities, and scenario analysis

Recommendations for the disclosure of physical climate risks			
	Supply chain	**Operations**	**Markets**
1. Hazards	• Assess exposure to heat stress, extreme rainfall, drought, cyclones, rising sea levels, wildfire and other industry-relevant and/or locally specific climate hazards across the corporate value chain.		
2. Timeframe	• Assess exposure to first-order (direct) impacts in the short to medium term (2-5 and 5-20 years) using a probabilistic approach; use scenario analysis for long-term risk (more than 20 years) and possible exposure to second-order (indirect) impacts.		
3. Level	• Location (country or city) of key supplier facilities and a measure of their importance	• Location (country or city) of critical business facilities (such as production or support systems) and key distribution or logistics sites, as well as a measure of their importance	• Breakdown of sales by country and by segment
4. Impacts from recent extreme weather events	• Decreased production capacity due to supply-chain interruption	• Reduced revenues, including situations where a significant number of staff members are unable to get to work • Increase in operational expenditure (opex), such as repair costs, insurance premiums • Increase in capital expenditure (capex)such as impairment of fixed assets, inventory write-downs	• Reduced revenues from lower sales due to the consequences of extreme weather events
5. Impacts of weather variability	• Increase in supply-chain costs due to changes in the availability of commodities	• Increase in opex (energy costs, negative impacts on the workforce) • Increase in capex due to weather or natural resources	• Reduced revenues from lower sales due to variability in the weather
6. Future risks of climate change	• Suppliers or commodities likely to be affected by climate change • Value-at-risk (VaR) from 1:100 or 1:200 and annual average loss projections from disruption to key supplier(s)	• Number of sites and business lines exposed to relevant impacts of climate change • Projected change in production, revenues, opex or capex due to climate change • VaR from 1:100 or 1:200 impact on operations or production • Annual average losses from projected impacts of climate change	• Markets or sales likely to be affected by climate change • VaR from 1:100 or 1:200 loss projections from impact on key customer(s) or markets
7. Physical climate risk management and climate resilience strategy	• Supply-chain risk-management strategy • Engagement with suppliers to help identify, assess and manage climate-related physical risks • Engagement of suppliers with local and national governments to identify, assess and manage these risks	• Insurance and risk management instruments and total cost of risk (net risk exposure after risk management) • Planned improvements, retrofits, relocations, or other changes to facilities that may reduce their vulnerability to climate impacts • Engagement with local or national governments and local stakeholders on local climate resilience	• Logistics, distribution and sales risk management strategy • Engagement with distributors and key customers to help identify, assess and manage climate risks

Table ES-2. *(continued from previous page)*

Recommendations for the disclosure of physical climate opportunities	
8. Opportunities	• Identify opportunities inherent in managing existing and emerging physical climate risks • Identify opportunities based on adapting to market shifts driven by a changing climate

9. Timeframe	• Assess and disclose opportunities using an adequate timeframe, according to the industry and the type of opportunity:
	  • snapshot of current context (shortest timeframe)
	  • business planning timeframe
	  • asset lifespan (longest timeframe)

10. Level	• Disclose physical climate opportunities at the segment level • Disclose climate resilience benefits at the facility level for critical facilities
11. Metrics for climate resilience benefits	• Disclose benefits of climate resilience investments using the same metrics that are used for the disclosure or physical climate risks • In addition, whenever possible, assess and disclose public co-benefits from climate resilience investments (in other words, the wider economic benefits of managing physical climate risks)

12. Metrics for business opportunities	• Disclose qualitative information on the lifecycle of a new commercial opportunity, including:
	  • the development stage of an endeavour
	  • the business area and connection to company's core business
	  • the size of the potential market
	  • the approximate timeframe for commercial viability

Recommendations for scenario analysis disclosures	
13. Climate scenarios	• Consider current and 'aspirational' GHG concentration pathways and related warming projections as a basis for scenario analysis of physical climate risks and opportunities
14. Motivation	• Integrate scenario analysis of physical climate risks and opportunities into existing planning processes to ensure strategic, flexible and resilient businesses and investments
15. Scenario building	• Avoid standardised scenario analysis in order to have a more comprehensive range of outcomes
16. Data	• Consider data from a wide variety of sources and scales when developing scenario analysis of physical climate risks and opportunities
17. Scientific uncertainty	• Take account of scientific uncertainty inherent in climate data and in scenario analysis of physical risks and opportunities
18. Scenario analysis and disclosures	• Disclose qualitative information that is relevant to the company and its investors • Consider scenario analysis of physical climate risks and opportunities as an initial step towards building climate resilience

Introduction

The Task Force on Climate-related Financial Disclosures (TCFD) seeks to "develop recommendations for voluntary climate-related financial disclosures that are consistent, comparable, reliable, clear, and efficient, and provide decision-useful information to lenders, insurers and investors." It has crystallised a growing concern among investors and business leaders about the physical impacts that climate change could have on the economy and on financial markets.

The TCFD's initial report noted a lack of understanding about the impact of climate change on corporate value chains and infrastructure, the channels through which these impacts are transmitted to financial markets, and a lack of transparency in reporting these risks. The final report, released at the G20 summit in the summer of 2017, recommended that financial disclosures should include metrics on the physical risks and opportunities of climate change but did not provide detailed guidance on appropriate metrics.

Without formal or regulatory guidance on metrics and indicators, firms are uncertain about what to include in their disclosures. Investors are therefore likely to receive a heterogeneous mix of financial reports including diverse indicators, metrics, assumptions and timeframes, which will fail to provide comparable data across a portfolio or provide the necessary transparency.

Recognising the challenges in the path towards standardising disclosure of physical risks and opportunities related to climate change, the European Bank for Reconstruction and Development (EBRD) and the Global Centre of Excellence on Climate Adaptation (GCECA) launched an initiative, "Advancing TCFD guidance on physical climate risks and opportunities". The initiative aims to work with innovative thinkers in the financial and corporate sectors to identify the greatest needs for guidance, research and development. It also seeks to lay the foundations for a common conceptual framework and a standard set of metrics for reporting physical climate risks and opportunities.

Early engagement with the disclosure of climate risks and opportunities enables companies to get ahead of forthcoming regulations, particularly in Europe. It allows them to anticipate and respond to investor concerns, and play an active role in shaping the field and establishing the standards that will eventually become the norm. This EBRD-GCECA report aims to inform and support early adoption efforts of this kind, recognising that the field is evolving rapidly and that best practices will emerge over time.

Participants in the initiative

The EBRD hosted the initiative and funded its technical secretariat. The EBRD is the leading multilateral development bank on private-sector climate resilience financing, and the Bank's extensive experience of delivering finance, technical cooperation and policy dialogue in support of wider market action on climate resilience has informed this project. The GCECA provided a secondment to the technical secretariat. Established by the government of the Netherlands, in partnership with the government of Japan, the United Nations Environment Programme, the Global Environment Facility and other international partners, GCECA is working to accelerate progress on climate change adaptation. One of the three cross-cutting themes that GCECA will focus on is "finance, investment and business."

The technical secretariat was provided by Four Twenty Seven, a provider of intelligence on climate risk to financial markets, and by Acclimatise, an advisory company specialised in adaptation to climate change.

The expert working groups in the initiative included participants from Agence Française de Développement, Allianz, APG Asset Management, AON, the Bank of England, Barclays, Blackrock, Bloomberg, BNP Paribas, Citi, Danone, the Dutch National Bank, DWS Deutsche AM, the European Investment Bank, Lightsmith Group, Lloyds, Maersk, Meridiam Infrastructure, Moody's, S&P Global Ratings, Shell, Siemens, Standard Chartered, USS and Zurich Alternative Asset Management.

Scope

In its initial report, the TCFD laid out seven fundamental principles for effective disclosure. According to these, disclosure should:

1. present relevant information
2. be specific and complete
3. be clear, balanced and understandable
4. be consistent over time
5. be comparable among companies within a sector, industry or portfolio
6. be reliable, verifiable and objective
7. be provided on a timely basis.

While these principles align fully with general principles of financial disclosure and with previously established frameworks for climate-related disclosure, they raise a number of practical challenges when applied to the disclosure of physical climate risks. Climate science continues to evolve, as does global climate policy, making it difficult to be consistent over time. Climate impacts affect businesses and the economy well beyond the walls of any given firm, but accounting for these indirect, 'second-order' risks in a specific and complete manner is extremely challenging. Lastly, the lack of an accepted methodology for measuring and quantifying the risks and opportunities of climate change is a major hurdle that limits access to information comparable among companies within a sector, industry or portfolio.

The preliminary guidance in this report aims to build on the TCFD recommendations and provide common foundations for the disclosure of climate-related *physical* risks and opportunities. The report also identifies areas where further research or market action is needed so that detailed, consistent, industry-specific guidelines can be developed on the methodology for quantifying and reporting these risks and opportunities.

The TCFD recommendations identify four core elements for climate-related financial disclosure: governance, strategy, risk management, and metrics and targets. The recommendations further identify metrics for physical climate risks and opportunities as an element that could benefit from further research and development. This report focuses on the challenging question of how to identify and quantify the risks and opportunities of a changing climate and on the possible metrics for disclosing these. It also aims to inform strategy and risk management.

The project focused on disclosure metrics that are specific to corporations. Improving the quality of firms' climate disclosures is not just important for them, but also critical to managing climate risks and opportunities in financial markets. Better corporate disclosure will enable more efficient pricing of risks and opportunities, and better performance in equity and corporate bond markets. It will provide banks with a better understanding of the climate-related risks they carry in their loan books. Robust and consistent disclosure of climate risks will also address emerging regulatory requirements in Europe and beyond, enabling a productive dialogue between regulators, asset owners, asset managers, rating agencies and firms to allow for consistent monitoring and effective engagement.

Project process

The EBRD-GCECA initiative involved three industry working groups of a dozen participants, with a mix of financial institutions (asset owners, asset managers, banks, insurance), corporations, credit rating agencies, and a financial data provider. Each working group met several times over the first half of 2018 to discuss and consider research questions related to the topic on hand. The working groups debated how best to help the market make progress on disclosure.

- **Working group 1: Metrics for disclosing physical climate risks.**
  This group focused on identifying a set of metrics that firms should include in their financial disclosures to

enable investors and creditors to assess their holdings and their own exposure to physical climate risks in their portfolios.

- **Working group 2: Metrics for disclosing climate resilience opportunities.**
  This second group worked to identify a set of metrics that firms may include in their financial disclosures that will enable investors and creditors to report on how these firms are (i) improving their resilience to climate-related physical risks and (ii) leveraging business opportunities associated with climate resilience in order to enhance their financial performance.
- **Working group 3: Climate intelligence for business strategy and financial planning.**
  This third group focused on developing guidance for using scenario analysis to assess uncertain second-order impacts of climate change on corporate value chains, trade flows and the broader macroeconomic environment.

The working groups built on the TCFD guidance. They also built on reporting frameworks such as the UN-supported Principles for Responsible Investments (PRI), the Climate Disclosure Standards Board (CDP), the United Nations Environment Programme Finance Initiative (UNEP FI), and an extensive review of literature to develop a set of recommendations on physical risks and opportunities.

This report captures the findings and recommendations of all three working groups and of other experts in the market. It aims to advance the TCFD recommendations, laying the foundations on how to identify, measure and disclose physical risks and opportunities, building on the best available science and with the thoughtful input of practitioners from financial and non-financial corporations. The report also highlights key research questions and the need for further developments in methodology.

The recommendations we developed aim to serve a dual purpose. They seek to:

1) improve corporations' understanding of their own exposure and risk profile as well as opportunities arising from climate change, and

2) provide clear signals for financial institutions to understand risks and opportunities implicit in individual holdings as well as portfolio-wide exposures.

As a general rule, this report has prioritised recommendations that are consistent with current industry practices and that leverage metrics and frameworks already used for financial disclosures. It also includes a mix of recommendations that focus on providing better information, as well as recommendations that require more sophisticated analysis. In line with the TCFD recommendations, the recommendations of this EBRD-GCECA are geared to facilitating comparability across companies within a sector, industry or portfolio, and to promoting disclosure of reliable and verifiable information.

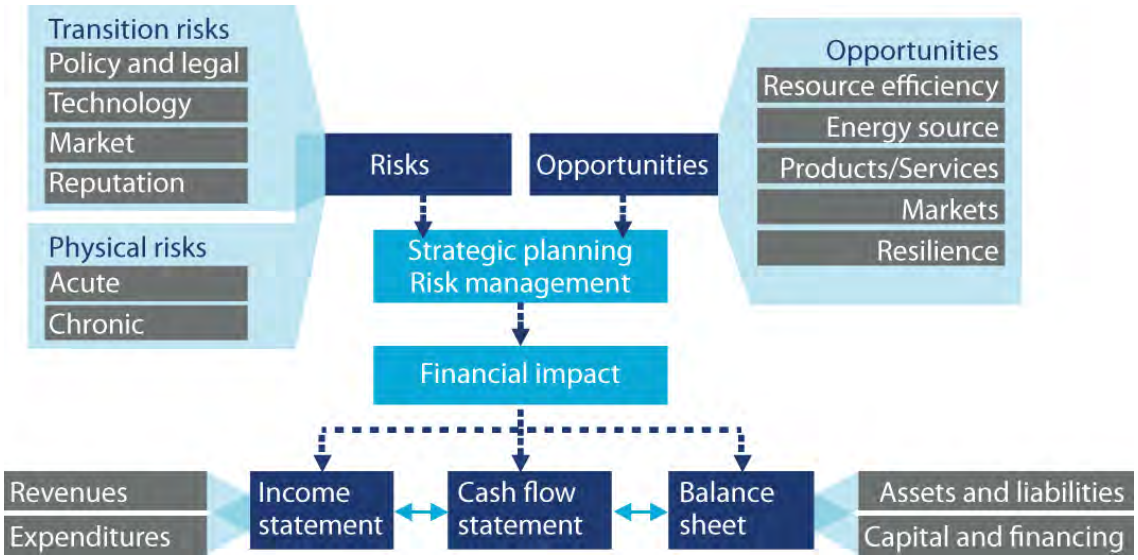
This report does not answer all questions related to physical risks and opportunities. The challenges, and the need for further research, clear standards and protocols, and accepted market practices remain deep. Furthering these recommendations will also require substantial input from legal and accounting experts. Yet it is hoped that the collective efforts in this initiative to frame the issue, develop a taxonomy, set guidelines for scope, timeframe and disclosure levels, and the attempt to develop metrics for risks and opportunities, will help advance TCFD recommendations and raise market awareness of the business impacts of a changing climate.

1. Disclosing physical climate risks

a. TCFD recommendations on physical climate risks and opportunities

The TCFD recommendations identify physical climate risks as one of the two main risks that financial and non-financial corporations should disclose, including both acute (event-driven) and chronic risks (those due to longer-term shifts in climate patterns). The TCFD views climate risks and opportunities as driving financial impacts on firms, as Figure 1 illustrates. It does not see them as environmental or sustainability issues.

Figure 1. Climate risks and opportunities drive financial impacts



Source: TCFD final recommendations (June 2017).

As Figure 1 shows, climate change may affect all and any part of a company's financials:

- **Expenditures**
  - **Operational expenditures** such as an increase in energy costs due to heat waves or cold snaps, an increase in insurance costs.
  - **Capital expenditures**, such as the cost of repair to or retrofitting of a site, the acquisition of a new site, and so on.
- **Revenues** – losses arising from business interruptions due to a flood or storm, reduced asset productivity, for example, a manufacturing plant running at lower capacity because of heat or reduced demand from consumers
- **Assets and liabilities**, such as a complete or partial loss due to extreme weather events, liability after a spill or explosion caused by an extreme weather event, asset impairment due to changes in the operating environment (for example, drought, or land loss due to sea level rise)
- **Capital and financing**, for example, increased cost of capital due to concerns about the insurability of a site.

The TCFD recommends that organisations disclose the following elements:

- **Governance**
  - The board's oversight of climate-related risks and opportunities
  - Management's role in assessing and managing climate-related risks and opportunities

Strategy
- Climate-related risks and opportunities identified with regard to the short term, medium term and long term
- The impact of climate-related risks and opportunities on business, strategy and financial planning
- Climate resilience of the organisation's strategy, taking into account different climate-related scenarios

Risk management
- Processes for identifying and assessing climate-related risks
- Processes for managing climate-related risks
- How processes for identifying, assessing and managing climate-related risks are integrated into the organisation's overall risk management

Metrics
- Metrics used by the organisation to assess climate-related risks and opportunities in line with its strategy and risk-management process
- Targets used to manage climate-related risks and opportunities and performance against these targets.

The final recommendations from the TCFD highlight the need to develop additional guidance on metrics for disclosing physical risks, including standardising and calculating key metrics.

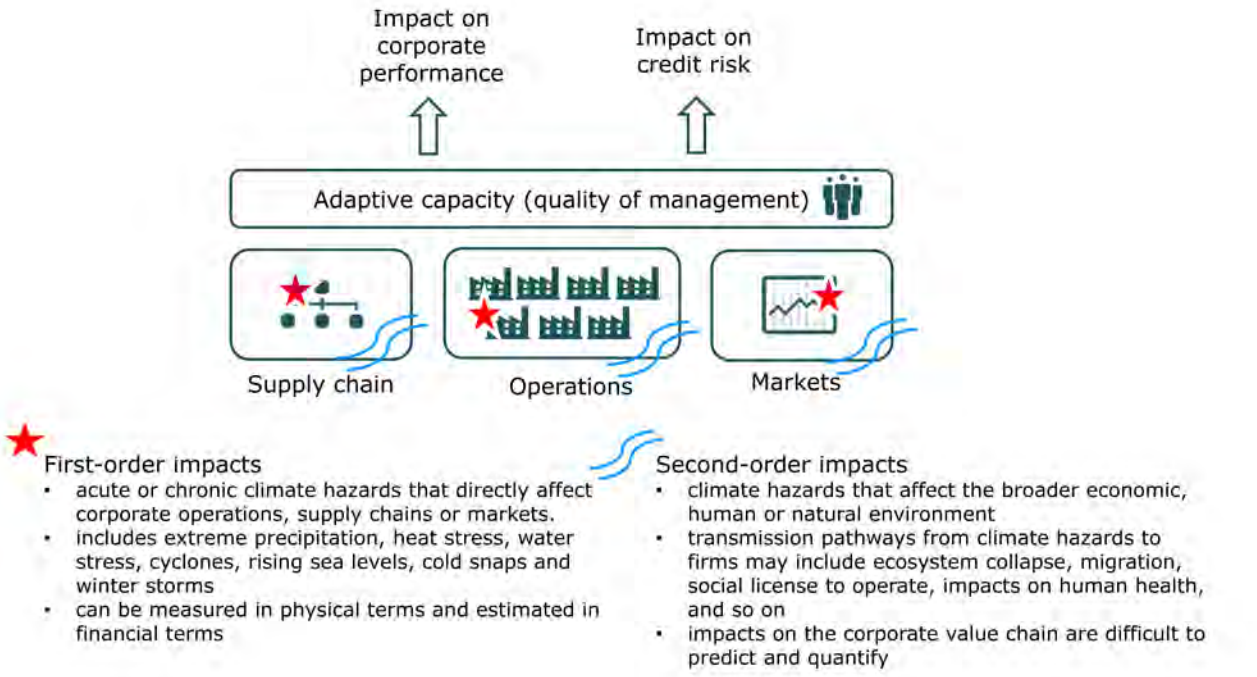
b. Identifying physical climate risks

i. How climate change affects corporate value chains

Climate change is multifaceted and affects all parts of our economic system. Climate-related hazards affect physical economic assets such as buildings, factories, plants and pipelines, as well as offices and retail facilities. A corporation's vulnerability to climate impacts also goes well beyond the physical exposure of its facilities: it includes supply chains, distribution networks, customers and markets. Impacts on a single site may be more or less material depending on the type of site and activities, business inventory, supply chain, continuity plans, and so on.

Furthermore, a company's resilience to extreme weather events, chronic stresses or changes in weather conditions depends on its risk management and business plans, as well as its governance. Figure 2 provides an illustrative summary of the impacts of a changing climate on corporate value chains, defined broadly as including supply chains, operations, logistics and markets. This report distinguishes between the type of climate-related risk driver, namely, 'first-order impacts' and 'second-order impacts'.

Figure 2. How climate change affects corporate value chains



Source: Four Twenty Seven, © Four Twenty Seven (2017).

Together, exposure to climate hazards and corporate capacity to adapt determine whether a potential impact is material (for the purposes of financial reporting) and whether this material risk should affect equity valuation or credit risk.

ii. Climate hazards: a taxonomy

First-order impacts

The Intergovernmental Panel on Climate Change (IPCC) identifies a number of extreme weather and climate events that have already been observed and will worsen significantly over the 21st century:[2]

- Heat stress: Warmer and/or more frequent hot days and nights; fewer cold days; warm spells and heatwaves.
- Extreme precipitation: Heavy precipitation events; increases in the frequency, intensity and/or amount of heavy precipitation
- Drought: Increases in the intensity and/or duration of drought
- Cyclones: Increases in intense-tropical-cyclone activity
- Sea-level rise: Increased incidence and/or magnitude of extremely high sea levels.

The manifestation and the combination of these extreme weather events and climate trends increase the frequency and intensity of floods and wildfires. These extreme weather events are part of what businesses may already experience occasionally and have historically managed as part of their enterprise risk-management process. Climate change brings an important difference, however, because these events become more frequent and/or more intense and therefore the probability that they will have a material financial effect also

increases. Climate change also drives gradual changes in long-term weather patterns: changes in average temperatures, precipitation patterns and rising sea levels, which can also affect corporate performance.

From the perspective of a corporation, we define these climate hazards as **first-order impacts** – in other words, direct hazards from climate change, both acute and chronic, that can be measured in physical terms (in degrees Celsius, millimetres of rain, sea temperature, acres burned, and so on) and that affect specific regions or locations, often during a discrete timeframe (days, weeks, years). **These first-order hazards are relevant to all economic and human activities.**

In addition, certain industries may be sensitive to other changes in the earth's physical conditions related to or caused by climate change, for example:

- fisheries may be affected by ocean acidification, which threatens vital parts of the ocean's ecosystems[3]
- extractive industries and the transport sector, among others, may be affected by ice melt and permafrost melt in northern regions.
- the agricultural sector may be affected by hydrological variability (even if it is not extreme) and by soil degradation
- the tourism industry and other sectors (agricultural, retail) may be affected by changes in snow cover.

Table 1 provides an illustrative, but not exhaustive, list of industries and their sensitivities to the impacts of climate change.

The manifestation of climate hazards varies widely from region to region and at the local level. Precipitation in particular may see the most variability between regions, and within the same region over time.

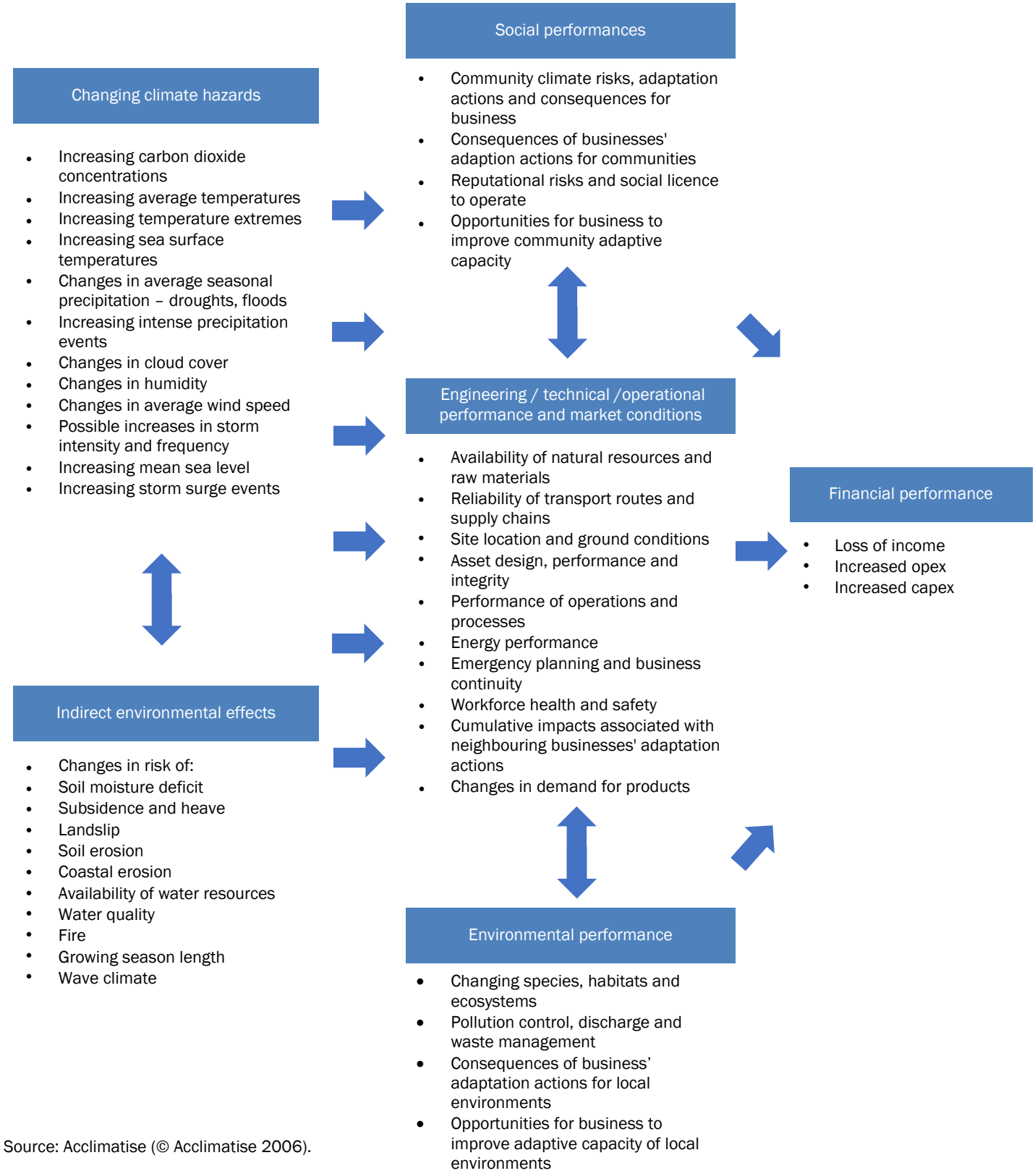
The common characteristic of these hazards and their financial impacts is that, for the most part, they can be measured. Climate models project the changes in frequency and magnitude of physical hazards (albeit with many limitations). The financial effects of these changes can in turn be quantified and monetised, even if there are some limitations related to economic-modelling techniques, the availability of data, and scientific uncertainty.

Second-order impacts

Second-order impacts include all **impacts of climate change on economies, people and ecosystems beyond the boundaries of a corporation**. Examples of second-order impacts include changes in the availability of natural resources, agricultural productivity, and the geographic distribution of species, disruption to transport, changes to global trade routes, migration, and macroeconomic indicators such as GDP, employment and interest rates. For instance, there is an opportunity cost to society in terms of the reconstruction of hard assets following damage from extreme weather events. Figure 3 offers an expanded view of first- and second-order risk pathways, from first-order impacts through to financial impacts.

Unlike first-order (direct) climate hazards, second-order (indirect) impacts are **difficult to predict and even harder to mitigate** through traditional approaches to risk management. The uncertainty around both the impact of a changing climate, and the policy and regulatory responses to this change, present significant new challenges when compared with other environmental problems that society faces.

Figure 3. From climate hazards to financial performance: risk pathways



Source: Acclimatise (© Acclimatise 2006).

iii. Sensitivity to climate impacts, by industry

The impacts of a changing climate on corporate value chains depend on where a company operates and what impacts may affect the relevant locations, but they also depend on the company's activities. For example, firms whose production processes consume high volumes of water may be particularly sensitive to changes in drought patterns and the availability of water. Similarly, corporations with high energy consumption or significant use of outdoor labour will experience greater challenges as average temperatures rise, affecting both energy costs and labour productivity.

Table 1 summarise sensitivities to climate hazards, by industry. It includes both acute impacts (extreme weather events such as storms and cyclones, extreme rainfall, extreme heat) and chronic changes (variability in precipitation, temperature, water stress and sea-level rise). All businesses are assumed to be sensitive to storms and flood risks due to extreme rainfall or rising sea levels. Sensitivity to weather variability and water stress is assessed based on the type of activity prevalent in each industry group and on its average water and energy intensity.

This sensitivity matrix is indicative only and should not be used as a substitute for a materiality assessment for any individual corporation. Each business model, process and operating location is unique and may create sensitivity to hazards other than those listed in Table 1.

Table 1. Sensitivity matrix, by industry

GICS sector	GICS industry group	Storms and cyclones	Extreme rainfall and flood	Extreme heat	Variability in precipitation	Variability in temperature	Water stress	Sea-level rise	Other climate hazards
Consumer discretionary	Automobiles and components	High	High	High	Medium	High	Medium	High	Degraded air quality
	Consumer durables and apparel	High	High	High	Medium	High	Medium	High	Degraded air quality
	Consumer services	High	High	Low	Medium	Medium	Medium	High	
	Media	High	High	Low	Low	Low	Low	High	
	Retailing	High	High	Low	Low	Low	Low	High	
Consumer Staples	Food and staples retailing	High	High	Low	Medium	Medium	Medium	High	
	Food, beverage and tobacco	High	High	Medium	High	High	High	High	Soil degradation, ocean acidification
	Household and personal products	High	High	Medium	Medium	High	Medium	High	
Energy	Energy	High	High	High	Medium	High	Medium	High	Icemelt, permafrost melt
Financials	Banks	High	High	Low	Low	Low	Low	High	

GICS sector	GICS industry group	Storms and cyclones	Extreme rainfall and flood	Extreme heat	Variability in precipitation	Variability in temperature	Water stress	Sea-level rise	Other climate hazards
	Diversified financials	High	High	Low	Low	Low	Low	High	
	Insurance	High	High	Medium	Medium	Medium	Medium	High	Hail storms, landslides, wildfires
Health care	Healthcare equipment and services	High	High	High	Low	Low	Medium	High	Wildfires, humidity, degraded air quality
	Pharmaceuticals, biotechnology and life sciences	High	High	High	Medium	High	Medium	High	
Industrials	Capital goods	High	High	High	High	Medium	High	High	
	Commercial and professional services	High	High	Low	Low	Low	Low	High	
	Transport	High	High	Medium	Low	Low	Low	High	Permafrost melt, ice melt
Information technology	Semi-conductors	High	High	High	Low	High	Medium	High	
	Software and Services	High	High	Low	Low	Low	Low	High	
	Technology hardware and equipment	High	High	High	Low	High	Medium	High	
Materials	Materials	High	High	High	High	High	High	High	
Real estate	Real estate	High	High	Low	Low	Low	Low	High	
Telecommunication services	Telecommunication services	High	High	Low	Low	Low	Low	High	
Utilities	Utilities	High	High	High	High	High	High	High	Wildfires

Source: Four Twenty Seven (© Four Twenty Seven 2017).

Note: 'GICS' denotes the Global Industry Classification Standard.

c. Scope, timeframe and level for disclosing physical climate risks

The long-term nature of climate change and the complexity and diversity of climate hazards raise challenges for firms and investors. This section provides pointers on how to address these challenges, and discusses approaches to disclosure that balance the interests of investors and corporations.

i. Scope

Recommendation 1: Assess exposure to all first-order physical climate impacts

Description

This report recommends that corporations consider all first-order impacts when undertaking an assessment of physical climate risks: heat stress, extreme rainfall, drought, cyclones, sea-level rise and wildfires. it also recommends that corporations consider in their risk assessments additional climate hazards relevant to their industries, using peer-reviewed literature and sector-specific industry research on climate risks.

Exposure to these climate hazards should be assessed at the local level (such as flood risk to a land parcel, extreme rainfall and heat in a city), using the most recent climate data and literature.

Industries with moderate or high sensitivity to variability in precipitation and temperature due to their activities (see Table 1) or sensitive to other climate-related hazards (such as permafrost or ocean acidification) should also include these impacts when conducting a risk assessment.

Lastly, for second-order, indirect or uncertain impacts that may not be quantified or modelled, we recommend the use of scenario analysis as a tool to support decision-making (see Section 3).

ii. Timeframe

The impacts of climate change are already being felt globally and will continue to worsen over the coming decades. Climate models provide sophisticated projections of changes in the climate hazards identified above over this period. However, data for medium-term impacts (two to five years) is lacking.

Decisions made in corporations typically focus on the near to medium term. Cycles of decision-making are usually managed on a quarterly or annual basis, with financial-planning projections three to five years out. Financial markets tend to focus on even shorter timeframes, with an emphasis on quarterly reports and average holding periods for some financial assets (that is, stocks, bonds and so on) ranging from a few days to a few years. A number of industries, however, also invest and rely on physical assets with long lifetimes – 20-50 years for many infrastructure assets and sometimes up to 100 years.

Recommendation 2: Assess physical climate risks over the duration of an asset's lifetime or over the lifetime of a financial instrument

Description

In general, this paper recommends that a physical climate risk assessment should include projections for a 5- to 20-year timeframe, with a focus on 'tail risks'. Impacts beyond a 20-year timeframe should be assessed using scenario analysis to account for the uncertainty in climate policy and for the cascading impacts of climate change.

Specifically, this report recommends that corporations consider climate impacts over the following timeframes:

3. Assess changes in asset performance over the past 5-10 years (or longer) that are attributable to extreme weather events or to climate variability, in order to detect the possible impacts of climate change.
4. Assess impacts over the expected lifetime of the asset and/or over the lifetime of the investment or loan.

Table 2. Timeframe and recommended approach to assessing physical climate risks

	Recommended timeframe	Approach for first-order impacts	Approach for second-order impacts
Short term	3-5 years	Probabilistic	Scenario analysis
Medium term	5-20 years	Probabilistic	Scenario analysis
Long term	20+ years	Scenario analysis	Scenario analysis

Rationale

In defining the relevant timeframe and looking at lifetime, corporations should account for systemic impacts: a loan may have a three-year maturity but the relationship with a client is likely to extend well beyond this specific line of credit. Similarly, a real estate firm may plan to sell an asset within three years, but the next buyers may perform their due diligence by looking ahead at least another three to five years, effectively extending the relevant time period for a risk assessment by several years or more for the initial holder.

Corporations may use the difference between historical conditions and future conditions (in the medium term) as a proxy for short-term exposure.

iii. Level

For investors and creditors, identifying exposure to physical climate risks and assessing how climate impacts may affect the financial performance or credit rating of companies in their portfolio is extremely challenging, because they do not have access to facility-level data (location and financials) for sites owned by a corporation in their equity or loan portfolio, and cannot perform a climate-risk assessment of their holdings. They are therefore reliant on the corporation's own risk assessment and what it discloses as they seek to assess risk in their holdings.

For all physical climate disclosures, the focus should be on material risks, in other words, disclosure that climate-related physical risks are assessed at the asset level (many of which are also handled at the local level) as well as disclosure of specific risks that are material at the group level, rather than making detailed facility-level information the default. The focus on materiality will ensure that disclosures are relevant and proportionate.

In addition, this report recommends that corporations provide more information about the location of their critical operations and suppliers, thus enabling stakeholders to conduct supplementary analysis on possible exposure to physical climate risks.

Recommendation 3: Disclose locations that are critical to value chains

Description

Corporations typically disclose a form of geographic breakdown of their production or revenues. In the United States of America, for example, firms must disclose details by segment, including geographic regions, for parts of the activities that account for at least 10 per cent of the firm's revenues, 10 per cent of the profit or loss, or 10 per cent of the combined assets of the entity. However, segment reporting is often done at the regional level using inconsistent geographic breakdowns (such as "EMEA" or "rest of the world") and primarily for sales. Financial filings sometimes also include information on key production sites, but this information is largely inconsistent.

This report recommends that corporations **provide consistent and granular reporting on the geographic location of production and sales alike, as well as key suppliers by business line, if this information is available**. The information should be presented at least by country, although city location would be most useful with regard to production sites. The disclosures may also include a measure of how important various locations are

to overall company revenues and profitability (for example, the percentage of production or revenues for which they account), or otherwise note which facilities are critical.

Rationale

This recommendation is an incremental change from current reporting practices, using information that is readily available for corporations and hence creating limited additional burden for corporations. Yet this small change addresses two major concerns of financial institutions. First, it enables investors and creditors to perform their own high-level assessments of a corporation's exposure to physical climate risks. Second, it enables financial institutions to disclose potential correlated risks and high exposure within a country or region due to the composition of their portfolios and the geographic exposure of the underlying assets.

d. Metrics for disclosing physical climate risks

Assessing and quantifying the impacts of a changing climate is critical to determining the materiality of the impact, and to developing a forward-looking view of how future impacts will affect the corporate value chain. Our recommendations focus on building an understanding of past and recent impacts of climate change, based on corporate financial data, then provide pointers on how to use this understanding to develop a forward-looking assessment of climate impacts.

i. Metrics for recent impacts of climate change on company performance

Climate change has been affecting weather patterns for years, as the increased frequency of certain weather events, and the changes in temperature and precipitation patterns around the world illustrate. While these recent changes are not all clearly attributed to climate change, they provide a rich dataset to help understand the influence of weather on business, even for businesses that have not used this information before.

Recommendation 4: Provide detailed information on the financial impacts of recent extreme weather events

Description

Firms should provide in their financial filings detailed information on the historical impacts of extreme weather events, including, as relevant, a combination of the following metrics:

- facilities and business line(s) affected
- time and duration of the impact
- cost of business interruption
- inventory write-downs
- lost wages
- cost of repairs or upgrades
- fixed-asset impairment
- detailed insurance payments
- impacts of related power outages
- loss or damage to primary office or business facility
- loss or damage to critical business applications
- loss or damage to critical vendor chains or supply chains (or value chains)
- significant unavailability of staff
- lost revenues and/or market shares.

Rationale

Corporations are already exposed regularly to extreme weather events, yet reporting on the financial impacts of these events is uneven. Single-event occurrences may not meet the threshold for financial materiality, especially if they were adequately provided for or covered by insurance. However, repeated occurrences across a company or over several years can affect corporate performance and warrant better disclosure. Gaining a better understanding of the financial impacts of recent extreme weather events is also a critical starting point to anticipating and quantifying the impacts of more frequent and/or more intense extreme weather events in the future. This recommendation applies to all extreme weather events, whether a connection with climate change has been established or not.[4]

Recommendation 5: Disclose the impacts of weather variability on value chains

Description

Firms with moderate or high sensitivity to variability in temperature and precipitation should identify and disclose whether and how changes in temperature and precipitation have materially affected their performance. This recommendation applies primarily to corporations that undertake manufacturing activities, as well firms in the agriculture and food, energy, utility, tourism and retail sectors (see Table 1 for a complete list).

Rationale

The TCFD recommends that "metrics should be provided for historical periods to allow for trend analysis" and encourages corporations to "provide a description of the methodologies used to calculate or estimate climate-related metrics." Yet beyond a few, well-identified industries where analysing historical weather is standard practice (energy, agriculture and retail, for example), most corporations do not typically factor in weather as a driver of business performance. However, recent manifestations of climate change show that a broad range of industries are sensitive to weather conditions that can affect labour, equipment, energy consumption and markets, to name just a few factors. Quantifying the financial impacts of changes in past weather conditions may provide a baseline against which to assess the implications of changes in future conditions.

ii. Metrics for future physical climate risks

Assessing future physical climate risks is extremely challenging. The combination of uncertainty about timing, climate impacts, business consequences, and the effectiveness of risk management efforts will require additional work from companies if they are to gain a sophisticated understanding of what lies ahead. The next section of this paper provides a series of suggestions on metrics and methods to assess physical climate risks, and calls for further work to develop industry standards and methodologies that give corporations clear guidance and ensure comparability of data for financial institutions.

Recommendation 6: Perform forward-looking assessments of physical climate risks

Description

Corporations should disclose 1) their assessment of the types of physical climate risks to which they may be subject in the future due to the geographic exposure of their facilities and 2) the estimated financial impacts from the risks they have identified as being material. The risk estimates should build on vulnerabilities identified in recommendations 1, 2 and 3 above, based on the location of critical assets, financial impacts from past extreme weather events, and financial impacts from past variability in weather conditions. Future impacts may be disclosed using projections based on the same metrics (for example, future impacts of heat on sales) or using aggregate metrics that reflect the net risk for the firm, accounting for risk-management

measures (such as insurance, planned retrofitting of facilities). Physical climate risk assessments should cover, at a minimum, all material facilities or critical facilities, as well as vital suppliers.

Metrics for projected impacts may include a combination of:

- the number of sites and business lines exposed to relevant climate impacts
- the projected changes in production, revenues, operational expenditure (opex) or capital expenditure (capex) due to climate change
- value-at-risk from probabilistic estimates (for example, 1:100 or 1:200) extreme weather event disruption to operations or production, key suppliers, customers or markets
- annual average losses from projected climate impacts.

Rationale

Estimating the potential financial impacts of a changing climate is complex and data-intensive but not impossible. Climate scientists have developed a broad body of knowledge that predicts expected trends resulting from climate change. Corporations have a responsibility to use the best available science to assess physical climate risks to their activities. They can start by providing simple insights from their assessments of whether any of their facilities or activities are exposed to physical climate impacts. Firms can then leverage their knowledge of how past climate-related extreme weather events or weather variability have affected corporate performance, in order to estimate the potential effect of the forecasted impacts.

The most sophisticated (or most exposed) corporations should consider estimating their annual average losses and value-at-risk, using climate models to obtain probabilistic estimates of the likelihood of certain events, and providing a probability-weighted estimate of future financial losses. The TCFD recommended such disclosures for insurance companies in particular: “Insurance companies should provide aggregated risk exposure to weather-related catastrophes of property business (i.e. annual aggregated expected losses from weather-related catastrophes) by relevant jurisdictions”.[5] This same methodology could perhaps be applied more widely for corporations and industries that are highly vulnerable to the effects of climate change.

Recommendation 7: Describe risk management processes for physical climate change impacts

Description

Corporations should describe their processes for identifying, assessing and managing physical climate risks, as noted by the TCFD. For these physical impacts, aspects of particular interest to financial institutions and banks include:

- processes to identify and assess material physical climate risks (in line with TCFD recommendations) and, where relevant, a description of why certain risks are not material.
- insurance coverage: hazards and business perils covered, cost of insurance, total cost of risk
- other risk management tools, including financial risk transfer instruments, self-insurance
- planned improvements, retrofits, temporary or permanent relocation of production capacity, or other changes to facilities or activities that may reduce their vulnerability to climate impacts
- awareness of critical components in supply chains and plans to increase redundancy or replace those supply chain components
- engagement with local or national governments and local stakeholders to identify joint strategies for mitigating climate impact and building climate resilience locally
- corporate climate resilience strategies and relevant efforts (such as management of water, energy and waste) to increase resilience to the predictable or unforeseen impacts on firms and their value chains.

Rationale

A firm's approach to managing physical climate risks will make a tremendous difference in its ability to withstand impacts over time. While this is a new topic for many firms, showing awareness and engagement on the issue can help provide comfort and show how the companies' leadership is paying due attention to these issues and taking the right steps to effectively mitigate risk. Companies should include concrete, specific information on how they are assessing impacts, including with regard to their processes and governance, as well as their technical approaches and use of climate models. Investors, insurers, rating agencies and banks are most interested in understanding the risk management strategies of corporations: insurance coverage, remaining net exposure, as well as plans to address known risks that cannot be transferred.

Engagement and cooperation with local, regional and national governments is also critical to improving the climate resilience of company facilities as well as to protecting the local communities where a company's staff and customers live. Firms may be able to take certain actions to improve the climate resilience of their own facilities, but improved protection may require investments in hard infrastructure at the community or regional level, 'national capital' protection measures such as restoring wetlands, mangroves and natural drainage, as well as community education efforts.

e. Summary table: recommendations on disclosing physical climate risks

Table 3. Recommendations and examples of metrics for the disclosure of physical climate risks

	Recommendations		
	Supply chain	Operations	Markets
1. Hazards	• Assess exposure to heat stress, extreme rainfall, drought, cyclones, sea-level rise, wildfire and other industry-relevant and/or locally specific climate hazards across the corporate value chain.		
2. Timeframe	• Assess exposure to first-order impacts in the short to medium term (2-5 and 5-20 years) using a probabilistic approach and using scenario analysis to assess long-term risks (more than 20 years) and possible exposure to second-order (indirect) impacts.		
3. Geography	• Location (country or city) of key supplier facilities and a measure of their importance	• Location (country or city) of critical business facilities (production, support systems) and key distribution or logistics sites, and a measure of their importance	• Breakdown of sales by country and by segment
4. Impacts of recent extreme-weather events	• Decreased output and revenues due to supply chain interruptions	• Reduced revenues, including if a significant number of staff members are unable to get to work • Increase in opex (repair costs, insurance premiums) • Increase in capex (fixed-asset impairment, inventory write-downs)	• Reduced revenues from lower sales due to consequences of extreme weather events
5. Impacts from weather variability	• Increase in supply chain costs due to changes in commodity availability	• Increase in opex (energy costs, negative impacts on workforce) • Increase in capex due to weather or natural resources	• Reduced revenues from lower sales due to variability in weather
6. Future physical climate risks	• Suppliers or commodities likely to be affected by climate change • VaR from 1:100 or 1:200 and annual average loss projections on disruption to key supplier(s)	• Number of sites and business lines exposed to relevant climate impacts • Projected change in production, revenues, opex or capex due to climate change • VaR from 1:100 or 1:200 impact on operations or production	• Markets or sales likely to be affected by climate change • VaR from 1:100 or 1:200 and loss projections for impact on key customers or markets

		• Annual average losses from projected climate impacts	
7. Physical climate risk management and climate resilience strategy	• Supply-chain risk management strategy • Engagement with suppliers to help identify, assess and manage physical climate risks • Engagement of suppliers with local and national governments to identify, assess and manage these physical risks	• Insurance and risk management instruments and total cost of risk (net risk exposure after risk management) • Planned improvements, retrofits, relocation, or other changes to facilities that may reduce their vulnerability to climate impacts • Engagement with local or national governments and local stakeholders on local climate resilience	• Logistics, distribution and sales risk-management strategy • Engagement with distributors and key customers to help identify, assess and manage physical climate risks

2. Disclosing physical climate opportunities

The TCFD also encourages firms to disclose opportunities arising from, and in response to the impacts of a changing climate. This recommendation is critical to ensuring that businesses and financial institutions continue to thrive in a changing environment. It is also vital for promoting the healthy development of products and services that cater to new market needs for climate resilience. When considering opportunities, it is important to emphasise the role of businesses and financial institutions in responding to a changing climate and providing the necessary goods and services for climate resilience. Identifying these opportunities by no means implies that an altering climate should be seen as a positive development.

However, the evaluation and analysis of opportunities related to the physical impacts of climate change have so far received far less attention than the risks. In general, these opportunities are also not as well understood, and there is a lack of literature to provide in-depth, quantitative analysis.

This section of the report focuses on defining climate resilience opportunities and drafting an appropriate taxonomy for them. It aims to build awareness of the potential opportunities, and of the role that firms and investors can play in achieving climate resilience. It identifies the issues that corporations should consider when preparing disclosures and acknowledges that the development of suitable metrics is still required.

a. TCFD recommendations on disclosing opportunities

In its final report, the TCFD defines "climate-related opportunity" as being "the potential positive impacts related to climate change on an organisation" and notes that opportunities "will vary depending on the region, market and industry in which an organisation operates". The TCFD also recommends that "organisations provide information specific to the potential impact of climate-related risks and opportunities on their markets, businesses, corporate or investment strategy, financial statements and future cash flows". Lastly, the TCFD also advises firms to disclose how they are improving their resilience to these physical climate risks and leveraging associated business opportunities, in order to enhance their financial performance in the short, medium or long term.

The TCFD final report also contains a typology of opportunities and financial impacts covering carbon transition and physical changes. It presents these under the following categories: resource efficiency; energy sources; products and services; and markets and resilience. The TCFD recommendations generally emphasise carbon transition more than the physical impacts of climate change, and risks more than opportunities. This reflects the focus of the Paris Agreement. It also reflects the limited information and guidance available to the private sector on the financial risks and opportunities arising from a changing and more variable climate.

This section aims to supplement with more detailed guidance the high-level TCFD recommendations on disclosing these opportunities.

b. Identifying climate-related opportunities

i. How climate change creates opportunities for businesses

Discussing business opportunities from climate change is a sensitive topic: climate change portends disaster and loss of lives and value for many around the world, and businesses may be concerned about being seen as insensitive to the risks and damages that others face. Yet business engagement with climate resilience is critical to building socio-economic resilience. In a market economy, public welfare relies as least in part on the ability of markets to innovate, develop new technologies, and cater to new market needs as people adapt to new conditions. Business ingenuity and resources are needed alongside public efforts and community support to address climate change and its consequences.

Resilient infrastructure and the deployment of new technology also require massive investment, which public finance institutions actively seek to make more attractive to private capital. Highlighting the benefits of climate resilience and business opportunities linked to climate change is a natural first step towards engaging financial institutions on the topic of climate resiience.

ii. Climate opportunities: a taxonomy

There is no agreed methodology or protocol for identifying, assessing and disclosing opportunities arising from the physical impacts of a changing climate. Climate resilience is a highly complex market to measure. It lacks clear boundaries and few studies have attempted to quantify the economic implications of new products and services that would be needed as the world adapts to climate change. The acute and chronic changes in climate that the world will experience – even if the objectives of the Paris Agreement are fulfilled – are significant and will create market shifts.

This section builds on emerging analysis[6] to identify three broad types of opportunities related to physical climate change impacts.

1. **Opportunities related to managing existing physical climate risks:** Climate change already affects corporations throughout their value chains. As Section 1 on the disclosure of physical climate risks notes, although corporations may not yet have identified and reported the effects on core financials, the impacts remain real. The effective management of these risks may create opportunities to improve financial performance. Changes in revenues, costs and expenditure for example – attributable to preparation for extreme events, contingency planning, event recovery, changes in operating performance, supply chains and customer needs – may improve business processes, efficiency, savings, upgrades to equipment or site retrofits that benefit businesses more broadly. Thus, avoiding the costs of physical climate risks can indeed be seen as an opportunity.
2. **Opportunities to respond to new emerging physical climate risks:** As the acute and chronic effects of a changing climate become more visible, it is inevitable that new physical climate risks will emerge and require responses. Opportunities may arise from planning ahead to manage predicted physical climate risks.
3. **Opportunities to adapt to market shifts and cater to new market needs:** The fundamental shifts in climate over the longer term may affect value chains and drive new consumer needs. For example, water-permeable pavements, or technology to keep buildings cool, are likely to be in higher demand over time, along with water- and energy-efficient technologies, or crops that are better suited to chronic changes in precipitation and temperature.

This framework invites firms to consider short-term and long-term opportunities alike, as well as opportunities to improve internal processes (efficiency, risk management) and expand into new markets as the impacts of climate change become prevalent.

iii. Physical climate opportunities, by industry

Just as some industries are more sensitive to physical climate risks, due to the very nature of their activities, others are better positioned to provide the products and services needed as the world adapts to climate change.

Climate resilience investment opportunities can be broken down into 'horizontal' and 'vertical' solutions:[7]

- **Horizontal solutions** include products and services for physical climate risk analytics and climate resilience that are relevant to all public and private organisations looking to manage physical climate risks and build climate resilience. Products and services may include, for example, engineering, consulting, forecasting, modelling, monitoring and risk management, as well as data and technology development (climate and weather modelling, sector-specific data aggregation and analysis).

- **Vertical solutions** include products and services that cater to specific business sectors that actively manage physical climate risks to businesses and which have unique needs. Examples include:
  - Water sector: water-efficiency software and meters; technologies for water reuse and desalination.
  - Food and agriculture sector: companies developing drought-resistant seeds, drip irrigation and precision agriculture.
  - Healthcare sector: vaccine and pharmaceutical products that address tropical disease vectors.
  - Financial services sector: climate-related risk insurance, risk assessment and parametric insurance.

Table 4 presents examples of industries that could grow due to demand for climate resilience services and products. It gives examples of the climate resilience opportunities that could arise from either managing physical climate risks (existing or emerging) or responding to market shifts, along with their potential financial impacts. Opportunities related to market shifts can emerge from new geographies or new products and services, as well as from innovative ways to adapt existing circumstances to climate change. Note: this table is provided for illustrative purposes and is not an exhaustive list of opportunities for these sectors.

Table 4. Opportunities from climate change: examples for key industries

GICS sector	Opportunity to manage existing and emerging physical climate risks	Potential financial impact[8]	Opportunity to respond to market shifts, develop or promote new products or cater to new markets	Potential financial impact[9]
Consumer discretionary[10]	Anticipating higher or lower demand for specific goods due to physical climate impacts, and adjusting production accordingly	Increased reliability of supply chain and ability to operate under various conditions	Developing tourism in new locations	Better competitive position that reflects shifting consumer preferences, resulting in increased revenues Increased revenue through access to new and emerging markets
Consumer staples	Investing in climate and weather modelling for the purposes of growing crops Investing in drought-resistant seeds	Increased reliability of supply chain and ability to operate under various conditions Increased revenue thanks to new products and services related to ensuring climate resilience Increased revenue through access to new and emerging markets		
Energy	Maintaining power generation plants to ensure they can cope with a changing climate Using water-efficiency software to ensure better planning for hydropower plants	Increased reliability of supply chain and ability to operate under various conditions	Providing customers with responsive energy services that help manage variability in temperature and energy consumption	
Financial services	Implementing new modelling techniques that include the impacts of climate change on core financial metrics	Increased market valuation through climate resilience planning	Providing climate-related risk insurance	Increased revenue through products and services ensuring climate resilience
Health care	Reducing distances travelled for temperature-sensitive products	Increased reliability of supply chain and ability to operate under various conditions	Providing mosquito nets to areas exposed to vector-borne diseases	Increased revenue through products and services ensuring climate resilience
Information technology	Protecting servers and information storage devices against extreme heat	Increased reliability of supply chain and ability to operate under various conditions	Providing data analytics and developing software on climate-related impacts	Increased revenue through new solutions to climate resilience needs Increased revenue through access to new and emerging markets Increased revenue through products and services that ensure climate resilience

Industrials	Investing in energy efficiency and water efficiency for manufacturing sites Enhancing airport infrastructure to adapt to climate impacts (for example, longer runways)	Reduced operational costs Increased reliability of supply chain and ability to operate under various conditions	Responding to new insulation needs in the built environment due to higher temperatures	Increased revenue through access to new and emerging markets Increased revenue through products and services that ensure climate resilience
Materials			Providing climate-resilient construction products Providing advisory services on techniques for constructing resilient buildings	Increased revenue through products and services that ensure climate resilience
Real estate	Consulting services on asset location to assess climate exposure	Increased market valuation through climate resilience planning	Investing in buildings that are both energy efficient and climate resilient Commercial and retail property owners investing in technologies to cool buildings and retrofit existing properties	Adopting a better competitive position that reflects shifting consumer preferences, resulting in increased revenues
Telecommunication services	Protecting data centres against flooding and extreme heat (switching from copper to fibre-optic cables)	Increased reliability of supply chain and ability to operate under various conditions		
Utilities	Using remote monitoring of assets	Increased reliability and efficient operation of assets, boosting ability to operate under various conditions and maintain operational flexibility		

Source: Acclimatise.

Note: 'GICS' denotes the Global Industry Classification Standard.

c. Scope, timeframe and level for disclosing physical climate opportunities

Disclosing opportunities that may arise from climate change raises challenges with regard to the disclosure of forward-looking information. Corporations may also be sensitive about disclosing to investors and competitors quantitative or qualitative forward-looking information about market analyses and anticipated market conditions. This section suggests approaches to addressing these issues.

i. Scope

Recommendation 8: Identify opportunities based on managing physical climate risks and related market shifts

Description

Corporations and financial institutions should strive to identify opportunities in **managing existing physical climate risks and responding to emerging risks**.

Corporations should also assess the potential changes in their value chains and **explore the potential market shifts as customer needs change**. They should target their products and services to cater to growing demand for climate resilience solutions.

Rationale

Climate change is under way, and the impacts can be seen in past and current financial indicators. Companies that are able to assess the indicators within their current core financials and the changes they have observed in recent years will be well placed to manage their existing risks, reduce costs and improve performance.

As the acute and chronic impacts of a changing climate increase, they will become more evident throughout all the elements of corporate value chains. Firms may build on their internal climate risk assessments to identify how addressing these risks may drive cost savings or other business improvements. These improvements may include efficiency, better risk management (across all risks, not just climate change), more effective internal communications and culture, a reduced risk of disruption in the supply chain, and so on. In general, most metrics identified as being potential signals of financial impacts from physical climate risks may become indicators of opportunities to reduce these risks.

Similarly, firms may not be aware of the growing business opportunities tied to climate change if they do not actively seek information about their customers' and target markets' risk profiles and evolving needs. Companies in the sectors highlighted in Table 4, in particular, are advised to investigate opportunities in key markets and opportunities to invest in innovation and develop new products.

ii. Timeframe

Recommendation 9: Assess physical climate opportunities over timeframes relevant to business planning

Description

Corporations should define the appropriate timescales in which to report opportunities in consultation with their investors. The preferred timescales will vary by sector.

- Opportunities in response to managing existing physical climate risks that affect recent and current accounts and the next year's accounts should be reported as part of core financials.

- Those opportunities that arise from responding to emerging physical climate risks should be included in core financials where the impact is expected to affect current management accounts and future short-term trading as well as statements issued to investors on market conditions.
- Opportunities arising from market shifts are unlikely to be reported quantitatively and their disclosure would be more appropriate in the context of general reporting on future business expectations.

Rationale

When considering the timescale for opportunities, this report emphasises the need for corporations and their investors and banks to take a longer-term view than they currently do. Corporations and financial institutions should increase their understanding and awareness of the changes in our climate. Those sectors that might typically have used shorter strategic timeframes for planning must recognise that maintaining business models that use a restricted time period may result in a failure to identify the systemic changes under way and the opportunities they create.

Entities making disclosures need to ensure that they communicate clearly the timespans over which core financial information is reported, especially if these periods extend beyond typical accounting periods. This is necessary to encourage investors, analysts and commentators to focus on the rationale driving the assessments of future opportunities.

iii. Level

Recommendation 10: Disclose physical climate business opportunities at the segment level; for critical facilities, disclose climate resilience benefits at the facility level

Description

Opportunities may be disclosed at different levels to best serve firms and investors.

Opportunities due to shifting market demand or new products should be reported at the segment level,[11] in line with risk disclosures.

Benefits from managing existing or emerging physical climate risks may be disclosed at the segment level (for process or supply-chain improvements, for example). For critical facilities, it may be advantageous for firms to disclose significant climate resilience upgrades or strategic improvements at the facility level, to showcase good stewardship and provide confidence that critical facilities are protected.

Rationale

It may be seen as desirable to report climate resilience opportunities at the level of individual assets within a business. However, caution may be required in promoting disclosure at levels below those of business models, market geographies or products and services, when no similar reporting is currently undertaken at this level by corporations. As Section 1 suggests for physical climate risk disclosures, a pragmatic level of disclosure for corporations might be at the segment level for their key products and services. Alternatively, reporting on key elements of a firm's value chain may be desirable.

d. Metrics for disclosing physical climate opportunities

The TCFD's focus on disclosing against core financials is essential if the private sector is to accept its role in achieving the transition to low-carbon economies, managing and responding to the physical climate risks and providing solutions to help social, economic and environmental systems adapt and build climate resilience.

Firms should acknowledge the importance of accurately accounting for the opportunity effects on their core financials arising from actions to manage current physical climate risks and respond to emerging risks. Concerns about commercial confidentiality and forward-looking statements, however, are relevant and cannot be dismissed lightly. The recommendations in this section cover this focus on financials and provide pointers on addressing concerns about confidentiality.

i. Metrics for climate resilience benefits

Recommendation 11: Disclose benefits from climate resilience investments using the same metrics as for the disclosure of physical climate risks

Description

It is essential to develop metrics to assess opportunities, thus enabling comparisons to be made between companies and across sectors.

- Corporations should adopt the same core financial metrics as those recommended in Section 1d for opportunities that arise from the management of existing physical climate risks and responses to emerging risks. These metrics may include impacts on revenues, operating expenses, capital expenses, supply chain costs, value-at-risk, or projected annual average losses (see Table 3).
- Whenever possible, companies should disclose public co-benefits from their climate resilience investments. These benefits may be disclosed qualitatively or quantitatively.

Rationale

Quantifying the reduction in costs and the losses avoided is consistent with the disclosure of physical climate risks and provides a direct way to quantify financial benefits. Entities making disclosures may find it difficult to identify in their accounts physical impacts of climate change and/or expenditure related to their response to these impacts (for example, through building climate resilience). Corporate financial data[12] should eventually be a useful source of information, but at present its use is limited because accounting practices do not take into account the assessment and disclosure of physical climate risks and opportunities. Revenue changes driven by customers responding to acute and chronic physical impacts of climate change, or investments in capital expenses and/or operational expenses to build climate resilience, may not be identifiable in a company's accounts as being driven by physical climate change.

Qualitative 'soft' reporting is more easily achievable at present. Indeed, this may be the form that many corporations choose to adopt for their reporting, particularly in situations where it is not possible to provide core financial metrics because of the constraints of existing accounting processes. Corporations should still seek to develop quantitative metrics that would allow external disclosure and subsequent interrogation by shareholders and other stakeholders, where appropriate. Where risks and materials could become material in the future, the TCFD advises "disclosure of climate-related financial information outside financial filings to facilitate incorporation once the issues are determined to be material".

Public co-benefits from climate resilience investments include a company's investments in climate resilience that have broader socio-economic or environmental benefits for communities, ecosystems and public infrastructure. These benefits may be accidental or intentional; for many firms, the best way to build climate resilience is to invest in surrounding communities.

It would be beneficial to understand how positive externalities associated with climate resilience activities can be factored into the disclosure of opportunities, recognising that they may deliver a broader dividend that safeguards the firm's licence to operate within the social and environmental context where it is located. There

may also be 'ripple' effects as secondary and tertiary benefits are created beyond the primary financial benefits of an investment in an opportunity that derives from climate change. Assessing these externalities will require a widely agreed accounting framework across multiple regulatory regimes if there is to be any consistency. Such a framework would provide investors with a degree of confidence that the benefits may be reflected in core financials and valuations

Recent work by multilateral development banks (MDBs) on the development of metrics for climate resilience results may provide some insights into how metrics may be used for disclosing climate-related physical opportunities. The MDB Climate Finance Group has developed a system of metrics for climate resilience results[13] that centres on defining the inputs, outputs and outcomes of climate resilience investments in both non-financial and financial terms. The EBRD has developed a further iteration of this joint MDB approach, which it has integrated into the monitoring, reporting and evaluation of its Green Economy Transition approach.[14] This entails expressing climate resilience outcomes in non-financial or physical terms, and then valorised in order to express a monetised climate resilience outcome (or 'climate resilience benefit') in monetary terms. However, further work may be needed to explore how corporations and commercial financial institutions could apply these approaches in the context of climate-related financial disclosures as recommended by the TCFD.

One of the main issues to be addressed is that MDBs and development financial institutions are required to report the wider 'public good' benefits – including climate resilience benefits – that their investment operations deliver, whereas commercial entities are primarily interested in how the physical impacts of climate change affect their core financials. A possible way forward on this issue would be to explore how the above MDB system could be applied through the core financials that are set out in the TCFD, namely, expenditures, revenues, assets and liabilities, and capital and financing.

ii. Metrics to disclose business opportunities from a changing climate

Recommendation 12: Include physical climate business opportunities in qualitative disclosures

Description

The disclosure of opportunities involving market shifts and new products and services can be achieved by qualitative disclosures of the lifecycle of new commercial opportunities. The disclosures may include information on:

- the **development stage** of endeavours
- how the **new area of business explored is related to the company's existing core lines of business**: is this a minor non-core business or adjacent to and synergistic with a core business of the company?
- **size of the potential market** (at a qualitative level): does the new climate-related business that may potentially emerge address a sizeable market where the company has substantial advantages or is it a minor, non-core business?
- approximate length of **time until commercial viability** (in order to avoid creating premature expectations).

Rationale

Corporations face a trade-off between communicating to investors that they are adequately and proactively preparing for climate change, including by seeking new opportunities, and concerns over disclosing potentially sensitive information to competitors. They also need to set and manage reasonable expectations for investors regarding the timeframe and size of the opportunity, against a backdrop of relative uncertainty. Disclosing qualitative information about the process and strategy, as noted above, without providing explicit details of their plans, may achieve a suitable balance between these concerns.

These disclosures can then be used to assess the firm's capacity to respond to the challenges of a changing climate. They can also provide a clear indication to investors and other stakeholders that the company's management is proactive and understands the implications for its business model. The disclosures will also allow investors and others to recognise trends (for example if several firms in the same sector indicate that they are pursuing a promising opportunity that is already at the prototype stage and is about three to five years from commercialisation).

In order to set out their strategies for assessing market alterations driven by a changing climate, companies may use collaborative market analyses, commissioned and planned research, results of pilot tests, assessments of market potential undertaken with government agencies, and identification of markets, products and services representing new and/or synergistic business opportunities and the associated timeframes.

e. Summary table: recommendations on disclosing physical climate opportunities

Table 5. Recommendations on metrics for the disclosure of physical climate opportunities

	Recommendations
8. Opportunities	• Identify opportunities inherent in managing existing and emerging physical climate risks • Identify opportunities based on adapting to market shifts driven by a changing climate

9. Timeframe	• Assess and disclose opportunities using adequate timeframes, according to the industry and the type of opportunity:
	  • snapshot of current context (shortest timeframe)
	  • business planning timeframe
	  • asset lifespan (longest timeframe)

10. Level	• Disclose business opportunities at the segment level • Disclose climate resilience benefits at the facility-level for critical facilities
11. Metrics for climate resilience benefits	• Disclose benefits from climate resilience investments using the same core financial metrics that are used for the disclosure of physical climate risks • In addition, whenever possible, assess and disclose public good co-benefits from climate resilience investments (in other words, the wider economic benefits of managing physical climate risks)

12. Metrics for business opportunities	• Disclose qualitative information on the lifecycle of a new commercial opportunity, including:
	  • the development stage of the endeavour
	  • the business area and connection to company's core business
	  • the size of the potential market
	  • the approximate timeframe for commercial viability

3. Scenario analysis for physical climate risks and opportunities

The numerous uncertainties surrounding climate change naturally lend themselves to the use of scenario analysis. Yet the specifics of how best to use scenarios to explore these uncertainties and integrate climate change into business planning also raise many challenges.

The TCFD recommendations strongly advocate the development and use of scenarios when analysing climate risks and opportunities, a recommendation that many financial institutions and some corporations are already dealing with. The implementation of these recommendations, however, raises methodological and conceptual issues that call for further guidance. In order to contribute to the discussion about physical risk scenarios, this section focuses on how to use scenario analysis to assess uncertain second-order impacts of climate change on corporate value chains, trade flows, and the broader macroeconomic environment, in the context of business planning and possible financial disclosure.

a. What we mean by scenarios

i. Scenarios are different from forecasts

Scenario analysis is generally defined as a method for developing and thinking through possible future states on the basis of different scenarios.[15] The technique does not aim to accurately predict the future but rather seeks to focus attention on causal processes and crucial decision points. By doing so, scenario analysis highlights fundamental uncertainties underlying the strategic decisions that managers must make and helps develop better strategies to overcome the perceptual bias of managers. [16] [17] [18] [19]

The public and private sectors have used scenario analysis and strategic planning since the 1950s. Royal Dutch Shell (Shell) is often cited as the originator of scenario analysis as we know it today. In Shell's approach, scenarios are not descriptive predictions but rather hypotheses about what the future may look like. Therefore, multiple scenarios can be created to accommodate alternative views such as the perspectives of different stakeholders. This helps decision-makers build consensus for change.[20]

In the context of TCFD recommendations, scenario analysis is intended as a tool to address challenges and acquire key information.[21] Scenarios are understood to provide a narrative, either qualitative or quantitative, which "describes a path of development leading to a particular outcome".[22]

Shell notes that it uses different types of scenario: from published 'context exploring' scenarios used to consider external issues that may affect their business, to 'decision-centred' scenarios, which are part of their internal decision-making processes.[23]

The types of scenario that could ideally be considered for scenario analysis are 'context-exploring' scenarios ('views of the world') modelled on the approach of Shell, which allow organisations to capture opportunities and understand risk. The value of developing context-exploring scenarios is in being able to establish a company view of various plausible futures in the face of uncertainty. It also provides investors with a narrative about the company, its management capabilities and its awareness of emerging changes to markets and of new business drivers.

ii. Developing physical climate risk scenarios requires socio-economic and climatic input

In order to encourage the adoption of scenario analysis, the TCFD recommendations include a technical supplement on the use of scenario analysis in disclosure of climate-related risks and opportunities. However, this supplement focuses almost exclusively on carbon transition risk. It offers limited guidance on how to include physical climate risks and opportunities in scenario analysis. This is also true of most other published guidance documents and best practice examples of scenario analysis. In fact, the development of physical

climate risk scenarios has lagged behind in comparison to carbon transition scenarios; comprehensive hypothetical scenarios have not yet been developed or established for scenario analysis of these risks.

A wide body of literature has emerged that suggests various scenarios for energy and carbon transition, with organisations such as the International Energy Agency spearheading the effort, with over 100 carbon transition-pathway scenarios.[24] [25] For carbon transition risks, scenario analysis involves setting out changes in the global energy balance and in country-specific energy, developments in international policy such as carbon prices, and implementation of the Paris Agreement, as well as technology breakthroughs such as electric vehicles.

In contrast with these scenarios, which model the impact of carbon transition risk, the economic implications of physical climate change have not been modelled and packaged for business use with breakdowns for sector and country impact. Sector-level climate impact studies, which use climate model outputs, and integrated assessment models (IAMs), in which biogeochemical and socio-economic components are integrated into the overall model, can be used to explore risks at the sector, system and spatial levels over time. However, the use of IAMs to analyse climate impacts has been far less systematic and limited to a few sectors (for example, agriculture, water, and coastal zones).[26]

iii. Climate scenarios are at the root of scenario analysis of physical climate risks and opportunities

Climate change is just one of the drivers that influence scenario analysis as intended in this report.

The bases of evaluating physical climate risks are Intergovernmental Panel on Climate Change (IPCC) climate scenarios that show how increases in global mean temperatures are driven by concentrations of GHG emissions in the atmosphere. The higher the concentration of GHGs, the higher the likely increase in global mean temperature will be. The difference between one GHG concentration scenario and another depends on the carbon transition pathways taken (that is, the use of regulations and technologies that influence the emission of GHGs into the atmosphere). Four possible pathways for GHG concentration (Representative Concentration Pathways or RCPs) are described by the IPCC, as illustrated in Table 6.[27]

Table 6. IPCC projections of increases in global mean temperatures, based on different RCPs over the medium and long term

	Medium term: 2046-2065	Long term: 2081-2100
GHG concentration scenario	Mean and likely range (in °C)	Mean and likely range (in °C)
RCP 2.6	1.0 (0.4 to 1.6)	1.0 (0.3 to 1.7)
RCP 4.5	1.4 (0.9 to 2.0)	1.8 (1.1 to 2.6)
RCP 6.0	1.3 (0.8 to 1.8)	2.2 (1.4 to 3.1)
RCP 8.5	2.0 (1.4 to 2.6)	3.7 (2.6 to 4.8)

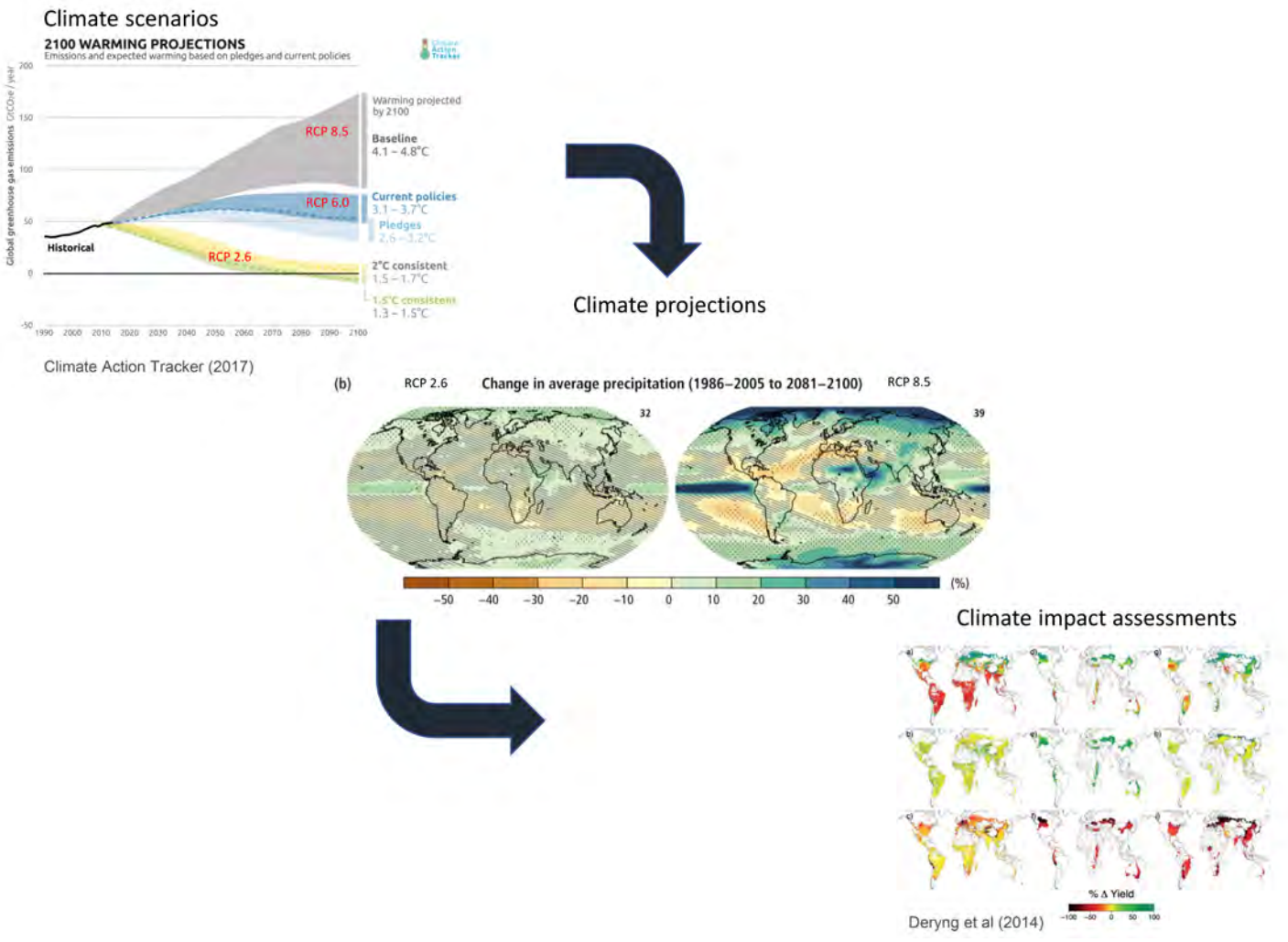
The temperature increases corresponding to the different GHG concentration pathways are then used in climate models to project how changes in global mean temperature may affect other climate-related variables, such as wind speed, rainfall patterns and tropical cyclones. These models are built on the fundamental laws of physics and chemistry. Their outputs are generally used in climate risk assessments (also called climate impact assessments or models) to analyse how a temperature scenario associated with a particular GHG concentration pathway may affect various sectors of the economy. IAMs, as mentioned earlier, have been used to assess impacts in a number of sectors.

In the example provided in Figure 4, various GHG concentration pathways result in a range of projected changes in global mean temperature. The consequent projected changes in climatic conditions across the globe (temperature, precipitation and so on) are then used in climate impact models to calculate the effects on yields of agricultural commodities, for instance. The financial implication of these scenarios may then be measured in terms of changes in commodity production and price.

Similar climate impact assessments can be undertaken to calculate the effects of changes in global mean temperature on other climate-related variables and other economic sectors. For example, climate projections can be used to evaluate the potential future frequency of floods, which can then be used to evaluate the financial implications of such events, such as the impacts on property values.

Figure 4. IPCC climate scenarios are at the root of physical climate impact assessments and further evaluation of potential impacts in socio-economic systems.

Different GHG concentration pathways result in ranges of projected changes in global mean temperature. The "Baseline" area shows the path in the absence of climate policies. "Below 2°C" shows the path needed to keep warming below 2°C from pre-industrial levels by 2100. The temperature ranges shown are the median pathways required to meet targets with a certainty of 66 per cent. The "pledges and Intended Nationally Determined Contributions (INDCs)" area is based on pledges or promises that governments have made since 2015 in the context of the Paris Agreement. In turn, projected changes in climatic conditions (temperature, precipitation and so on) are then used in climate impact assessments or models to calculate the effects in a particular sector.



Recommendation 13: Consider current and desired GHG concentration pathways and related warming projections as a basis for scenario analysis of physical climate risks and opportunities

Description

Firms should not be concerned with developing new climate scenarios themselves. Instead, as a basis for their scenario analysis of physical risks and opportunities, they should consider at least two main types of climate scenario that have already been developed. These cover the current and desired pathways of GHG concentration (see Figure 4 above). They are:

- **Current GHG pathway**: National climate policies currently in place around the world are projected to reduce baseline emissions, which would result in warming of about 3.4°C above pre-industrial levels.[28]
- **Desired ('aspirational') GHG pathway**: These are scenarios compatible with limiting warming to below 1.5°C by 2100 (with a probability ≥50 per cent), and to below 2°C in the 21st century (with a probability of about 80 per cent).

Some degree of consistency in the use of climate scenarios would also enable potential comparison of scenario outcomes for corporations, for example within an investor's portfolio. However, a fully standardised approach is not desirable (see the following sections).

Rationale

In carbon transition-risk scenario analysis, corporations and investors have to explore the reasonable worst case in terms of financial impacts, which corresponds to the 1.5°C scenario in which fossil fuels would be abandoned. However, on the physical climate risk side of scenario analysis, corporations must assess the emissions pathway that the world is currently on, namely, nearly 4°C of warming. The unconditional pledges or promises that governments have made, including Nationally Determined Contributions (NDCs) to the Paris Agreement as of November 2017, would limit warming to about 3.16°C above pre-industrial levels, or in probabilistic terms, would likely limit warming to below 3.5°C.[29] However, these NDCs cannot yet be considered to be business as usual. As a wide gap remains between the current policies and the pledges made by governments, for the time being it is wise to use warming projections that reflect only existing policies.

Corporations should also jointly assess the desired 2°C and 1.5°C scenarios, because long-term impacts under these two scenarios are likely to be similar over the next 20-30 years. For this reason, the climate resilience investments that firms need to undertake for either scenario would be indistinguishable.

b. Why conduct scenario analysis for physical climate risks and opportunities?

Climate change impacts affect most sectors and most regions in the world. Climate impacts – in particular, second-order impacts – are difficult to predict and even harder to mitigate through traditional approaches to risk management. The uncertainty about the impacts of a changing climate and the policy and regulatory responses present significant new challenges when compared with other environmental problems that society faces.

The main reason to undertake scenario analysis is, therefore, to obtain a comprehensive assessment from firms of their physical climate risks and opportunities. Firms should achieve this by exploring different possibilities of what might happen in future despite uncertainty and by integrating climate change considerations into their existing business strategies and financial planning.

For corporations and financial institutions the direct value added by undertaking scenario analysis is that it enables them to align their business strategies, which will make them more robust.

This exercise will also be beneficial in light of policy and regulatory developments. These developments include compliance with TCFD recommendations and further integration of climate considerations into current reporting frameworks, as well as stronger mandates for climate-related financial disclosure.

A general set of principles for the use and development of scenarios emerged from the 2017 TCFD-BoE conference. These principles could help guide organisations through scenario selection: [30]

- Use multiple sources for data and narratives, and search out insights from new sources.
- Ask "What do I have to believe for this scenario to be plausible?"
- Be sceptical about scenarios that look like the past.
- Use the most current data and reference sources.
- Ensure that your scenarios reflect the variety of spatial, political, social, regulatory and environmental factors in the countries and subnational areas in which you operate.

Recommendation 14: Integrate scenario analysis of physical climate risks and opportunities into existing planning processes to ensure strategic, flexible and resilient businesses and investments

Description

Climate scenarios and output should be integrated into the existing business and investment planning of corporations. Some firms – particularly large companies in specific industries – already produce scenarios as part of their business-planning and risk-management processes.

In an ideal situation, companies and investors alike would develop scenarios and undertake scenario analysis of physical climate risks and opportunities.

Rationale

Running scenarios on physical climate risks and opportunities provides assurance that a company is considering a broad range of potential outcomes arising from a changing climate, in addition to other parameters, and can put in place measures to tackle those. It enables the company to make strategic decisions while demonstrating to investors that various risks and opportunities have been considered. Furthermore, although investors do not currently require transparency on climate issues, it is likely that they will as more climate data becomes available.

Therefore, the main motivation for firms (and in turn, for investors) to undertake scenario analysis is to understand a changing world and make the right strategic decisions. **In this sense, the real value of scenario analysis is the ability to ensure strategic, flexible and resilient businesses and investments, and is not the disclosure process in itself.**

Scenario analysis from the perspective of firms:

- provides a strategic business planning tool to identify changes in the risk landscape and potential business opportunities
- enables the construction of plausible views of the future
- allows 'what-if' analysis to be undertaken as well as stress-testing of existing and alternative business plans.

Scenario analysis from the perspective of financial institutions and investors:

- demonstrates that there is a high degree of management capability and expertise
- builds confidence that a company has an external perspective
- provides a view of the future and a vision
- enables investors to assess growth potential and current & short-term performance
- enables investors to compare and contrast corporates' scenarios against their own scenarios.

Some remaining challenges may slow the adoption of scenario analysis. First, the development of scenarios requires leadership at the board level and an ongoing commitment from firms to use time and resources. Not all companies are ready or willing to invest in scenarios such as those used by Shell, which would imply considerable effort and often exceed the information requirements of the company's investors. However, a company could undertake scenario analysis without deploying a full team of scientists.

Second, scenario development is iterative; scenarios need regular reviews to ensure that they reflect the latest information available. Companies would therefore need to monitor their scenarios constantly. But while they need to monitor risks, the scenarios themselves do not necessarily need to be updated constantly in order to see benefits.

Recommendation 15: Avoid standardised scenario analysis in order to have a more comprehensive range of outcomes

Description

Firms are developing their ideas about if and how to standardise their approach to running scenario analyses. In this endeavour, they could use scenarios of physical climate risks and opportunities that others have already developed or build new ones of their own.

Ideally firms should look at more than one scenario and multiple climate models in order to have a more comprehensive range of potential outcomes. Although a degree of comparability is desirable, this report also recommends that corporations develop their own scenarios, which should be highly contextual and based on the values and views of individual firms.

Rationale

As scenarios are meant to be alternative views of the future, no single scenario will be correct on its own. In addition, the use of climate change scenarios to assess business implications remains at an early stage. Due to scientific uncertainty, none of the current scenarios can be seen as the most plausible view of the future.

A standardised scenario would mean overlooking risks and would prevent different businesses from having their own view of the world in the context of their own value chains. Ultimately, it would stifle innovation. What *can* be standardised, however, is the guidance on undertaking scenario analysis, which would enable easier comparisons across companies, sectors and assets.

There would be significant value in having more scenarios published. It would help to capture a wider variety of risks, opportunities and market shifts. Sharing experiences of scenario analysis across organisations is therefore critical to advancing their use.[31]

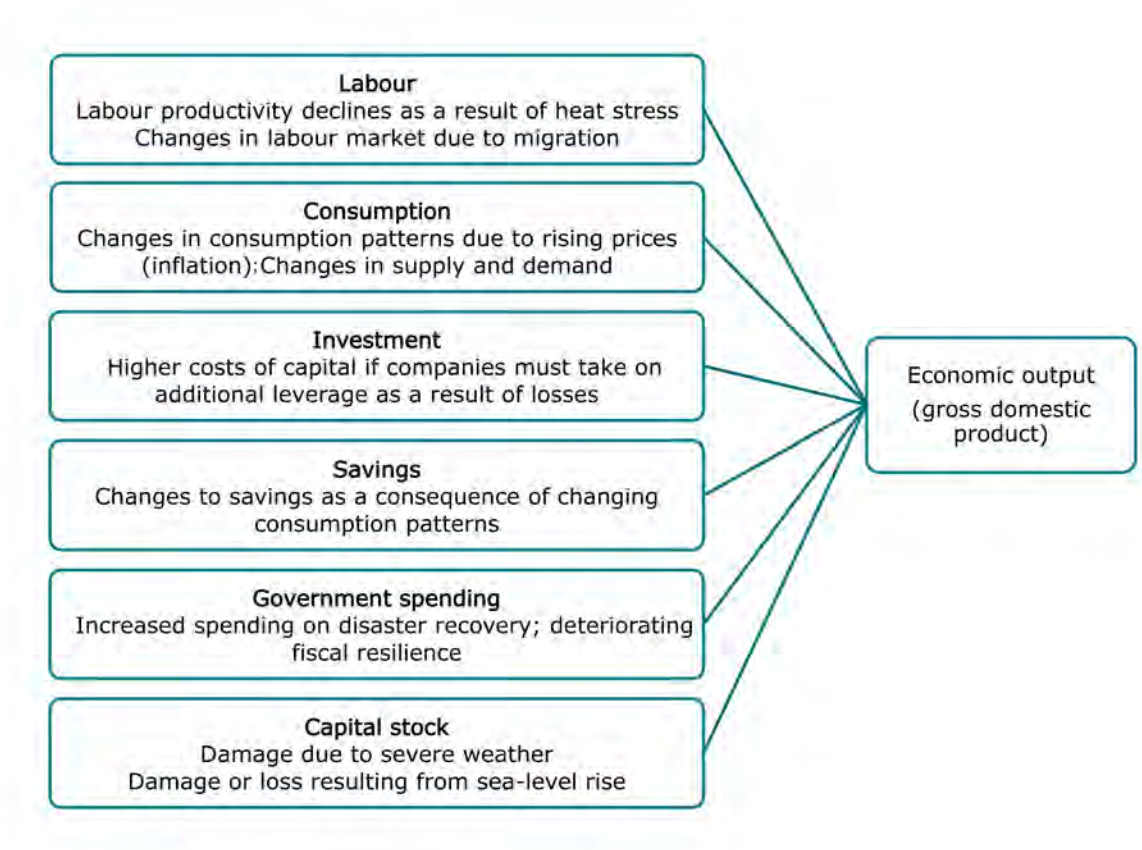
c. Which climate impacts should be considered

Section 1 on the disclosure of physical climate risks provided a simple overview of climate impacts by industry. First-order impacts such as extreme heat and extreme rainfall can be explored using probabilistic modelling. They can therefore be integrated into a standard risk assessment. Second-order impacts are much harder to model and predict, as they follow diffuse pathways from the initial hazard or trigger to the final impacts. They are well suited to scenario analysis because they are impossible to predict with precision, but must be considered due to their wide-ranging and potentially catastrophic effects. Three examples of the macroeconomic impacts of climate are shown below.

i. Climate impact on economic growth

Among other elements, economic growth is affected by factors such as resource endowments,[32] productivity, consumption, and the amount of private and government investment. Each of these determinants is likely to be affected by climate change, as Figure 5 illustrates.

Figure 5. Macroeconomic impacts of climate change



Source: Four Twenty Seven.

We can also expect monetary indicators to be affected by climate change. Inflation can be expected to accelerate due to any economic activity that reduces the supply of goods, such as agricultural products. Interest rates are also sensitive to climate events. For instance, Hurricane Harvey in 2017 affected market expectations, temporarily slowing the job market, retail sales and manufacturing. The economic effects of the hurricane played a role in keeping central bank interest rates low through the third quarter of 2017.[33]

ii. Climate impact on global trade flows

Changes to the climate will affect global trade patterns through long-term impacts such as changes to the comparative advantages of countries. They will also have first-order impacts such as flooded ports and disruption to supply chains.

All business sectors can be directly affected by acute (extreme event) and chronic (slow-onset and incremental) climate changes and the impacts on value chains. Sectors are also affected by second-order impacts, for example the grain price in the United States of America would be affected by movements in the global grain price due to extreme events affecting rice production in South-East Asia.[34] Understanding how climate change

(along with other social, economic and environmental drivers) will affect a business and its value chain offers a comparative advantage in terms of adapting and building climate resilience.

Changes to comparative advantage, which drives international trade, will create new economic winners and losers.[35] But in an increasingly interconnected world, all countries face the risk of economic shocks from damaged infrastructure and supply chain disruptions.

iii. Climate impact on human migration

One of the most important structural impacts of climate change is changes to human migration. Although as yet there is no legal definition of "climate refugees" or "environmental migrants," changes to the climate are already driving forced migration.[36] Subsistence economies are particularly vulnerable as changing weather patterns and effects on water resources lower agricultural output.

The macroeconomic effects of climate change are an area rich with opportunities for further study. Researchers are just beginning to understand the extent of the uncertainties that the world faces with regard to physical climate risks, and how to best incorporate current knowledge into business strategies and financial planning. Deepening our understanding of the links between these risks and economic growth can yield important insights for businesses as they plan for the future.

d. Different types of scenario planning exercise

There is more than one way to conduct scenario analysis. It may be done as a standalone workshop or as a longer-term planning process undertaken on a regular basis by a single company.

The workshop approach: In long-term planning for financial and operational risk management, financial institutions such as banks and insurance companies have used a workshop approach. These workshops seek to incorporate the views and goals of a range of stakeholders.[37]

The firm's approach: scenario planning as a regular exercise. Shell is often cited as having incorporated regular scenario planning into the firm's formal long-term planning process. Its approach is to examine in detail plausible future states (without assigning to them a probability of occurring) in order to challenge the perception – prevalent in many firms – that present circumstances will persist into the future. In the insurance industry, Lloyds Realistic Disaster Scenarios help insurers to consider unlikely – but not implausible – scenarios so they can evaluate the potential implications of a worst-case scenario.

Key steps to scenario planning

Below are some general steps a company might consider during a scenario-planning exercise or when dedicating resources to scenario planning:[38]

- **Define the geographic scope and the planning goal**; identify relevant stakeholders and facilitators.
- **Define the most relevant drivers of change** (climate and non-climate).
    - Address questions about certainties or uncertainties of the relevant physical climate risks and opportunities.
    - Address other drivers of change (socio-economic, political).
- Rank these factors based on their **level of uncertainty** and **importance**.
- **Procure data:** Using robust data to support scenario development ensures a higher quality of output.
- **Build scenarios:** Develop scenarios based on uncertainties identified in the previous step. Build distinct scenarios that portray plausible futures. Consequences of these future scenarios should be considered.
- **Define strategy:** Participants in the scenario-planning exercise can think of strategic alternatives, depending on several possible future states. This should strengthen the company's strategies and it should consider those that are applicable in multiple future scenarios.

- Identify opportunities to **monitor change**, identify signposts and scan for changes to the key drivers of change.

e. How and where to get data

Recommendation 16: Consider data from a wide variety of sources and scales when developing scenario analysis of physical climate risks and opportunities

Description

It is critical to obtain access to datasets covering climate change and other macroeconomic sources of uncertainties in climate projections and in the ability to model and forecast (or not) climate impacts. Access to these datasets makes it possible to lay the foundations for scenarios, including the availability of data at the appropriate scale.

In order to construct plausible physical climate risk and opportunity scenarios, firms should consider inputs from a wide variety of sources and levels of detail. These include: scientific data (not only on climate change); macroeconomic data; socio-economic data; data on political economics and policy; corporate data; a company's vision for growth and market-analysis data; 'big data', and so on.

Rationale

The data used to build those scenarios should take into consideration the global, national and sectoral levels. Moreover, using climate-related data only to build physical climate risk scenarios is not sufficient if firms are to assess the potential financial impact arising from climate change. The boxes below refer to climate, economic, policy and sectoral data as a starting point for establishing scenarios.

The sources identified in these two boxes include mainly open-source datasets, unless otherwise specified. Some datasets provide forward-looking data while others give baseline assessments. Both are useful, as looking to past and present trends can help to develop assumptions about the future. The lists shown here are not exhaustive.

Climate-related data

Global models and studies: IPCC; IIASA SSP database; KNMI; World Bank Climate Change Knowledge Portal, OASIS Hub

Regional or national models and studies: Environmental agencies – European Environment Agency, United States Environment Protection Agency (EPA), Australian Department of the Environment and Energy

Global tools assessing climate risks: Aqueduct (water risk), Swiss Re CatNet,[39] UNEP GRID, AON's Catastrophe Insight (especially on droughts)

Sector-level climate impact studies: Bloomberg maps (thermal and hydro power plants)[40] Four Twenty Seven (corporate and sovereign risk)[41]

IAMs:[42] International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT)

Economy, policy and sectoral data

Global level:

Economy: International Monetary Fund (IMF), World Trade Organization (WTO),[43] OECD, World Bank

Policy: National Determined Contributions (NDCs), Center for Strategic and International Studies (CSIS)

Sectoral: International Energy Agency (IEA), Food and Agriculture Organization (FAO), Asset-Level Data Initiative, Wood Mackenzie[44] (energy), Rystad Energy[45] (energy), IHS[46] (cross-sectoral), International Water Management Institute (IWMI) (water), World Business Council on Sustainable Development (WBCSD) (energy, food, land, water)

Technology: Strategy&, Nasdaq[47]

National level:

Economy: information from central banks, institutes of statistics

Policy: documents available on portals of ministries of environment, economy, finance

Sectoral: information from national provider networks, for example, the UK national grid

Recommendation 17: Take account of scientific uncertainty inherent in climate data and in scenario analysis of physical climate risks and opportunities

Description

Corporations and financial institutions are very well accustomed to making decisions within a large spectrum of uncertainty. **In the same way, they should consider and manage the uncertainty that surrounds the use of climate data and climate science for scenario analysis. Scientific uncertainty should be taken into account and made explicit when assessing climate-related financial risks and opportunities.**

For the purposes of physical climate risk scenario analysis, for example, one main concern is the uncertainty about the magnitude of climate change after 2050. Temperature variations reach a 0.4 to 1.6°C increase under RCP2.6 and up to 1.4 to 2.6°C under RCP8.5 for the period 2046–65.[48] This implies that longer-term scenarios are subject to stronger uncertainty compared to those built on shorter timescales.

The timeframe of scenarios is however to be determined based on the company, sector and assets for which it is constructed. When undertaking scenario analysis of physical climate risks, **no timescale should hence be prescribed as scenarios must fit corporate needs and goals (such as assessing risks, opportunities and market shifts).**

Rationale

It is inevitable that there will be scientific uncertainty about how the climate will evolve in future at the global, regional and country levels. This is due to uncertainties about:

- future changes in society (population growth and development)
- future GHG emissions that drive man-made climate change
- how to model the earth's climate system at global and regional scales
- impacts of climate change
- adaptation responses.

Some aspects are more uncertain than others. For example, firms can be confident that average and extreme temperatures will rise because observations and a range of different climate models all agree this will happen. But there is less confidence with regard to projecting other aspects of the climate, such as changes in precipitation and potential exposure to tropical cyclones. Another important source of uncertainty is how these changes will affect certain infrastructure, sectors and people.

Figure 6 illustrates the so-called 'cascade of uncertainty' in which a range of possible scenarios depend on how future societies evolve and the amount of GHG they emit. In turn, various global and regional climate models predict a range of climate change outputs based on these scenarios. Lastly, the effects of these changes are interpreted through local impact studies.

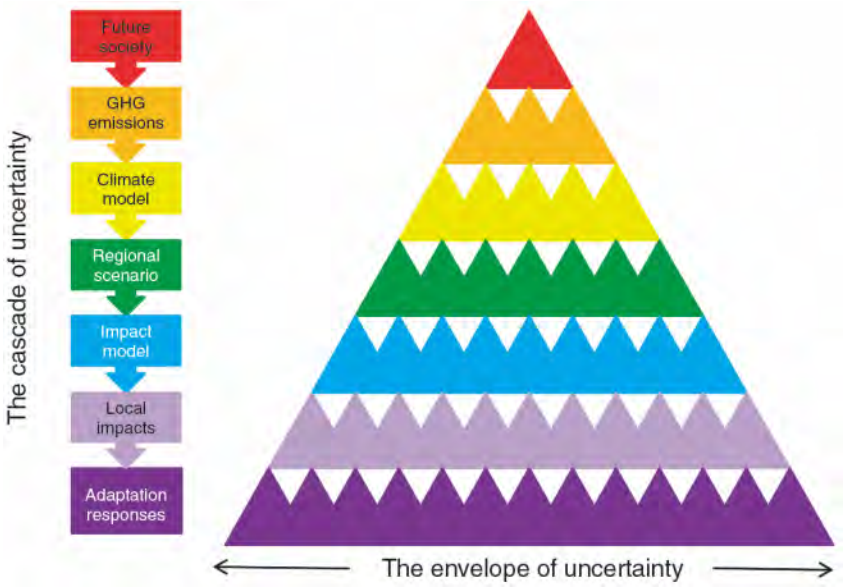
Taking rainfall as an example, models often disagree on the direction of change (whether rainfall will increase or decrease in the future at a given location), as well as the magnitude of change. The impact of this relatively large range on an individual economic system, company or asset relies on many interdependent projections of other factors, for example, socio-economic development, which are likely to be even more uncertain than the original rainfall projections. Decision-makers are left with uncertainty (see Figure 6) against which they need to plan, which can lead them to consider a wide range of adaptation options.

There are a number of ways in which the uncertainty surrounding climate change impacts can be reduced, or at least better accounted for – first, through advances in climate science (such as observations and modelling). However, even with continued improvements in climate modelling, uncertainties in projections will remain for the foreseeable future.

Second, uncertainty can be addressed by a systematic assessment of physical climate impacts and risks – including scenario analysis. Decision-makers can then test adaptation responses against a wide variety of plausible future conditions to discover which are the most robust.

In practice, uncertainty should not be a barrier to action. Rather, it needs to be addressed through adaptive management and the adoption of low regret, win-win measures to build climate resilience.

Figure 6. The cascade of uncertainty and envelope of uncertainty which confront decision-makers



Source: R.L. Wilby and S. Dessai (2010) https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/wea.543

f. What to include in disclosures following scenario analysis

Recommendation 18: Disclose qualitative information that is relevant to the company and its investors

Description

The ultimate objective in disclosing the use of scenarios is to build investor confidence that a company is meaningfully engaged on the topic of climate change, that it is looking at a broad range of outcomes and is responsive and proactive, rather than defensive and reactive. **In this context, firms should disclose information on their physical climate risks and opportunities in the way that is most appropriate to them, as well as to their investors, and to the type of information disclosed or its format (quantitative or qualitative).**

For example, companies may not be comfortable about disclosing sensitive commercial information regarding future investments, or potential liabilities arising from forward-looking disclosures. This complexity should not, however, deter companies from disclosing at least qualitative information or completing scenario analysis.

Rationale

The outcomes of scenarios can also be used as a basis for starting private conversations with investors on business strategy before this information is fed into financial reports. Another way to circumvent the issue is to use scenarios as a way of looking at correlations between climate change and financial impacts. 'Backcasting' (as opposed to forecasting) can then help to set up a baseline that makes it easier to grasp future risks without providing direct, forward-looking disclosures.

Scenario analysis is meant to meet corporate needs and is not aimed solely at climate-change-related financial disclosures. It is a tool that can suit a company's purposes. **Running a scenario analysis, however, should be considered only an initial step; a company must then demonstrate how it will address the outcomes of the analysis through appropriate adaptation measures**.

Scenario analysis can be a helpful tool for engaging and communicating with the investment community. It should be seen as a means more than an end producing a specific metric. As a result, informed discussions between corporations and investors can enhance business strategies that consider physical climate risks and opportunities, among other economic and financial factors.

g. Summary table: recommendations on scenario analysis

Table 7. Recommendations on scenario analysis

	Recommendations
13. Climate scenarios	• Consider current and aspirational GHG concentration pathways and related warming projections as a basis for scenario analysis of physical climate risks and opportunities
14. Motivation	• Integrate scenario analysis of physical climate risks and opportunities into existing planning processes to ensure strategic, flexible and resilient businesses and investments
15. Scenario building	• Avoid standardised scenario analysis in order to have a more comprehensive range of outcomes
16. Data	• Consider data from a wide variety of sources and scales when developing scenario analysis for physical climate risks and opportunities
17. Scientific uncertainty	• Take account of scientific uncertainty inherent in climate data and in scenario analysis of physical climate risks and opportunities
18. Scenario analysis and disclosures	• Disclose qualitative information that is relevant to the company and its investors • Consider scenario analysis of physical climate risks and opportunities as an initial step towards building climate resilience

Conclusion

Efforts to formalise and standardise the assessment and disclosure of physical climate risks and opportunities are still in their infancy. As science and business continue to progress in their understanding of climate impacts, the recommendations made in this report will evolve over time, informed by emerging practices and the continuous efforts of corporations, financial institutions, credit rating agencies, industry groups, think-tanks, regulators and governments to further refine our grasp of what climate change means for business.

For physical climate risks, the key remaining questions to address touch on the materiality of risks and how best to model and quantify future climate impacts. Fully deploying the recommendations included in this report will require significant efforts to determine which methodology and assumptions are best suited to estimating potential future losses or value-at-risk. Over time, quantitative metrics are also expected to emerge, enabling better reporting and comparison of adaptive capacity and risk management strategies. Lastly, corporate engagement by investors and banks is likely to play a critical role in improving our understanding of what constitutes good physical climate risk management practices, and how governance and strategy drive long-term performance against climate impacts.

With regard to opportunities related to the physical impacts of a changing climate, many questions also remain to be addressed. One key area for further research is to deepen our understanding of market opportunities, and develop a methodology or protocol for identifying, assessing and disclosing these opportunities. Questions also remain about how much corporations would and should disclose about of forward-looking opportunities, and what information investors can make the best use of. But the greatest challenge of all is probably the question of how to quantify climate resilience benefits, both public and private. Understanding and measuring benefits beyond a firm's direct sphere of influence could prove critical for building broader social resilience.

Lastly, for scenario analysis, this report explored the benefits from a corporate standpoint and, in turn, for investors. However, this research mostly investigated how to build scenarios rather than how to use them in making business decisions, or how investors might actually use them. Further guidance is needed on scenario methodologies, data used, and assumptions, as well as on how scenario analysis relates to business processes and strategic planning. Such guidance is vital in order to provide a degree of standardisation and comparability.

For all of these topics, broader cross-cutting challenges may also emerge. For example, in light of ongoing policy and regulatory developments for climate disclosures, corporations may need to recognise and address the implications of different regulatory regimes for companies that have multiple reporting requirements. Climate disclosures will remain a topic of active research and discussion, and this reports aims to support the emergence of market practices that bring transparency to markets and help build climate resilience in firms and financial institutions.

References

[1] Climate Action Tracker. See https://climateactiontracker.org/global/temperatures/

[2] See T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds), "Summary for Policymakers", in "Climate Change 2013: The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change", Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. p7 http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_SPM_FINAL.pdf (Last accessed on 25 May 2018).

[3] National Oceanic and Atmospheric Administration (NOAA) – Ocean Acidification: https://www.fisheries.noaa.gov/insight/ocean-acidification (Last accessed on 25 May 2018).

[4] Event attribution is a rapidly developing science, and attribution of select events for the past year is now systematically assessed in the Supplement to the State of the Climate Reports, published annually since 2013 in the Bulletin of the American Meteorological Society. It is likely that confidence in extreme event attribution will continue to improve in the near future. However, while this field remains in development, we recommend including all extreme weather events in financial disclosures, regardless of whether they have been attributed to climate change.

[5] TFCD Final Report, "Recommendations of the Task Force on Climate Related Financial Disclosures" (2017).

[6] For example, the UNEP FI 'Pilot Project on Implementing the TCFD Recommendations for Banks', which is also considering, in the context of TCFD recommendations, opportunities related to the physical impacts of climate change.

[7] J. Koh, S. Swann and E. Mazzacurati, "*Bridging the Gap for Adaptation Finance",* Global Adaptation and Resilience Investors (GARI), (2016).

[8] TFCD Final Report, "Recommendations of the Task Force on Climate Related Financial Disclosures" (2017). Annex II lists examples of opportunities by type.

[9] Ibid.

[10] According to the GICS classification, these are the businesses that tend to be most sensitive to economic cycles (automotive, household durable goods, leisure equipment, textiles and apparel, hotels, restaurants and other leisure facilities, media production and services, and consumer retailing and services).

[11] As defined in recommendation 3.

[12] A similar problem has been encountered in the analysis of climate finance flows through the public sector. This has resulted in the development of techniques for tracking public sector climate expenditure (budgetary analysis, public expenditure review and budget tagging) but these have not been applied in the private sector.

[13] A Framework for Climate Resilience Metrics: Working Paper for Consultation, prepared by the MDB Working Group on Climate Finance Tracking, January 2018 (https://gallery.mailchimp.com/5f1465198e67845c4f22c9dc2/files/4cd94429-7ba3-4070-bf08-576539d5a028/A_Framework_for_Climate_Resilience_Metrics_FINAL4PublicConsult_by_MDB_IDFCWkGrp.pdf)

[14] Implementing the EBRD Green Economy Transition, EBRD May 2018 (www.ebrd.com/documents/climate-finance/implementing-the-ebrd-green-economy-transition.pdf)

[15] Paul H.J. Schoemaker (1995) "Scenario planning: a tool for strategic thinking". *Sloan Management Review*; Cambridge, Mass. Vol. 36, Iss. 2, (Winter 1995): p25.

[16] M.E Porter. (1985) "Competitive advantage", The Free Press, New York.

[17] P.Wack (1985) "Scenarios: Unchartered waters ahead". Harvard Business Review, Sept.-Oct.: pp73-89.

[18] P. Wack (1985b) "Scenarios: Shooting the rapids". Harvard Business Review, Nov.-Dec.: pp139-150.

[19] R.P. Bood and T.J.B.M. Postma (1998), "Scenario analysis as a strategic management tool."

[20] J.N. Maack "Scenario Analysis: A Tool for Task Managers", The World Bank. http://siteresources.worldbank.org/INTPSIA/Resources/490023-1121114603600/13053_scenarioanalysis.pdf (Last accessed on 25 May 2018)

[21] Acclimatise (2017), "Using scenarios in corporate disclosure of physical climate risk", Acclimatise Briefing Note. http://www.acclimatise.uk.com/wp-content/uploads/2017/11/Acclimatise-Briefing_TCFD-Recommendations.pdf (Last accessed on 25 May 2018)

[22] TCFD (2017), "The Use of Scenario Analysis in Disclosure of Climate-Related Risks and Opportunities", Technical Supplement.

[23] "TCFD and BoE Conference on Climate Scenarios, Financial Risk and Strategic Planning" Conference, 31 October -1 November 2017. https://www.fsb-tcfd.org/event/tcfd-boe-conference-climate-scenarios-financial-risk-strategic-planning/ (Last accessed on 25 May 2018)

[24] "TCFD and BoE Conference on Climate Scenarios, Financial Risk and Strategic Planning" Conference, 31 October -1 November 2017. https://www.fsb-tcfd.org/event/tcfd-boe-conference-climate-scenarios-financial-risk-strategic-planning/ (Last accessed on 25 May 2018)

[25] Acclimatise (2017), "Using scenarios in corporate disclosure of physical climate risk", Acclimatise Briefing Note. http://www.acclimatise.uk.com/wp-content/uploads/2017/11/Acclimatise-Briefing_TCFD-Recommendations.pdf (Last accessed on 25 May 2018)

[26] J. Weyant (2017), "Some Contributions of Integrated Assessment Models of Global Climate Change", Review of Environmental Economics and Policy, Volume 11, Issue 1, 1 January 2017, pp115–137.

[27] IPCC AR5 WG1 (2013), Stocker, T.F.; et al., eds., "Climate Change 2013: The Physical Science Basis". Working Group 1 (WG1) Contribution to the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report (AR5), Cambridge University Press.

[28] Climate Action Tracker. See https://climateactiontracker.org/global/temperatures/ (Last accessed on 25 May 2018).

[29] Climate Action Tracker. See https://climateactiontracker.org/global/temperatures/ (Last accessed on 25 May 2018).

[30] "Using scenarios in corporate disclosure of physical climate risk", Acclimatise Briefing Note (2017) http://www.acclimatise.uk.com/wp-content/uploads/2017/11/Acclimatise-Briefing_TCFD-Recommendations.pdf (Last accessed on 15 May 2018).

[31] See "The Use of Scenario Analysis in Disclosure of Climate-Related Risks and Opportunities", Technical Supplement, TCFD (2017).

[32] In economic theory, resource endowments are often referred to as the amount of capital and land in a country.

[33] "Coupled with a debt ceiling showdown postponed to December and some dovish central bank speeches, that prospect has helped bring down the market-implied probability of another US interest rate increase this year to just 25 per cent, down from more than 40 per cent a month ago [in August]," (R. Wigglesworth and G. Meyer, "Investors braced for Irma's impact on markets.", *Financial Times*, (10 September 2017). https://www.ft.com/content/5fb63590-94d8-11e7-a9e6-11d2f0ebb7f0 (Last accessed 11 November 2017).

[34] A. Willis and S. Keyes, "Climate Change Briefing: Questions for Directors to Ask" Chartered Professional Accountants of Canada (CPA Canada), p14 (2017). https://www.cpacanada.ca/en/business-and-accounting-resources/strategy-risk-and-governance/corporate-governance/publications/climate-change-questions-directors-should-ask (Last accessed on 25 May 2018)

[35] The World Trade Organization (WTO) acknowledges in a report that climate change may "lead to shifts in the pattern of international trade. This effect will be stronger for those countries whose comparative advantage stems from climatic or geophysical reasons" ("Trade and Climate Change - World Trade Organization." WTO-UNEP, p64 (2009)) (Last accessed 20 November 2017). https://www.wto.org/english/res_e/booksp_e/trade_climate_change_e.pdf

[36] J. Benko,"How a Warming Planet Drives Human Migration", *New York Times*, 19 April 2017. https://www.nytimes.com/2017/04/19/magazine/how-a-warming-planet-drives-human-migration.html (Last accessed 20 November 2017).

[37] S.S. Moore, N.E. Seavy and M. Gerhart,(2013) "Scenario Planning for Climate Change Adaptation: A Guidance for Resource Managers", Point Blue Conservation Science and California Coastal Conservancy, p10 .

[38] Adapted from T. Wulf, P. Meissner, C. Brands and S. Stubner, "A Scenario-based Approach to Strategic Planning: Integrating Planning and Process Perspective of Strategy", Center for Scenario Planning: Roland Berger Research Unit, p10 (25 March 2010).

[39] Access to this tool entails a fee (unless the company is a SwissRe client).

[40] Access to this tool entails a fee (unless the company already accesses a Bloomberg terminal) and currently focuses only on thermal and hydropower plants.

[41] Access to this tool entails a fee.

[42] As IAMs already build on economic analyses, it is important to avoid double-counting when considering additional economic data within a single scenario.

[43] Access to this tool entails a fee.

[44] Access to this tool entails a fee.

[45] Access to this tool entails a fee.

[46] Access to this tool entails a fee.

[47] Access to this tool entails a fee.

[48] See "Climate Change 2014 Synthesis Report", IPCC, p59 (2014).

European Bank for Reconstruction and Development
One Exchange Square
London
EC2A 2JN
United Kingdom
www.ebrd.com

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