



Assessment and disclosure of corporate climate risks and opportunities

A review of risk in the TCFD recommendations

Academic report from Department of Environmental Science

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Data

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Summary	Climate risks are insufficiently understood and managed by the global business community and as such they present a threat to the stability of the global financial system. The long-term detailed risk analysis in this phase is not covered by the TCFD and will not be met by complying with the current TCFD recommendations, but the TCFD recommendations provide important momentum that can initiate the wider spreading of climate-risk analysis. Based on the work done for this report we can conclude, that climate will increasingly be a strategic factor in business decision-making processes based on risk and opportunity analysis. Corporate disclosure of climate-related risks will gain momentum and importance in corporate financial, CSR and other reporting and disclosure obligations in the near future. Currently it is mainly driven by market demand lead by investors, insurers and the supply- and value-chain of companies. If the current momentum, built from the market, is supported by public policies it could help mature the practice faster and lead it to gain significant prominence in a shorter period of time. This would be a significant contribution to the low-carbon transition.
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1. Introduction

Climate risks are not well understood and acted upon in the global business community¹. Nevertheless, climate change is recognized as the biggest global risk according to the World Economic Forum. Addressing this requires a system wide review – including the business community, which has to contribute more actively to reduce global risks - politics can't make it alone².

The governor of the Bank of England, Mark Carney, pointed in a seminal speech he gave in 2015, to a significant risk. He described that the relative calm the financial markets experience today after the turmoil of the financial crisis in 2007 could be abruptly disrupted by a massive instability due to market shifts caused by global climatic change. In other words, that the financial market could be facing a *climate Minsky moment*³ causing a major threat towards the global financial stability. Mark Carney is also the chairman of the Financial Stability Board (FSB) for the G20 countries and as initiated the FSB Task Force on Climate-Related Financial Disclosures (TCFD) to inform the market about the severe threat climate change pose to financial stability. The former New York Mayor Michael Bloomberg is the chair of the FSB TCFD and candidly stated, regarding climate-related risks, that “*if you can't measure it – you can't manage it*”, highlighting the importance disclosure and transparency so that the market could rationally assess the risks and steer accordingly⁴.

If you can't measure it – you can't manage it—Michael R. Bloomberg, TCFD Chair

How big a risk is it really? And how do we measure it? In 2016 Dietz et al. published a paper in *Nature Climate Change* outlining that the global business community face value assets at risk from climate change of up to US\$24 trillion/yr⁵. The World Bank found in 2015 that Europe suffers losses of approximately US\$3.5 billion/yr of assets value from flooding alone. If emissions remain flat or increase at 2% a year, then total cost increases to at least US\$89 trillion and potentially up to US\$535 trillion. That's US\$1.1 to US\$6.7 trillion every year for eight decades (the global annual defense budget is US\$1.7 trillion)⁶. There are also opportunities in the wake of these risks – the IEA estimates that to meet the reduction targets there is a need to add US\$1 trillion/yr in energy transition investments⁷.

¹ Global Compact (2016) <https://www.unglobalcompact.org/what-is-gc/our-work/environment/climate>

² World Economic Forum Risk Report (2017) <https://www.weforum.org/reports/the-global-risks-report-2017>

³ Coined after the American economist H. Minsky on massive shifts in market stability.

⁴ Christophers, B. 2017. Climate change and financial instability: Risk disclosure and the problematics of neoliberal governance. *Ann Amer Assoc Geo.* (107) 1108-1127.

⁵ Dietz, S., Bowen A., Dixon C., Gradwell (2016). Climate value at risk of global financial assets. *Nature Climate Change, Letter 4/4-2016*. DOI. 10.101338/NCLIMATE2972.

⁶ Hansen, J., M. Sato, P. Kharecha, K. von Schuckmann, D.J. Beerling, J. Cao, S. Marcott, V. Masson-Delmotte, M.J. Prather, E.J. Rohling, J. Shakun, P. Smith, A. Lacis, G. Russell, and R. Ruedy, 2017: Young people's burden: requirement of negative CO2 emissions. *Earth Syst. Dynam.*, **8**, 577-616, doi:10.5194/esd-8-577-2017.

⁷ <https://www.iea.org/newsroom/news/2014/june/world-needs-48-trillion-in-investment-to-meet-its-energy-needs-to-2035.html>

It is the aim of this report to provide an up to the moment snap-shot (31/12-2017) of the most important developments in the work by the TCFD and how this relates to other international developments regarding the assessment and reporting of corporate climate risk and opportunities. We have conducted document analysis of TCFD reports and organized a series of semi-structured interviews with key stakeholders (see further down in section 2) in these developments.

2. The recommendations of the Financial Stability Board (FSB) Task Force on Climate-related Financial Disclosures (TCFD)

The TCFD was launched on 21st January 2016 with the mandate to develop voluntary, consistent climate-related financial risk disclosures for use by companies in providing information to investors, lenders, insurers, and other stakeholders. The Task Force considers the physical, liability and transition risks associated with climate change and what constitutes effective financial disclosures across industries. The work and recommendations of the Task Force will help companies understand what financial markets want from disclosure in order to measure and respond to climate change risks, and encourage firms to align their disclosures with investors' needs. The TCFD recommendations for voluntary climate-related financial disclosures aim to be consistent, comparable, reliable, clear, and efficient, and provide decision-useful information to lenders, insurers, and investors. The TCFD's initial 32 members were chosen by the FSB to include both users and preparers of disclosures from across the G20's constituency covering a broad range of economic sectors and financial markets. The users group consists of large investors, including pension funds (e.g. PGGM) and commercial banks (JPMorgan Chase), whereas the preparers are global operating industry companies (e.g. Tata Steel, Dow Chemicals). Better access to data will enhance how climate-related risks are assessed, priced, and managed. Companies can more effectively measure and evaluate their own risks and those of their suppliers and competitors. Investors will make better informed decisions on where and how they want to allocate their capital. Lenders, insurers and underwriters will be better able to evaluate their risks and exposures over the short, medium, and long-term. TCFD represents an opportunity to bring climate-related financial reporting to a mainstream audience. The TCFD engages extensively with key stakeholders to ensure that it builds on existing work and produces recommendations that can be used by the private sector, globally. In short, increasing transparency makes markets more efficient, and economies more stable and resilient⁸.

Increasing transparency makes markets more efficient, and economies more stable and resilient—Michael R. Bloomberg, TCFD Chair

The lack of consistent information on the financial implications around the climate-related aspects of an organization's business, hinder investors and other financial intermediaries from considering those climate-related issues in their asset valuation and allocation processes. Investors need to know which companies are most at risk from climate change or which ones are best prepared to avoid financial instability. Given such concerns the Task Force's final report (June 2017) has published a voluntary, consistent framework that provides recommendations to companies, on more effective disclosure about the risks and opportunities presented by climate change. These recommendations could "promote more informed investment, credit, and insurance underwriting decisions" and, in turn, "would enable stakeholders to understand better the concentrations of carbon-related assets in the financial sector and the financial system's exposures to climate-related risks". The framework improves the ease of both producing and using climate-related financial disclosures. The Task Force focuses on financial impact by identifying four major categories of financial impacts—revenues, expenditures, assets and liabilities, and capital and financing—that are likely to be most relevant for

⁸ <https://www.fsb-tcfid.org/>

specific industries. The first two are related to income statement and the second two are related to the balance sheet:

1. Revenues. Transition and physical risks may affect demand for products and services. Organizations should consider the potential impact on revenues and identify potential opportunities for enhancing or developing new revenues.
2. Expenditures. The organization's cost structure. Lower cost suppliers may be more resilient to changes in cost resulting from climate-related issues and more flexible in their ability to address such issues.
3. Assets and Liabilities. Supply and demand changes from changes in policies, technology, and market dynamics related to climate change could affect the valuation of organizations' assets and liabilities.
4. Capital and Financing. Climate-related risks and opportunities may change the profile of an organization's debt and equity structure, either by increasing debt levels to compensate for reduced operating cash flows or for new capital expenditures or R&D.

The Task Force encourages organizations to undertake both historical and forward-looking analyses when considering the potential financial impacts of climate change, with greater focus on forward-looking analyses as the efforts to mitigate and adapt to climate change are without historical precedent. Moreover, for many organizations, identifying and assessing the financial impacts of climate-related issues are not always clear or direct, and much more challenging ensuring these issues are reflected in financial filings. This is one of the reasons the Task Force believes scenario analysis is important for organizations. They need to assess potential business, strategic and financial implications of climate related risks and opportunities and disclose those, as appropriate, in their annual filings.

A critical aspect of the scenario analysis is the selection of a set of scenarios (not just one) to cover a variety of possible future conditions (both favourable and unfavourable) for the companies. Taking into account that the level and type of exposure and the impact of climate-related risks differs by sector, industry, geography, and organization, the Task Force recommends using a 2°C or lower scenario in addition to two or three other scenarios most relevant to the organization's circumstances (Nationality Determined contributions, physical climate-related scenarios, etc.).

The Task Force recommends a qualitative approach for those companies beginning to use scenario analysis, but for organizations with more extensive experience in conducting scenario analysis recommend greater rigor and sophistication in the use of data, quantitative models and analysis. Therefore, organizations may decide to use existing external scenarios and models or develop their own, in-house modeling capabilities.

The Task Force structured its recommendations around four thematic areas that represent core elements of how organizations operate—*governance, strategy, risk management, and metrics and targets*. For each of these areas, it provided the climate-related recommended financial disclosures—referred to as recommended disclosures—that organizations should include in their financial filings or other reports to provide decision-useful information to investors and others, see Figure 1 below.

Recommendations and Supporting Recommended Disclosures

Governance	Strategy	Risk Management	Metrics and Targets
<p>Disclose the organization's governance around climate-related risks and opportunities.</p>	<p>Disclose the actual and potential impacts of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning where such information is material.</p>	<p>Disclose how the organization identifies, assesses, and manages climate-related risks.</p>	<p>Disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material.</p>
Recommended Disclosures	Recommended Disclosures	Recommended Disclosures	Recommended Disclosures
<p>a) Describe the board's oversight of climate-related risks and opportunities.</p>	<p>a) Describe the climate-related risks and opportunities the organization has identified over the short, medium, and long term.</p>	<p>a) Describe the organization's processes for identifying and assessing climate-related risks.</p>	<p>a) Disclose the metrics used by the organization to assess climate-related risks and opportunities in line with its strategy and risk management process.</p>
<p>b) Describe management's role in assessing and managing climate-related risks and opportunities.</p>	<p>b) Describe the impact of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning.</p>	<p>b) Describe the organization's processes for managing climate-related risks.</p>	<p>b) Disclose Scope 1, Scope 2, and, if appropriate, Scope 3 greenhouse gas (GHG) emissions, and the related risks.</p>
	<p>c) Describe the resilience of the organization's strategy, taking into consideration different climate-related scenarios, including a 2°C or lower scenario.</p>	<p>c) Describe how processes for identifying, assessing, and managing climate-related risks are integrated into the organization's overall risk management.</p>	<p>c) Describe the targets used by the organization to manage climate-related risks and opportunities and performance against targets.</p>

Figure 1: TCFD analysis⁹.

⁹ Source: TCFD Implementing the recommendations of the Task Force on climate-related financial disclosures, June 2017

Companies are encouraged to comply with the scenario development outlined in Figure 2 below:

A Process for Applying Scenario Analysis to Climate-Related Risks and Opportunities

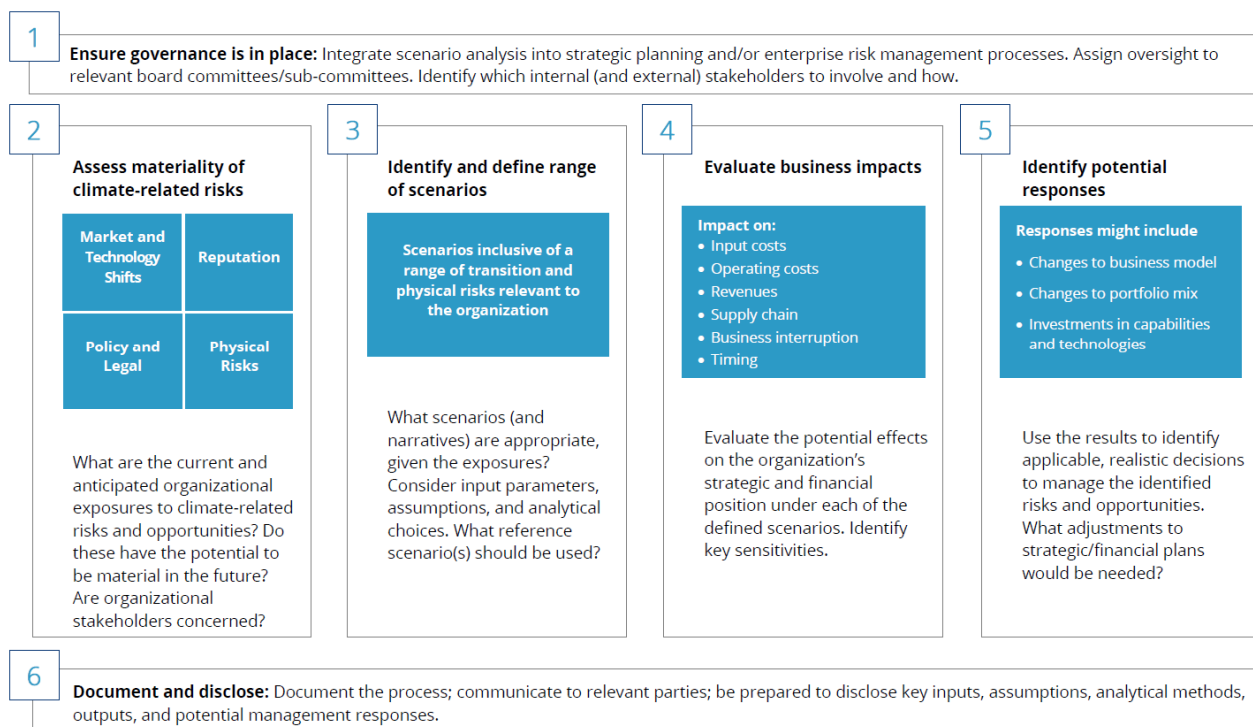


Figure 2: TCFD scenario analysis¹⁰

The final TCFD report of June 2017 has helped mainstream the importance of climate-related financial disclosures and has received strong support from stakeholders. As an example of this momentum, consider the following public expression of support to TCFD recommendations:

- 237 global companies with a market capitalization of US\$ 6.3 trillion publicly supports the TCFD plans;
- 24 global new companies signed up during the one planet summit in Paris Dec 2017
- 11 companies have committed to implementing the TCFD's recommendations in the next three years through CDSB's commitment;
- 130 investors (with over US\$13 trillion AUM) have written to the G20 to encourage the group to consider the TCFD's recommendations as input to their national disclosure rules;
- the UK Government has publicly welcomed the TCFD recommendations and subsequently established the Green Finance Taskforce to develop recommendations for the UK Government on green finance;
- All six major UK banks support TCFD
- to feed into the UK Governments Green Finance Taskforce, the City of London has established the Green Finance Initiative (GFI);
- the Council of Europe conclusions from the climate finance forum in October welcomed the development of the TCFD recommendations;

¹⁰ Source: TCFD, Technical supplement – the use of scenario analysis in disclosure of climate-related risks and opportunities, June 2017.

- the World Council on Sustainable Development (WBCSD) endorsed the TCFD (Dec 2017)
- the High-Level Expert Group recommended in its interim report (July 2017) the integration of the TCFD recommendations in EU policy framework to strengthen disclosure on all sustainability dimensions by financial and non-financial;
- the World Bank announced in Dec 2017 that they will not invest in oil and gas projects in the future due to the Paris agreement and the TCFD recommendations¹¹
- CDP, in recognition of the important role of TCFD in mainstreaming climate-related information and advancing the availability of financially relevant information for global markets, will align its 2018 climate-disclosures with the TCFD's recommendations, alongside introducing a sectoral focus and adopting a forward-looking approach to climate-risk disclosure.

In the past, there has also been relevant guidance on climate-related risks, e.g. the Security Exchange Commission (SEC) 2010 guidance on climate risk disclosure. However, the lack of clear mandates for this information, detailed guidance on how to do climate-related risk assessment and recommendations on how to report it have undermined the wide-adoption and consistency of climate-related risk disclosure. The expectation is that considerable momentum is built around TCFD work, namely by entities with regulatory powers and supervision mandates – such as ESMA, European Banking Authority (EBA), European Insurance and Occupational Pensions Authority (EIOPA), SEC, etc. - which will help drive its adoption and momentum. The widespread adoption of the recommendations will ensure that the effects of climate change become routinely considered in business and investment decisions. That will lead to smarter, more efficient allocation of capital, and help smooth the transition to a more sustainable, low-carbon economy.

¹¹ <https://www.theguardian.com/business/2017/dec/12/uk-banks-join-multinationals-pledge-come-clean-climate-change-risks-mark-carney>

3. Types of risks facing businesses

In the investment journey, investors and businesses face many types of risks and opportunities. In the case of climate these risks respect to increased physical risks hurting the high-carbon economy as a result of its incapacity to transform itself; as well as the risks of business model disruption from the technical, policy and social responses to mitigate and adapt to climate change. The TCFD defines these as two main types of risks for businesses and financial institutions: 1) physical risks and opportunities and 2) transitional risks and opportunities. Both of these risks have an acute (short-term) and a chronic (long-term) phase, which needs assessment. Physical risks are the traditional climate related impacts such as acute risks of flooding; drought; storms; etc., which affect the company directly or indirectly via the value and supply-chain if they are affected by extreme weather (acute risk). The impact can also be more gradual and long term such as sea level raise; desertification; temperature increase; novel diseases and others.

As an example of direct and indirect physical risk exposure the 2011 floods in Thailand is a powerful example. It caused \$ 45 billion US dollars in damages and Thailand GDP shrunk by 10% - taking more than 1 year to recover and return to normal (World Bank, 2015). The supply chain disruption of the floods was felt around the world: more than 800 companies affected - mainly IT - as Thailand is the second largest hard-drive producer in the world (affecting companies such as Acer; Samsung; Apple; Lenovo). Car manufacturers like Toyota, Nissan and Mazda, whose major manufacturing and assembly productions in Thailand moved from Japan, faced massive losses and global ripple effects, with 50% of operations not having restart after 6 months.

The transitional risks (and opportunities) are mainly related to changes in the policy cycles (e.g. the EU Road Map towards a low carbon economy; the Paris Agreement; etc.) and investment portfolios. For example, an increase in carbon pricing as a consequence of the Paris Agreement: e.g. the current carbon price in Denmark is 26\$ (2016) and this is conservatively expected to quadruple in 2030 to more than \$100 according to the World Bank (2017)¹². Also the expected transition to a lower-carbon economy by the International Energy Agency, is estimated to require around \$1 trillion of investments a year for the foreseeable future, generating new investment opportunities¹³. These risks can also be short (e.g. conflicts; dramatic shifts in politics) and long term (e.g. national and international policies and agreements). It is clear from the Figure 3 below that significant policy changes and thus transition risks are forthcoming in the near future to meet the goals set by policy makers. It is clear that the current policy will need revision to meet the greenhouse gas emission targets. It is also clear that the current policies and the pledges made are not on track to a 1.5 to 2 degree temperature increase - hence transitions will take place to meet the targets.

¹² <https://openknowledge.worldbank.org/handle/10986/25160>

¹³ <https://www.iea.org/newsroom/news/2014/june/world-needs-48-trillion-in-investment-to-meet-its-energy-needs-to-2035.html>

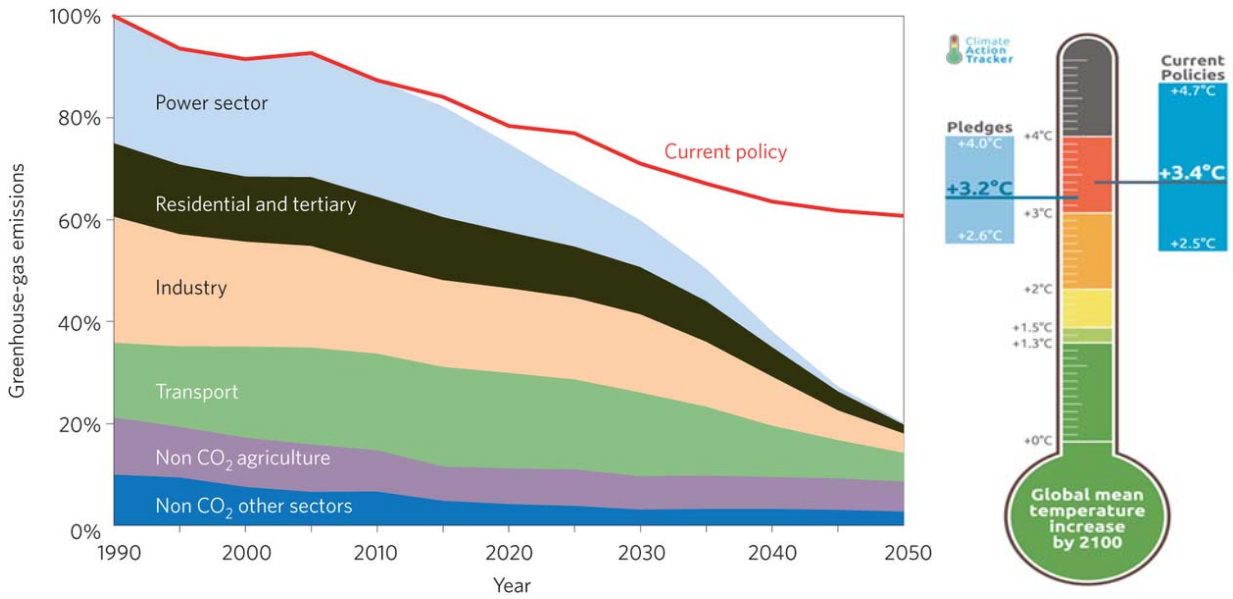


Figure 3: EU policy (EU Commission) vs. greenhouse gas emissions (Carbon Tracker Initiative)

Figure 4 below illustrates the two major types of risks from a TCFD perspective.

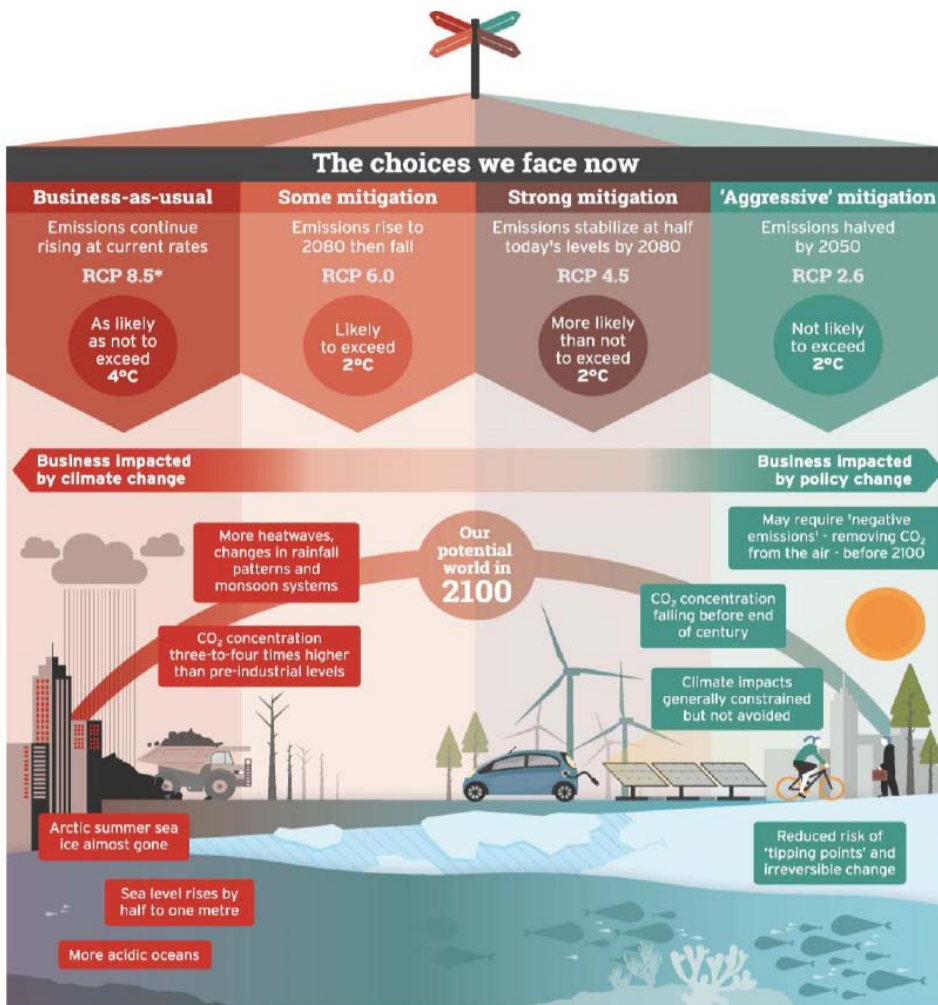


Figure 4: Physical and transitional risks (TCFD 2017)¹⁴.

It is clear that the real-world situation will have a blend of both physical and transitional risks opportunities, as well as a mix of acute and chronic risks in particular because a certain amount of climate change has already been committed too and certain impacts are already unavoidable. Companies will have to balance the different types of risks as well as the trade-offs between them, see Figure 5.

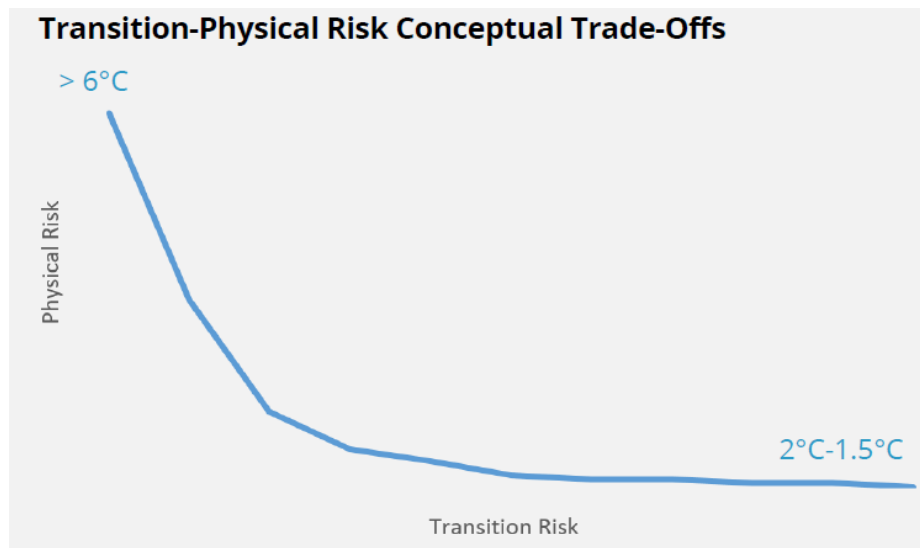


Figure 5: Climate risk-risk trade-offs (TCFD, 2017)¹⁵

Companies will be affected by both costs related to physical risks and/or transitional risks and need to assess the risks and opportunities in balancing their planned activities and investments accordingly. A prerequisite to do this successfully is an accurate and precise assessment of all types of risks and opportunities.

So how can businesses measure and manage their risks and opportunities? Firstly, the company needs to assess risks – the opportunities are the positive innovative upsides to the risks – both in terms of addressing cost savings as well as market openings, signals and milestones. Very briefly, the quantitative climate risk analysis (physical; transitional; acute; chronic) contains the same basic elements as all risk assessments; Problem formulation and defined protection aims → hind-cast assessment of climate risks and costs → initial desk-top risk screening for prioritization → assess the maximum allowable effect size of the impact → assess the probability of the impact occurring → assess the temporal and special extrapolation uncertainty → develop scenarios → assess options and the costs of actions and inactions → determine the risk-benefit-cost ratios of options → determine the return of investment → prioritize options and actions → prepare information for decision-making in near and longer term. These steps of course need to be co-created with in-house experts as well as external experts, and sub-divided in multiple business area in-house and in the value-chain.

¹⁴ Source: TCFD, Technical supplement – the use of scenario analysis in disclosure of climate-related risks and opportunities, June 2017.

¹⁵ Source: TCFD, Technical supplement – the use of scenario analysis in disclosure of climate-related risks and opportunities, June 2017.

The purpose of the risk assessment is of course to inform decision-making. Appreciation of the acute extreme weather related physical risks can be used to assess the maintaining of the *status quo* for businesses. Appreciation of the more chronic and systemic transitional risks, might cause companies to look more into new ways of doing business that challenge incumbents. In both cases, damages costs can be curtailed and profits can from the volatility in value assets in a “messy” changing system. For investors, the initial significance of these risks is highly depended energy transition away from fossil-fuels – but they also need to consider the temporal aspects¹⁶.

Climate change is the tragedy of the horizon. We don't need an army of actuaries to tell us that the catastrophic impacts of climate change will be felt beyond the traditional horizons of most actors – imposing a cost on future generations that the current generation has no direct incentive to fix. The horizon for monetary policy extends out to two to three years. For financial stability, it is a bit longer, but typically only to the outer boundaries of the credit cycle – about a decade. In other words, once climate change becomes a defining issue for financial stability, it may already be too late.” –Mark Carney, FSB Chair.

TCFD recommendations in practice: views of practitioners and influencers:

The following paragraphs result from the interviews conducted to users and developers of the TCFD recommendations, as well as a summary of the TCFD workshop in November 2017. They reflect somehow the state-of-the-art both in the understanding of climate-risk assessment that has done by businesses in practice and the expression of those assessments in climate-risk disclosures, as proposed by the TCFD.

Potential application of TCFD recommendations – results of interviews with users and developers and TCFD workshop in November 2017:

Corporations:

An ongoing dialogue with global multinational companies, in areas as diverse as personal and household care products, maritime transport or Oil & Gas has been conducted. All companies expressed very high interest in the TCFD work. Some companies noted that the qualitative scenario risk development would be possible to implement (while two companies had already developed it). However, a more detailed and quantitative full risk and opportunity analysis will require significantly more work and consideration to inform further strategic investments. The understanding of how scenarios can be used to inform risk-informed decision making is still incipient as well as the methods to quantify the financial impacts of those risks. However, at least in some of the companies, if not all, there seems to be the technical capacity to do these type of analysis.

¹⁶ <https://www.theguardian.com/environment/2015/sep/29/carney-warns-of-risks-from-climate-change-tragedy-of-the-horizon>

Investors:

The 2degree-initiative confirmed the obvious overlap between the TCFD and the High Level Expert Group on sustainable finance to the EU Commission (HLEG) ¹⁷ and that the two are somewhat in alignment. Several stakeholders confirmed that the inclusion of TCFD recommendations in the non-financial reporting (NFR) directive would be an important step forward. This reinforced the important aspect of having TCFD recommendations (market driven and voluntary) embedded also in a regulatory framework or at least, having regulatory frameworks that drive demand for its use – without mandating it. The importance of Article 173 in the French Energy Transition Law in driving momentum and interest by financial institutions in France for climate-risk assessment was commented at least by one stakeholder. Central banks and insurers are already internally conducting climate risk analysis to inform their decision making. This was confirmed from our discussion with AVIVA investors who mentioned that they already use the TCFD framework in their discussions with companies. The European Security and Markets Authority (ESMA)¹⁸, which contributes to safeguarding the stability of the European Union's financial system, could incorporate TCFD guidelines via the HLEG recommendations. AVIVA also commented on the importance of streamlining guidelines, indicators, and the creation of standards for climate-risk assessment and disclosure in order to allow comparison between different companies. There are already 10-15 large investment organizations that are promoting the TCFD and they expect that this group will grow significantly next year and the years to come. Currently, mostly transitional risks are being addressed. Furthermore, recognizing the importance of the TCFD effort for the industry, CDP has aligned its information requests with the TCFD's recommendations, alongside introducing a sectoral focus, and adopting a forward-looking approach to climate-risk disclosure. This harmonization will help to drive the adoption of TCFD recommendations by reporting companies, optimize the reporting burden and speed-up the generation of decision-useful information for data users.

Consultants:

We discussed the suggested risk analysis methods with Environmental Resources Management (ERM) who are working with companies today on climate risk and opportunities and have supported TCFD in some of its work. They highlighted that the non-financial disclosure report should also include climate risks. Moreover, that it's important for the companies to clarify the first order impacts of climate (physical) to then better understand and forecast the potential transitional risks. Lastly, companies should also be aware of second-order (and up) indirect effects such as social disruption and systemic effects and shifts. It is important for companies to understand that the analysis are not projections but very likely and plausible futures facing the company. There is still a steep learning-curve on climate assessment and reporting within companies but this is being reduced; more and better analysis and disclosure models are being developed.

¹⁷ HLEG: <http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=3485&NewSearch=1&NewSearch=1&Lang=EN>

¹⁸ ESMA: <https://www.esma.europa.eu/>

Bloomberg (TCFD):

We discussed the guidance documents with a representative from Bloomberg. It is an ambition by the TCFD that the assessment and reporting is manageable. The sign-up is increasing and is expected to accelerate more in 2018 after also the World Business Council of Sustainable Development has provided their support to the TCFD reporting in December 11 2017 during the Paris meeting¹⁹. They will issue a new status report in early 2018 on the progress. Case studies will be reviewed and the guidance will be reviewed. Sign-ups are being made more stream-lined and not only CEO's can sign for a company.

TCFD international workshop in November in London held by Bloomberg:

We summarized the main points from the workshop can be found below:

- During the definition of the TCFD recommendations the two principal categories of climate risk: transitional and physical risks avoiding the detail level analysis of the first ones (market and technology shift, policy and legal, reputational).
- There was a generalised positioning about the benefits of scenario analysis, always framing this approach as data-driven stories, descriptions of external environment, hypothesis and identification of possible futures, but never as forecasts, acknowledging the several uncertainties inherent to climate change.
- Regarding this it was also pointed out that oil and gas is an advance sector when using scenario analysis for informing strategic decisions, using climate change among the key variables they apply. Anyhow, transition risks seem to be predominant with little consideration to physical risks. On the contrary, pioneer electricity utilities (ENEL and EDF), based on historic extreme events such as heatwaves and flooding which caused considerable damages in their assets and activities, are undertaking robust physical climate risks analysis to inform investment and operational decisions.
- Last but not least, the financial sector is seriously considering how climate risks could affect their investment portfolios, mainly focused in transitional risks through well positioned initiatives like "2ii", but also with incipient tools for integrating physical risks in the portfolio assessments.
- Significantly, no mention was done to the HLEG, being anyhow the concluding overarching message that this is just starting and will be progressively widespread to other economic sectors.

¹⁹ WBCSD: <http://www.wbcsd.org/Overview/Resources/General/CEO-Guide-to-climate-related-financial-disclosures>

4. Navigating climate-risk assessments for businesses in practice – where to start?

A number of methodologies, models, tools and data sets currently exist to allow organizations to begin using scenario analysis to assess the implications of climate change. This section has classified them in order to provide their functionality and usability for some organizations but also with the aim to identify gaps and possible further developments at this respect. This classification has started by taking into account the tools and data listed in the Appendix 4 of the Technical supplement²⁰, but has been complemented by additional ones not listed there.

Portals with a range of tools and data:

- The Applied Systems Analysis (IIASA) provides a wide variety of land, energy, transition, and water tools as well as online databases
- The European Climate Information Portal (CLIPC: <http://www.clipc.eu/>) provides access to climate information that includes data from satellite and in-situ observations, climate models, data re-analyses, and transformed data products enabling assessment of climate change impact indicators. Furthermore, CLIPC provides a toolbox to generate, compare, manipulate, and combine indicators.
- Copernicus is the EU satellite observation platform (<http://www.copernicus.eu/>)
- OASIS is an open source platform for modeling risks (<https://oasislmf.org/>)

Portals with a methodologies or frameworks to guide companies:

- Europe PROVIA and MEDIATION Adaptation Platform provides a methodological framework to go through scenario analysis. It also provides a toolbox with methods and tools that are suitable to inform decision-making.
- National Oceanographic and Atmospheric Administration (NOAA) provides a methodological framework (U.S. Climate Resilience Tool Kit) for companies to explore Hazards, Assess Vulnerability and risks, investigate options, prioritize, plan and take action. It also provides a visualization tool (Climate Explorer) to explore interactive graphs and maps of climate projections and observations for any county in the contiguous United States

Datasets specific tools:

- There are available a lot of datasets and data sources tools that provide charts, maps and data of observed and projected climate variables, such as the Climate Wizard (Nature Conservancy) that represents for the first time ever the full range of climate history and impacts at global level. ESRI ArcGIS ArcView (National Science Digital Library) distributes a subset of all data produced by the CCSM. One can view and/or download monthly mean, 2D atmospheric and land variables from the CCSM component models (see Annex for additional information).

²⁰ TCFD, 2017, Technical supplement - the Use of Scenario Analysis in Disclosure of Climate-Related Risk and Opportunities, June 2017.

Sector specific tools:

- Food and Agricultural Organization of the United Nations provides a Modelling System for Agricultural Impacts of Climate Change (MOSAICC).
- The World Resources Institute (WRI) provides a tool/database, known as Aqueduct, to help companies, investors, governments, and communities better understand where and how water risks are emerging around the world.
- WWF provides a similar tool known as “The Water Risk filter” that helps companies across the world assess their water risk.
- The U.S. Environmental Protection Agency (EPA) provides a tool known as the Climate Resilience Evaluation and Awareness Tool (CREAT), which is a risk assessment application for utilities in adapting to extreme weather events through a better understanding of current and future climate conditions. The U.S EPA also provides tools and guidance for water utilities called Creating Resilient Water Utilities (CRWU). CRWU provides water utilities with practical tools to increase climate change resilience and understand long-term adaptation options.

Scenarios:

Scenarios can be divided into two family of scenarios: climate-impact scenarios, resulting from physical models of earth’s climate system, including coupled components like atmosphere, oceans and land system models (e.g. Community Climate System Model or GISS Model E); and transition scenarios related to future transition pathways for the global economy, usually linked with socio-economic and/or energy system modelling and integrated assessment models. Notable examples include DICE (William Nordhaus), TIMES (ETSAP/IEA) and GREEN (OECD). Both these types of scenarios can be used to inform global and macro assessments of potential climate-related impacts to inform scientists and policy makers. IIASA, for example, maintains a database of long-term scenarios reviewed in the Fifth Assessment Report (AR5) of Working Group III of the Intergovernmental Panel on Climate Change (IPCC). However, both climate-impact and transition scenarios often do not provide the ideal level of transparency, range of data outputs, and functionality of tools that would facilitate their use in a business or investment context. Further developments related with the transparency on model inputs and assumptions, as well as a more detailed template of model outputs disaggregated at sector, geographical and industry level, is needed to be useful for companies.

Best practices/Sector specific examples:

There are only few portals with examples and best practice of climate risk assessments. Sharing of experiences across different organizations and best practices publications could also be important for learning purposes. Examples include Cambridge Center for Science and Policy publication “Climate Change: A Risk Assessment” and national risk assessments²¹. The Danish adaptation portal also includes a few examples – all of them in Danish²².

Physical risks assessments and decision making under deep uncertainty:

Recently, new approaches, methods and tools are emerging to facilitate risk assessments, strategic planning and investment decisions in the context of changing climate and the uncertainties associated to the future state of economy, environment and climate.

²¹ <https://www.theccc.org.uk/tackling-climate-change/preparing-for-climate-change/uk-climate-change-risk-assessment-2017/>

²² <http://www.klimatilpasning.dk/erhverv.aspx>

Decision Tree Framework:

This is a risk assessment method developed by the World Bank²³. The main objective of this framework is to assess the vulnerability of planned investments to physical risks that are related to potential future climate conditions, including the uncertainties herein, and the adjustments needed to improve the feasibility and profitability of the investments. The framework is based on a “bottom-up” approach to risk assessment that aims at a thorough understanding of vulnerabilities to climate change in the context of other non-climate uncertainties (for example, economic, environmental, demographic, or political). Recent applications include infrastructure, ports and harbors and hydropower sector. Another example of a bottom-up approach for risk assessment and decision making is CRIDA, Collaborative Risk Informed Decision Analysis Assessment. This approach is designed by the Alliance for Global Water Adaptation, and provides a stepwise approach to conduct a vulnerability assessment and to design robust climate Adaptation Pathways²⁴. As traditional approaches to assessing climate risks emphasize a top-down approach that begins with downscaling climate models to local scales, connecting these outputs to physical indicators of interest, the CRIDA top down approach begins with approaching stakeholders to define a vulnerability domain (“breaking points,” using criteria defined by stakeholders), mapping a variety of climate data onto that domain, and then evaluating according to socio-economic criteria. The concept of Adaptation Pathways contains a sequence of actions or investments over time to adapt with future climate conditions and its uncertainties and associated physical impacts²⁵.

Climate risk assessment service providers:

Commercial climate risk assessment service providers, specialized in climate risk assessment and using many of the data, methods and tools listed above have started to emerge. It is likely that these services will considerably scale up and generate new data-driven markets if TCFD recommendations and the goals of the Paris agreement are effectively pursued by both policy makers and markets. The critical issue will be one of quality of the services provided, as well as cost. Currently, there are however many commercial offers and some that are trying to build models that would allow the delivery of climate risk assessments at lower cost. Due to the difficulties of listing here all commercial service providers, we opted to list none.

²³ Ray, P. A. & Brown, C. M. 2015. *Confronting Climate Uncertainty in Water Resources Planning and Project Design: The Decision Tree Framework*. Washington, DC: World Bank. © World Bank. <https://openknowledge.worldbank.org/handle/10986/22544>

²⁴ Matthews, J.H., Jeuken A. & Mendoza, G. 2017. *Designing for Climate Confidence: Moving beyond uncertainty in sustainable water management*. http://alliance4water.org/resources/Designing_for_Climate_Confidence_WCCE.pdf

²⁵ Haasnoot, M. 2013. *Anticipating change: sustainable water policy pathways for an uncertain future*. Thesis. Technical University Twente, the Netherlands.

5. Conclusions and recommendations

As the Task force recognizes, financial climate-related risk disclosure represents a challenge, but the Task force recommendations provide a flexible enough framework to allow all types of organizations to develop their own disclosures. This challenge opens up a wide range of opportunities for companies to initiate an analysis of their climate-related risks and thereby opportunities to mitigate these. As well as for climate service providers to support this work. In light of the support to the TCFD recommendations in the years ahead reporting of climate-related risks is expected to rapidly evolve and increase as the understanding of climate-risk data, climate related models, climate scenarios and tools become more widespread and accessible for organizations, investors and others. To facilitate this we need to decrease the barriers for the improvement of climate risk assessment methodologies and accelerate the implementation of these. Therefore, we foresee the following implementation path and opportunities of climate risk analysis see figure 6 below. The curve synthesizes two types of dynamics: first an adoption of TCFD recommendations following a diffusion of innovation type of model; second a two stage approach for the adoption of TCFD recommendations, with first the adoption of qualitative assessment and a later and slower development of the quantitative climate risk assessment methodologies. These two combine themselves to reveal an overall maturity development model.

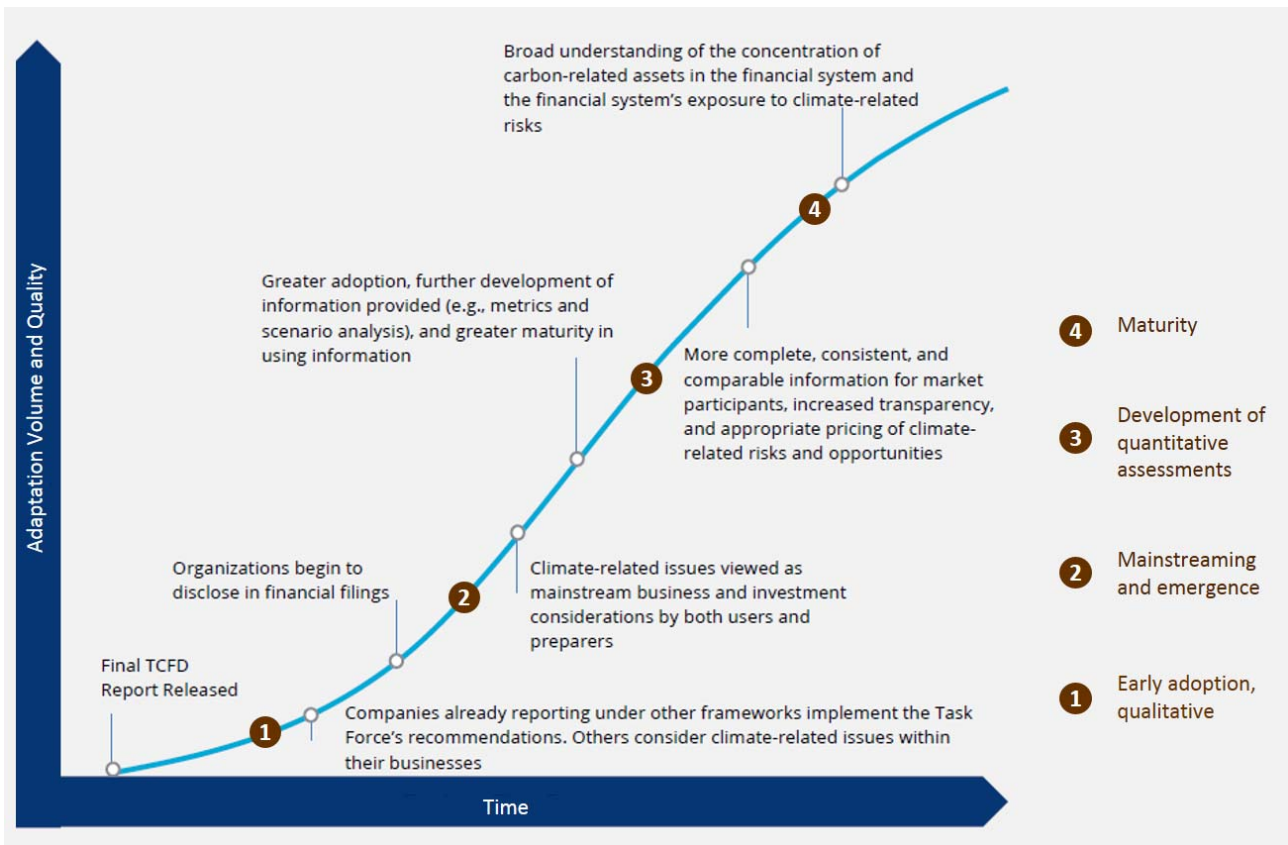


Figure 6: Climate risk modelling implementation path

In the short-term (step 1 to 2):

Organizations already reporting climate-related financial information under other frameworks (e.g. CDP) will be well positioned to disclose under the TCFD. In fact, CDP by harmonizing its questionnaires with the TCFD recommendations will be an important driver of adoption of TCFD globally. Organizations with less experience can begin considering how climate related issues may be relevant in their current governance, strategy and risk management practices (qualitative assessment). However, there will continue to be laggards and adoption by policy makers might be necessary to have a level playing field of all main companies performing climate-related risk assessment. This will likely come in later stages of development (step 3 and beyond). Organizations will start to develop business scenarios (sector specific) for existing climate scenarios; and the development of further metrics and indicators for evaluation and assessment of climate-related risks and opportunities will emerge. The TCFD will review and support this process in 2018.

In the medium-term (step 2 to 4):

When a significant number of leading companies (leaders and early adopters) have started to report under the TCFD recommendations, qualitative reporting of climate risk disclosure will start to mainstream across the business community (followers). The sharing of best practices among organizations will be critical to increase organizations' awareness, facilitating a greater adoption by companies and improving the quality of the practice, as well as support by the climate community in helping companies perform climate risk assessments. Financial risk and opportunities related to climate change will become part of organization's risk management and strategic planning processes. However, issues of comparability and method will emerge and at this point discussions and efforts will start on the standardization of climate risk assessment methods – and not just standardization of the reporting. It is to be expected that this will lead to a significant development of both the quality and adoption of quantitative climate risk assessment which will start spreading with a similar diffusion of innovation dynamic.

In the long-term (beyond step 4):

Companies will need support from standardization frameworks and expert consultancy services to guide and support actual risks and opportunities assessment (quantitative), as well as suitable adaptation measures to mitigate those risks. The quantitative risk assessment will become central to understanding transitional risks, namely the risk of stranded assets. The concentration of carbon related assets in certain companies and their role in the financial system will become increasingly more evident and with that the financial systems' exposure to climate related risks. Companies will have to assess and engage in:

1. Temporal and spatial extrapolation uncertainties
2. Value- and supply-chain management
3. Co-creation with experts
4. Assess both physical and transitional risks and opportunities
5. Assess the risk-benefit-cost and return of investments
6. Strategic decision-making informed by climate analysis
7. Avoid short-termism in planning – consider both acute and long term risks and opportunities

The long-term detailed risk analysis in this phase is not covered by the TCFD and will not be met by complying with the current TCFD recommendations, but the TCFD recommendations can initiate the analysis.

From all that has been said so far, we can conclude that climate will increasingly be a strategic factor in business decision-making processes based on risk and opportunity analysis. Corporate disclosure of climate-related risks will gain momentum and importance in corporate financial, CSR and other reporting and disclosure obligations in the near future. Currently, it is driven by market demand by investors, insurers and the supply- and value-chain of companies, but it will hopefully be complemented by smart public policies that can leverage the demand for corporate transparency on climate risk. In order for the maturity of climate risk assessment and disclosure to happen faster and better it is recommended to:

- Invest in the early adoption of TCFD recommendations by as a wider group of stakeholder as possible, e.g. CDP adoption of TCFD recommendations to its questionnaires will bring them to over 6000 companies around the globe;
- Build continuous momentum on the adoption of TCFD recommendations, namely by promoting its adoption and/or reference in regulatory frameworks and national policies. These do not have to mandate reporting or disclosure, instead they can focus on other levers that might drive demand for this type of assessment, for example, by imposing conditions on financial actors' fiducial duty of care;
- Support the adoption of TCFD recommendations by companies, by providing best in class examples, case studies, peer-learning and training;
- Engage early enough in standardization efforts of climate risk assessment, namely in efforts related with issues of access to data, establishment of methods and provision of accessible tools for climate risk assessments.

Notes:

6. Annex 1: The Use of Scenarios, Data and Tools in Disclosure of Climate-Related Risk and Opportunities

A number of tools currently exist to allow organizations to begin using scenario analysis to assess the implications of climate change. This section is reviewing the tools selected in the Appendix 4 of the TFCF Technical Supplement by giving a classification of what is the added value of each one. There is a wide range of Data and Tools available that are not mentioned in the TFCF Technical Supplement, for example the EU Portal on Climate Adaptation (Climate-ADAPT) provides an overview of data and maps, indicators, tools and models, guidance documents, reports and publications on climate change, risks and impacts, and adaptive capacity of countries and sectors in Europe. See Annex Table 1 below:

Annex Table 1: Tools and methods

Source	Methodology	Scenarios	Data sets/ data sources/tools	Modelling tool	Risk assessment tool	Geography
California Energy Commission. "Climate Tools." <i>Cal-adapt</i> . 2017. cal-adapt.org/tools/ .			Charts, maps and data of observed and projected climate variables			California
Climate and Development Knowledge Network (CDKN). "A guide to climate compatible development tools." <i>Climate Planning</i> . www.climateplanning.org/ .	Website on climate planning, carbon taxes, transport regulation and carbon marketing					
European Climate Adaptation Platform. "Observations and Scenarios." <i>Adaptation Information</i> . climate-adapt.eea.europa.eu/knowledge/adaptation-information/observations-and-scenarios .		Information on scenarios	Information on observations			European and global initiative
European Climate Information Portal. <i>CLIPC: Constructing Europe's Climate Information Portal</i> . www.clipc.eu/home . (provides climate, indicator and scenario information)	PORTAL for a wide variety of users, such as consultants, policy makers, private sector deci-		Includes data from satellite and in-situ observations,	Climate models	Data re-analyses, and transformed data products enabling assessment of climate	Europe

	<p>sion makers and scientists. Part of the toolbox is integrated with Climate-ADAPT: the European Climate Adaptation Platform (http://climate-adapt.eea.europa.eu/): this platform is Europe's gateway to climate information portals, datasets and maps, indicators, modelling tools, guidance, publications and reports.</p>				<p>change impact indicators. It provides a toolbox to generate, compare, manipulate, and combine indicators</p>	
<p>European Environment Agency. <i>European Environment Agency</i>. www.eea.europa.eu/. (provides information on land cover, water, air and other environmental data and indicators)</p>			<p>Provides information on land cover, water, air and other environmental data and indicators</p>			<p>Ensembles of different data sources provided by 33 EU member countries</p>
<p>Europe PROVIA / MEDIATION Adaptation Platform. "Scenario Analysis." <i>PROVIA / MEDIATION Toolbox</i>. www.mediation-project.eu/platform/tbox/scenario_analysis.html. (provides climate change adaptation methods and tools)</p>	<p>Methodology to go through scenario analysis</p>				<p>Toolbox with methods and tools that are suitable to inform decision-making</p>	<p>Europe</p>
<p>Food and Agricultural Organization of the United Nations. "Modelling System for Agricultural Impacts of Climate Change – MOSAICC." <i>Climate Change</i>. United Nations. www.fao.org/climatechange/mosaicc/66705/en/.</p>			<p>Climate data processing tools</p>	<p>Modelling System for Agricultural Impacts of Climate Change (Crop</p>		<p>Sectorial tool for end-users from data to economic model.</p>

				Model/Hydrological Model/Economic Model)		
Global Carbon Project. <i>The Global Carbon Project</i>. 2017. www.globalcarbonproject.org/. (provides information on the global carbon cycle, including its biophysical and human dimensions and the interactions and feedbacks between them, as well as carbon and methane budgets and trends)			Data and tools	-Patterns and Variability - Processes and Interactions: -Carbon Management		Global
Government of Canada. "Downscaling Tools." <i>Canadian Climate Data and Scenarios</i>. climate-scenarios.canada.ca/?page=dst-intro.		Information on climate scenarios, forcing scenarios, multi-model ensemble scenarios	Statistical downscaling tool is available	A synthesis of recent observation and modeling results for Canada		Canada
International Institute of Applied Systems Analysis. "Databases." <i>Models, Tools & Data</i>. www.iiasa.ac.at/web/home/research/researchPrograms/Energy/Databases.en.html.	PORTAL that provides a wide variety of land, energy, transition, and water tools and databases.	Scenario databases for energy, GHG mitigation strategies, and climate policies consistent with 2°C and IPCC scenarios	Repository for key datasets on energy, climate, population, and land cover	Provides a number of energy models Provides also a Catastrophe Simulation Model	Provides cost-effective emission control strategies assessment tool	Global
Mendelsohn, Robert, et. al. "Country-specific market impacts of climate change." <i>Climate Change</i>, 45: 553-569. 2000. www.researchgate.net/publication/227176953_Country-Specific_Market_Impacts_of_Climate_Change.				Paper explaining a new climate-impact model,		Response functions were calibrated only for the United States

<p>NASA. "Climate Effects on Food Supply." <i>Socioeconomic Data and Applications Center (SEDAC)</i>. 2017. sedac.ciesin.columbia.edu/data/collection/crop-climate.</p>				<p>Provides Data Sets from a Major Crop Modeling Study And Socioeconomic Data</p>	<p>Likely impacts of climate change on crop yields</p>	<p>Global Food Production</p>
<p>Natural Capital Project. "Our Software." <i>Scenario Support and Other Tools</i>. www.naturalcapitalproject.org/software/#scenario-generator.</p>				<p>MESH is an integrative modeling platform. InVEST is a suite of models to map and value the goods and services from nature.</p>	<p>ROOT is a tool to perform optimization and tradeoff analysis RIOS tool for cost-effective investments in watershed services OPAL tool for quantifying the impacts</p>	<p>Global. Open-source tools to make the science accessible and useful in real decisions</p>
<p>Nature Conservancy. <i>Climate Wizard</i>. www.climatewizard.org/index.html.</p>			<p>a web-based software tool to access leading climate change information and visualize the impacts anywhere on Earth.</p>		<p>ClimateWizard represents the first time ever the full range of climate history and impacts</p>	<p>Global</p>
<p>National Center for Atmospheric Research. "Climate Change Scenarios GIS data portal." <i>GIS Program</i>. 2017. gisclimatechange.ucar.edu/.</p>			<p>Free datasets of Global and downscaled climate change projections from the Community Climate System Model (CCSM-3) can be downloaded</p>	<p>(SIMMER). It displays places in Houston where you can go to stay cool, integrated with a model simulation</p>		<p>Global and regional Models and Tools</p>

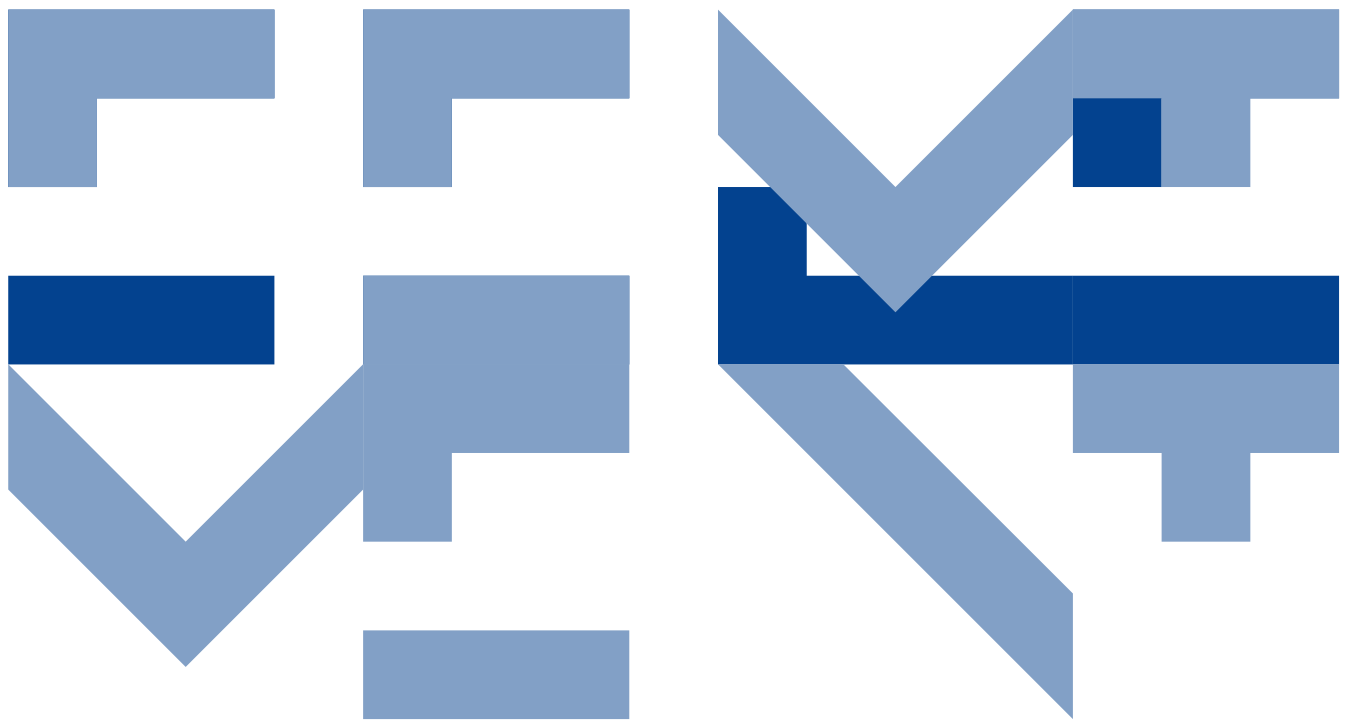
			in a common GIS format	tion of the average summer high temperatures.		
National Oceanographic and Atmospheric Administration. "Meet the Challenges of a Changing Climate." U.S. Climate Resilience Tool Kit. toolkit.climate.gov/.	It provides a framework (methodology); i. Explore Hazards i. Assess Vulnerability & Risks i. Investigate Options v. Prioritize & Plan v. Take Action and case studies.		Climate Explorer: A visualization tool to explore interactive graphs and maps of climate projections and observations for any county in the contiguous United States.			Global Methodology and United States based tools
National Science Digital Library. "Decision Making Using GIS Climate Change Simulation Data." <i>Using Data in the Classroom</i>. Carleton College. serc.carleton.edu/usingdata/datasheets/GISclimate.html.		Provides access to free global datasets of climate change scenarios that were generated for the 4th Assessment Report	Distributes a subset of all data produced by the CCSM. In particular, one can view and/or download monthly mean, 2D atmospheric and land variables from the CCSM component models. Software tools for Data Manipulation: ESRI ArcGIS ArcView			
Pyke, Christopher R., et. al. "A decision inventory approach for improving decision support for climate change impact assessment and adaptation." <i>Environmental Science and Policy</i>, 10: 610-621. 2007.	Approach for improving decision support for impact assessment and adaptation					Paper/publication

<p>UNEP and Copenhagen Centre for Energy Efficiency. <i>Best Practices and Case Studies for Industrial Energy Efficiency Improvement</i>. 2016. www.energyefficiency-centre.org/publications.</p>	<p>List of Publications/reports on Energy</p>					<p>for different countries and sectors</p>
<p>U.S. Department of Agriculture. "Climate Change Tools and Data". <i>Climate Hubs</i>. www.climatehubs.oce.usda.gov/content/climate-change-tools-and-data-0.</p>					<p>It provides specialized tools create maps, models and datasets estimating a variety of outputs (e.g., crop production, greenhouse gas flux, and species distribution).</p>	<p>Agriculture</p>
<p>U.S. Department of the Interior. "Climate Change – Selected Resources, Data, and Tools." <i>Climate Change</i>. Office of Insular Affairs. www.doi.gov/oia/climate-change/resources-data-tools.</p>			<p>Selected links to Resources, Data, and Tools</p>			<p>U.S. Federal Government</p>
<p>U.S. Environmental Protection Agency. "Models, Tools, and Databases for Climate Change Research." <i>Climate Change Research</i>. www.epa.gov/climate-research/models-tools-and-databases-climate-change-research.</p>			<p>It provides a set of Datasets and Tools</p>	<p>It provides a set of Models</p>		<p>U.S.</p>
<p>U.S. Environmental Protection Agency. "Climate Resilience Evaluation and Awareness Tool (CREAT)." <i>Creating Resilient Water Utilities (CRWU)</i>. www.epa.gov/crwu/build-resilience-your-utility.</p>	<p>CREAT 3.0 Methodology Guide. The U.S EPA also provides tools and guidance for water utilities called Creating Resilient Water Utilities (CRWU). CRWU provides water utilities with practical tools to increase climate change</p>				<p>CREAT (Climate Resilience Evaluation and Awareness Tool) version 3.0 : Risk assessment application to assist utility owners and operators in adapting to extreme weather events through a better un-</p>	<p>US water utility</p>

	resilience and understand long-term adaptation options.				derstanding of current and future climate conditions	
U.S. Forest Service, USDA. "Scenarios Network for Alaska and Arctic Planning (SNAP)." <i>Climate Change and Carbon Tools</i> . www.fs.usda.gov/ccrc/tools/snap .			Downloadable datasets for historic climate data and projected climate data Interactive tools to allows users to view and download temperature and precipitation projections	Online tools for viewing extreme temperature and wind events, and modeled future sea ice coverage		Alaska and western Canada
U.S. Geological Survey. "Climate and Land Use Change." <i>Data and Tools</i> . <i>Error! Hyperlink reference not valid..</i>						
United States Data.gov. "Climate Model Projections". <i>Climate</i> . www.data.gov/climate/portals/ .			It provides access to a growing body of data, generated by climate models: This includes raw climate model output, as well as model output that has been processed by "bias correction" and "downscaling"			North America
U.S. Global Change Research Program (USGCRP). "Scenarios." <i>Scenarios for the National Climate Assessment</i> . scenarios.globalchange.gov/ .		It provides quantitative and narrative descriptions of plausible future				U.S. National

		conditions (SCENARIOS) for climate sea level rise and populations				
USGCRP. "Scenarios: About Scenarios." <i>Scenarios for the National Climate Assessment</i>. scenarios.global-change.gov/content/scenarios.		<p>Scenarios for the Fourth National Climate Assessment:</p> <ul style="list-style-type: none"> • Climate • Sea Level Rise – (U.S. coastline). • Population and Land Use – population change as a function of demographic shifts and migration. 				U.S. National
World Wildlife Fund (WWF). Water Risk Filter. 2017. waterriskfilter.panda.org/.					Water Risk Assessment Tool to help companies and investors ask the right questions about water. It allows to assess risks and offers guidance on what to do in response	More than 2,900 organizations from 32 industry sectors have assessed facilities.

Notes:



Climate-KIC TCFD analysis report

