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The Climate Risk Landscape

A comprehensive overview of climate risk assessment methodologies

Acknowledgements

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1. Introduction

The forward-looking nature of climate risk assessments imply a myriad of assumptions, baselines, inputs and modelling choices that result in a great diversity of methodologies and tools available to financial institutions. This in turn leads to some difficulties for banks and investors to make transparent, informative choices on climate risk modelling approaches, while standardisation is hampered by the great uncertainty over the most appropriate model choices in a forward-looking risk assessment.

Since the publication of UNEP FI's 'Changing Course' report in May 2019, the tools available to financial institutions that wish to use scenario analysis to reinforce their climate-related risk assessments and disclosures have developed and expanded rapidly. This report is intended, not to provide a comprehensive guide to scenario analysis and risk assessment, but rather a summary of the key developments of the climate risk assessment landscape since May 2019, including new and updated scenarios, methodological tools, key guidelines, as well as an overview of the changing regulatory landscape and potential developments into 2021.

This report covers both physical and transition risks, though the headline results on physical risks have incorporated the results of an analysis of physical risk methodologies and data sources in chapters 2 (Data portals) and 4 (Methodologies) of Acclimatise's recently released report, 'Charting a New Climate' (2020) developed for UNEP FI's TCFD Banking Pilot Project Phase II. This overview has adopted a two-step process by engaging with methodology developers to provide information on their tools and methodologies, which have been subsequently verified through objective research.

The report opens with a chapter on the evolving landscape of climate disclosure since May 2019, taking a brief look at how new regulations and reporting guidelines have emerged, and the increasing regulatory push for climate stress-testing, as well as the development of portfolio temperature assessments.

The second and third chapters provide a broad overview of the landscape of scenario analysis methodologies for the estimation of transition and physical risks from climate change. The intention here is not to provide an endorsement of one methodology over another but to present some of the key strengths and differences in approaches.

The report concludes with an overview of advances in scenario development, a review of emerging trends and what financial institutions should look out for in 2021.

2. The Evolving Climate Disclosure Landscape

2.1 Recent developments in regulation

Over the past year, the number of climate risk reports has increased in quality and number (Carlin, 2020). However, as highlighted in 'Changing Course' and in the TCFD's own 2019 Status Report, scenario analysis remains far from commonplace aside from larger, more climate-aware institutions in leading countries (UNEP FI, 2019). Despite the relatively high interest – as of September 2020, 739 financial institutions had signed up as supporters of the recommendations of the TCFD (Mitchell et al, 2020) – very few financial firms are actively disclosing. Those institutions that do disclose have not been able to follow harmonised standards while the difficulty of accessing robust, high-quality data and scenarios has compromised the quality and usefulness of their disclosures. The COP26 Secretariat's Financial Coalition Coordination Mechanism is encouraging financial firms to conduct scenario analysis and implement climate-risk reporting, while the Principles for Responsible Investment (PRI, 2020) have made reporting on certain climate indicators mandatory – though disclosure remains voluntary.

2.1.1. Risk disclosure mandates

With the voluntary disclosure framework only providing piecemeal disclosures and limited data on the financial impacts of climate change so far, regulators, central banks and ratings agencies are increasingly under pressure to introduce mandatory climate risk disclosure frameworks. Mark Carney, the former chair of the Financial Stability Board and catalyst for the establishment of the TCFD, has advocated for a mandate (TCFD, 2019), while Ceres has called on the SEC to implement more stringent climate-related reporting (Ceres, 2020). The Basel Committee on Banking Supervision (BCBS) established the Task Force on Climate-related Financial Risks (TFCR) in February 2020, to maintain the stability of global financial systems in the face of climate-related risks, commencing with a stocktake of member initiatives on climate-related financial risks. In September 2020, the government of New Zealand became the first country to announce mandatory climate-related financial disclosures for publicly listed companies and large banks, investors and insurers (NZMFE, 2020). The following table gives a flavour of the status of the climate-related reporting mandates and voluntary initiatives in selected jurisdictions worldwide:

USA	2020	Commodity Futures Trading Commission (CFTC)	Establishment of Climate-related Market Risk Subcommittee (CRMS) and release of the Managing Climate Risk in the U.S. Financial System report (2020) urging financial regulators in the U.S. to "move urgently and decisively to measure, understand, and address these risks", taking advantage of "existing statutes".
	2019	New York State Department of Financial Services (NYDFS)	Non-binding expectations of insurers to consider "the financial risks from climate change into their governance frameworks, risk management processes, and business strategies" and to "start developing their approach to climate-related financial disclosure." (NYDFS, 2020)
UK	2019	Bank of England, Prudential Regulation Authority (PRA)	PRA supervisory statement SS3/19, "Enhancing banks' and insurers' approaches to managing the financial risks from climate change"
	2019	Department for Business, Energy and Industrial Strategy (BEIS)	Green Finance Strategy: Expectation for all companies to disclose in line with TCFD recommendations by 2022 (BEIS, 2019).
	2020	HM Treasury	Interim Report of the UK's Joint Government Regulator TCFD Taskforce, publishes a roadmap towards mandatory climate-related disclosures by 2025, with the majority of measures implemented by 2023.
European Union	2020	Non-Financial Reporting Directive (NFRD)	Targeted consultation on strengthening reporting of sustainability and climate-related information in the NFRD (2014/95/EU).
	2019	European Banking Authority (EBA)	Article 98.8 of the Capital Requirements Directive (CRD5) requires EBA to assess the inclusion of ESG risks in performance & evaluation.
France	2016	Article 173	Non-mandatory financial reporting, including climate.
Hong Kong	2020	HKEX	Mandatory ESG governance and reporting
New Zealand	2020	Ministry for the Environment	Mandatory climate risk reporting legislation to be presented to Parliament following 2020 general election. Disclosure by all registered banks, credit unions, building societies, managers of investment schemes, and licensed insurers with total assets of more than NZ$1bn and all equity and debt issuers listed on the NZX by 2023.
Canada	2020	Bank of Canada Canada Development Investment Consortium (CDEV)	Discussion / exploratory paper on scenario analysis. TCFD reporting mandatory for companies receiving emergency funding during the pandemic: Large Employer Emergency Financing Facility (LEEFF) (CDEV, 2020)
Japan	2019	Japan TCFD Consortium	The Consortium is a public-private partnership to promote TCFD disclosure. This has led to higher voluntary corporate TCFD reporting than in any other country (Ikeda, S., 2020).

Switzerland	2019	Federal Office for the Environment (BAFU)	Legal opinion shows that climate-related risks need to be taken into account according to existing law (Eggen & Stengel, 2019) Switzerland became a supporter of the TCFD in January 2021 and has launched a consultation on mandatory climate-related risk disclosure.
Australia	2020	Australian Prudential Regulation Authority (APRA)	2021 Climate Risk Vulnerability Assessment, for major banks (Australia's largest deposit-taking institutions, ADIs). Climate risk disclosure remains voluntary, however (APRA, 2020).

Table 1: Overview of mandatory and voluntary disclosure recommendations on climate-related risk from a selection of regulators and policy makers

Some private investors are starting to move the dial, particularly in jurisdictions where there has been relatively little regulatory guidance on climate risk disclosure in recent years, such as in the United States. BlackRock, the world's largest asset manager, has requested TCFD-aligned climate-related risk disclosures from all their investee companies by the end of 2020, holding board members of those companies directly accountable for reporting (Fink, 2020). To give one high profile example of this new approach, BlackRock issued a statement voting against Exxon Mobil directors for not taking sufficient action on TCFD-aligned risk disclosure (BlackRock, 2020). State Street Global Advisors are also threatening voting action against major publicly listed investees that fail to improve poor sustainability ratings, based on SSGA's proprietary R-Factor rating, including climate-related risk (SSGA, 2020).

2.1.2. Risk disclosure standards and guidelines

Figure 1: CDP's 'Building blocks' report showing how CDSB and CDP guidelines allow for the development of TCFD-standard reports

Whether mandated or not, climate-related reporting has come under criticism for its lack of standardisation, making it difficult to compare disclosures. Voluntary reporting frameworks remain the norm in an absence of mandates. In September 2020, several reporting standards organisations, including CDSB, SASB, CDP, GRI and IIRC[1] jointly committed to align their sustainability reporting requirements (CDP, 2020a), building on CDP's work with CDSB to integrate the recommendations of the TCFD (CDP, 2020b). This is certainly a step in the right direction, as they form the basis of voluntary reporting for global financial firms. In parallel, the Network for Greening the Financial System (NGFS) has developed technical guidelines to help its members integrate climate-related and environmental risks into prudential supervision (NGFS, 2020a), as well as working closely with scenario developers to issue a set of standard scenarios (NGFS, 2020b), built on existing well-developed Integrated Assessment Models (IAMs),[2] allowing for assessment of both transition and physical risks. The following table outlines some of the guidelines and standards that have been developed in a handful of jurisdictions, often to accompany mandatory or voluntary reporting:

USA	2010	Securities and Exchange Commission (SEC)	Guidance on Disclosure Related to Climate Change. No recent climate-related risk disclosure updates despite recent amendments to risk disclosure rules (Herren Lee, 2020)
European Union	2020	Disclosures Directive	Regulation 2019/2088 requires annual disclosure standards.
	2020	European Central Bank (ECB)	Draft guide on incorporating climate-related and environmental risks into existing risk framework (ECB, 2020)
	2020	European Insurance and Occupational Pensions Authority (EIOPA)	EIOPA is currently holding a consultation on its expectations of national competent authorities to supervise the integration of climate changes scenarios in their 'Own Risk and Solvency Assessments' (ORSAs).
Singapore	2020	Monetary Authority of Singapore (MAS)	Introducing guidelines on climate risk disclosure, currently under consultation (MAS, 2020).

Table 2: Overview of standards and guidelines on climate-related risk from a selection of regulators and policy makers

Leading climate finance groups such as the Climate Safe Lending Network, suggest that even mandating climate risk disclosure is not enough and financial institutions need to disclose their impact on systemic or planetary climate risks (Vaccaro, 2020) – in other words an "inside-out" risk assessment rather than an "outside-in" assessment.

1 CDSB: Climate Disclosure Standards Board; SASB: Sustainability Accounting Standards Board; GRI: Global Reporting Initiative; IIRC: International Integrated Reporting Council

2 GCAM, MESSAGEix GLOBIOM and REMIND MAgPIE

2.1.3. Stress testing

A handful of central banks are integrating climate change into stress tests to assess the stability of the financial system to these more systemic, longer-term risks:

- The Bank of England has extended its stress testing horizon to 30 years through the Biennial Exploratory Scenario (BES). The BES requires financial firms to run scenarios against their balance sheet exposure and set out management responses. In a second round, the BoE may ask firms for their responses in light of system-wide impacts. The BES is not strictly a stress test as it does not run high-impact scenarios.
- The Netherlands' Central Bank (Den Nederlandsche Bank, DNB) conducted an energy transition stress test in 2018, which has showed that Common Equity Tier 1 (CET1) ratio could drop by over 4 percentage points in a severe but plausible transition scenario.
- The French central bank's regulatory authority (*L'Autorité de contrôle prudentiel et de résolution*, ACPR) has developed stress testing based on the NGFS scenarios (see 3.1), and drilling down to explore national macroeconomic, sector and firm level risks using in-house models (ACPR, 2020b).
- These pilot stress tests by Eurozone national central banks have paved the way for the European Central Bank to integrate climate-related stress tests, integrating macroeconomic factors such as sudden transition risks (capital flight from certain sectors/regions).
- Outside of Europe, strengthening the finance sector's resilience to climate risk is one of the four pillars of the Monetary Authority of Singapore's (MAS) green finance action plan. Under these proposals, the MAS will include climate-related scenarios in its annual financial stress test by 2022.

2.2 Combining physical and transition risks

The physical impacts of climate change are already impacting on our economy and society, and further temperature rise is already baked in. Realistically, not even the most optimistic transition scenario can ignore the risks from the physical impacts of climate change. Therefore, scenario developers and methodology providers are increasingly working towards combined transition and physical risk methodologies to provide a complete picture of climate-related risk. Integration of these two approaches is not straightforward as physical and transition pathways are strongly dependent on different location- and sector-specific variables. Physical hazards are strongly location-specific and dependent on actual temperature rise, while adaptive capacity can vary between sectors. Transition risk is highly sector-specific and relates to politically determined mitigation targets.

The NGFS suite of scenarios aims to bridge the two risk frameworks, with methodologies being developed over 2020-21 to integrate the two aspects. Consolidation is also being delivered by commercial providers, while ratings agencies have moved to integrate climate risk specialists with both physical and transition risk expertise, for example Carbon Delta by MSCI and Moody's Analytics who have brought in physical risk expertise from Four Twenty Seven and transition risk specialists, Vigeo-Eiris (V.E), as part of the climate focus of the newly formed Moody's ESG Solutions Group.

While we focus in this report on scenario-based risk assessments, it must be remembered that the TCFD report also refers to other risks including litigation and reputation. UNEP FI's TCFD Pilot for insurers assesses the exposure of insurers to litigation risk in the face of climate change and UNEP FI are also aiming to publish a high-level briefing on litigation risk and climate change adaptation in March 2021.

2.3 Moving beyond the current risk disclosure framework

Mark Carney has suggested that current disclosure frameworks need to evolve in order to reflect financial institutions' climate-related risk, not only to their own portfolios, which are considered only through the very short-term lens of the investment horizon, but to take into account their contribution to systemic or global risks. In his 'Road to Glasgow' speech in 2020, he posited the need to expand the existing frameworks to adopt more active measures to address systemic risk, such as:

i. the net zero alignment of portfolios,
ii. reporting on transition progress, and
iii. reporting portfolio warming potential.

These approaches could act as a stepping-stone from the current risk assessment paradigm of the TCFD framework to a more active alignment with the key objective of Article 2.1(a) of the Paris Agreement to "hold the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the increase to 1.5°C" (UNFCCC, 2015). The TCFD Secretariat are currently exploring how portfolio warming potential may be integrated into the TCFD framework to better measure the impact of business operations on systemic risk, while the Bank of England's BES adopts a temperature alignment score. For more details on the different types of alignment and impact models, and a discussion on how appropriate these metrics are for measuring portfolio alignment, see the recent study by the Institut Louis Bachelier (Reynaud et al, 2020).

3. Overview of Transition Risk Approaches

3.1 Introduction

Developing a tool or methodology that can provide a robust assessment of climate-related risk, whether transition or physical, is a considerable undertaking. In terms of transition risk, it can require access to considerable data on future technology, access to a wide range of climate and macroeconomic models, and an understanding of forward-looking climate and economic assumptions. A number of proprietary tools and methodologies have been developed by commercial service providers.

This section provides an overview of eighteen transition risk tools and analytics. The set of service providers listed and reviewed in this section is certainly not exhaustive, but is an attempt to include the principal commercially available methodologies.

Almost all of the assessed methodologies' principal function is to analyse transition risk, using climate hazards and forward-looking carbon policy and technology variables as inputs in order to calculate the risk to clients, their operations and value chains, often in terms of financial metrics. A couple of exceptions to these risk assessment approaches have been included, as they may still be of use in assessing a portfolio's exposure to climate change transition. These are Carbone 4's Climate Impact Tool, which measures the impact of assessed portfolios on climate change, and 2DII's PACTA Stress Test Module, which assesses the level of exposure and potential losses of equity and bond portfolios to Paris-aligned transition pathways. Carbon Tracker's 2 Degrees of Separation tool is focused on one single sector (oil & gas), while the others cover all or most of the high emissions sectors.

This survey adopts the assessment framework developed in UNEP FI's Changing Course report last year, with some minor changes and including a number of supplementary criteria in order to complement the format of the overview of physical climate risk assessment tools in Chapter 4 of UNEP FI's Charting a New Climate report (pp. 42-53; UNEP FI, 2020). The information provided in this overview has been obtained firstly from publicly available sources and secondly from survey responses from most of the services providers covered below. Only Moody's Investor Services and PwC failed to respond to our survey.

The brevity of this overview does not allow for an in-depth review of each methodology. For more comprehensive research, the Swiss Federal Institute of Technology has published research on selected transition risk methodologies, including those developed by 2DII, Carbone 4, Climafin, ClimateWise, MSCI-Carbon Delta, Oliver Wyman, Ortec Finance, PwC/CO-Firm and Vivid Economics (now known as Planetrics) (Bingler & Colesanti Senni, 2020).

			Provider																		
			2DII (1)	2DII (2)	BAR	C4	CFIN	CT	CW	MA-VE	MIS	MSCI	OF	OW	OW-S&P	PwC	SP(1)	SP(2)	TCS	VE-PL	VR
	Scenario Basis		IEA ETP | (IEA WEO) | (G'peace)	IEA ETP	Bespoke, or | Industry standard, e.g. IEA	Bespoke | (based on IEA ETP, IPCC, ...)	IEA ETP | IEA WEO	IEA WEO | IEA ETP (B2DS)	IEA ETP | IEA WEO		IEA WEO	Bespoke (PIK-REMIND, IIASA, GCAM)	E3ME	NGFS | (PIK, IIASA, GCAM) | IAMC	NGFS Bespoke 3-yr Carbon Tax Scenario	IEA ETP	IEA ETP | IEA WEO | IIASA SSPs | AE[R] | DDD | NGFS	IEA ETP | IEA WEO | IIASA SSPs | AE[R] | DDD | NGFS	SSP3-60 | SSP3-45	Bespoke	Bespoke
Scenarios	<2.0°C (RCP 2.6)		✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	2.0°C (RCP 4.5)		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	3.0°C (RCP 6.0)		✓	✓	✓	✓				✓		✓	(✓)	✓	✓		✓	✓	✓	✓	✓
	>4.0°C (RCP 8.5)				✓	✓			✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
	Disorderly?			✓	✓		✓			✓		✓	✓	✓	✓	(✓)[i]	✓	✓		✓	✓
Time horizons	Near term (2025-2040)		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Medium term (2050)				✓		✓						✓	✓	✓	✓	✓	✓	✓	✓	✓[ii]
	Long-term (2100)						✓[iii]						✓				✓	✓	✓	✓	
Transition Hazards	Policy		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Technology		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
Risk analysis	Level of analysis	Asset	✓		✓			✓	✓	✓		✓			✓	✓		✓	✓	✓	✓
		Firm	✓		✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
		Sector	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓			✓	✓	✓
		Country			✓	✓	✓		✓	✓		✓	✓	✓		✓[iv]			✓	✓	✓
	Impact Channel	Macroenvironment		✓	✓	✓	✓		✓	✓		✓	✓		✓		✓	✓		✓	✓
		Supply chain			✓	✓	✓		✓	✓		(✓)[i]	✓	✓	✓		✓	✓	✓	✓	
		Operations and assets	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Markets and clients	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓
	Depth	Exposure	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Sensitivity	✓	✓	✓	✓	✓	(✓)[v]	(✓)[vi]	✓		✓	✓	✓	✓	✓		(✓)[vi]	✓	✓	✓
		Adaptive Capacity		✓	✓	✓	✓			✓			(✓)[vii]	(✓)[vii]	✓	✓		(✓)[v]		✓	(✓)[vi]
	Approach	Top-Down		✓			✓				✓		✓		✓		✓				
		Bottom-Up	✓		✓	✓		✓	✓	✓		✓		✓	✓	✓		✓	✓	✓	✓

		Provider																		
		2DII (1)	2DII (2)	BAR	C4	CFIN	CT	CW	MA-VE	MIS	MSCI	OF	OW	OW-S&P	PwC	SP(1)	SP(2)	TCS	VE-PL	VR
Asset classes	Equity	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	
	Bonds, Corporate	✓	✓	✓	✓	✓			✓	✓	✓	✓		✓	✓	✓	✓		✓	
	Bonds, Government			✓	✓	✓			✓			✓		✓			✓		✓	✓
	Loans, Corporate	✓	✓	✓	✓	✓			✓			✓		✓	✓		✓		✓	
	Loans, Project			✓	✓	✓			✓			✓	✓	✓	✓		✓		✓	✓
	Mortgages			✓	✓				✓			✓			✓		✓	✓	✓	
	Real Estate / Real Assets			✓	✓			(✓)[viii]	✓		✓	✓			✓		✓	✓	✓	✓
User inputs	Counterparty name	✓	✓	✓	✓	✓	✓		✓	✓	✓	[x]	(✓)[ix]	✓	✓	✓	✓	✓	(✓)[xi]	✓
	Location			✓				✓			✓		(✓)			(✓)[ix]	✓	✓	(✓)	✓
	Value of asset	✓	✓	✓				(✓)[ix]	(✓)[ix]		✓		(✓)			✓	✓	✓	(✓)	✓
Validity	Open-source	✓	✓	(✓)[xii]	(✓)[xii]			✓				(✓)[xiii]		(✓)[xvi]		(✓)[xii]	(✓)[xii]		(✓)[xii]	
	Peer-reviewed	✓		✓	✓			✓				✓		(✓)[xvii]		✓	✓	✓	(✓)[xiv]	
	Source references	✓	✓	✓	✓			✓				✓				✓	✓	✓	✓	✓
Outputs	Quantitative	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Semi-quantitative				✓		✓	✓	✓	✓						✓			✓	✓
	Non-financial metrics	✓	✓	✓	✓		✓	✓	✓	✓		✓						✓		
	Financial metrics		✓	✓		✓			(✓)[i]		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Temperature Alignment	✓	✓	✓	✓						✓	✓			(✓)[xv]				✓	

Table 3: Overview of transition risk assessment tools and analytics

Abbreviation	Service Provider	Tool
2DII (1)	Two Degrees Investing Initiative	PACTA for banks
2DII (2)	Two Degrees Investing Initiative	PACTA stress testing module
BAR	Baringa Partners	Climate Change Scenario Model
C4	Carbone 4	Carbon Impact Analytics
CFIN	Climate Finance Alpha	Transition risk toolbox
CT	Carbon Tracker	2 degrees of separation
CW	ClimateWise (CISL)	Transition risk framework
MA-VE	Moody's Analytics-V.E	On-demand transition climate risk scoring application
MIS	Moody's Investor Services	Carbon transition assessment
MSCI	MSCI-Carbon Delta	Climate Value-at-Risk (CVaR)
OF	Ortec Finance	ClimateMAPS
OW	Oliver Wyman	Transition Check
OW-S&P	Oliver Wyman & S&P Global Market Intelligence	Climate Credit Analytics
PwC-COF	PwC (formerly CO-Firm)	Climate Excellence
SP(1)	South Pole	Risk screening tool
SP(2)	South Pole	Climate risk deep-dive assessment
TCS	The Climate Service	TCS Climanomics
VE-PL	Planetrics	PlanetView
VR	Verisk Analytics	Transition risk

Notes

i. Under development for 2021
ii. Up to 2064
iii. Up to 2080
iv. At regional level
v. Operations only
vi. Not macroenvironment
vii. Macroenvironment only
viii. Infrastructure / real assets only
ix. Optional (but preferable)
x. Top-down approach does not need company/asset information
xi. Outside of ~20,000 company database
xii. Methodology, not source code
xiii. Open-source version will be available on OS-Climate platform
xiv. Within Vivid Economics' academic network
xv. Climate target alignment
xvi. Framework is open-source
xvii. Reviewed and vetted by financial institution, not academic

3.2 Scenarios

The foundation of forward-looking climate risk assessment is the design of a scenario or set of scenarios that best shapes assumptions around the climate, society and the economy. Scenarios are built around the core assumption of a global temperature target or emissions pathway, with temperature pathways being preferred by the TCFD in line with the objectives of the Paris Agreement (TCFD, 2017). However, a number of secondary assumptions including carbon pricing, technological development, consumer behaviour, resource scarcity, energy demand, discount rates and how quickly those assumptions change have a considerable influence on how those pathways develop over time. The Changing Course report focused largely on temperature-based scenarios given the TCFD's recommendations. In terms of the highest transition risk, scenarios tended to focus on 2°C pathways. Furthermore, the most widely available and granular scenarios at the time assumed a considerable contribution from Carbon Dioxide Reduction (CDR), or 'negative emissions' technology.

The availability of scenarios for transition risk analysis has expanded since last year's Changing Course report, in particular because demand for more aggressive transition scenarios has built as firms respond to increasing pressure from clients, investors and governments to meet the objectives of the Paris Agreement. Only 6 countries have implemented net-zero legislation, but many others have committed to Net Zero emissions targets by 2050, and most significantly for global emissions, China committed at the 2020 United Nations General Assembly to 'net carbon neutrality' by 2060 (Economist, 2020). In the finance sector, a number of firms have committed to align their business with the Paris Agreement, for example the Principles for Responsible Banking's Collective Commitment to Climate Action, or to net zero emissions by 2050 in the case of the Net-Zero Asset Owner Alliance.

Policies aiming at a 1.5°C pathway are therefore starting to be shaped and financial institutions need to assess this pathway, which poses the greatest transition risk. Moving to 1.5°C scenarios implies important changes in the rate and timing of decarbonisation, as outlined by Bingler & Colesanti Senni (2020), which will necessarily imply a considerable step change in transition risk. It is therefore important that these scenarios are adopted by service providers and many have already done so.

The IPCC's Special Report on Global Warming of 1.5°C (2018) laid out a number of pathways (P1 to P4) for achieving net zero emissions by 2050, including a pathway which minimises the need for carbon dioxide removal (CDR) technologies, which are currently "unproven and reliance on such technology is a major risk in the ability to limit warming to 1.5°C" (IPCC, 2018). This Special Report also provides a preview into the Shared Socioeconomic Pathways (SSPs), which will be showcased in the IPCC's 6th Assessment Report (AR6), and will provide more nuanced socioeconomic pathways and therefore largely replace the Representative Concentration Pathways (RCPs) outlined in AR5.

Scaling up ambition to align with the Paris Agreement is also the aim of the One Earth Climate Model, which is aiming to set a new standard in identifying a feasible path to 1.5°C with little or no reliance on CDR technologies. The Principles for Responsible Investment (PRI) have also developed a Forecast Policy Scenario, which assumes an "inevitable policy response" (IPR) to net zero in the short term, without necessarily meeting the 1.5°C temperature target, unless a second, medium-term, policy ratchet is initiated. This attempts to respond to criticisms of other <2°C scenarios as 'tail scenarios' that set overambitious and unrealistic short-term policy ambitions and whose modelled transitions are optimal rather than disorderly (Energy Transition Advisors, 2020).

A further development in scenarios over the past year has been the release of the NGFS reference scenarios, which set a standard for climate scenarios for the finance sector (NGFS, 2020b). These integrate both emissions pathways and shared socioeconomic pathways (SSPs) and thus provide a common set of scenarios for assessing both transition and physical risks. The NGFS scenario set includes three principal scenarios:

i. Orderly (1.5-2°C by 2100);
ii. Disorderly (1.5-2°C by 2100, though with greater transition risks than for an orderly transition);
iii. Hothouse world (3°C+ based on current policies, which do not meet even current Nationally Determined Contributions).

The NGFS scenarios have been based on integrated assessment models (IAMs) developed by PIK (REMIND-MagPIE), IIASA (MESSAGEix-GLOBIOM) and the University of Maryland (GCAM). It is likely that these scenarios will be adopted by central banks and regulators and will provide the basis for future climate stress tests for the finance sector. South Pole, Climate Credit Analytics and Oliver Wyman's Transition Check have already added the NGFS scenario set to their analytics.

A summary of available reference scenarios used for transition risk analysis is given in the below table:

Scenario Provider	Year	Name	Sector	Est. implied temp. rise	Basis
IEA World Energy Outlook (WEO) [updated annually]	2020	NZE2050 (Net zero emissions by 2050)	Energy	1.5°C	Outlines necessary technology, policies and behaviour change necessary to bring about net-zero emissions by 2050.
		SDS 2020 (Sustainable Development Scenario)	Energy	1.8°C (66%) 1.5°C (50%)	Takes in to account social (SDG) and climate goals
		STEPS (Stated Policies Scenario)	Energy	2.7-3.3°C	Takes in to account stated policies (replaces the New Policies Scenario, NPS)
		Delayed Recovery Scenario (DRS)	Energy	<2.7°C	STEPS with a delayed recovery from pandemic

IEA Energy Technology Perspec-tives (ETP) [2020 release feeds into SDS scenario]	2017	B2DS (Below 2 Degrees Scenario)	Energy	1.75°C	
		2DS (2 Degrees Scenario)	Energy	2°C	
		RTS (Reference Technology Scenario)	Energy	2.75°C	Takes into account existing energy- and climate-related pledges, including NDCs.
IPCC	2014	RCP (Repre-sentative Concentration Pathways)	All sectors	1.0°C (RCP 2.6) 1.8°C (RCP 4.5) 2.2°C (RCP 6.0) 3.7°C (RCP 8.5)	RCPs outline pathways according to different levels of radiative forcing in the CMIP5
IPCC	2018	SR15	All sectors	1.5°C	Set of P1-4 pathways to meet 1.5°C target, building on RCP 1.9
NGFS	2020	Orderly	All sectors	<2°C	Both orderly and disorderly have alternate scenarios with limited or full CDR
		Disorderly	All sectors	<2°C	Higher transition risk than for Orderly scenario
		Hot-house World	All sectors	3°C+	Only current policies imple-mented, not NDCs, i.e. equiv-alent to IEA STEPS
OECM	2020	One Climate Earth Model	All sectors	1.5°C	Minimal CDR. Released 2020.
PRI Inevita-ble Policy Response (IPR)	2020	Forecast Policy Scenario	All sectors	1.5°C	Based on the inevitable policy response to meeting the Paris Agreement.

Table 4: Overview of climate and transition scenarios

There are a number of other available scenarios, including IRENA's Remap, Greenpeace's Advanced Energy [Revolution] and IDDRI/SDSN's Deep Decarbonisation Pathways, which are less widely used in service providers' models.

In terms of the methodologies surveyed by UNEP FI, all now include a 1.5°C or below 2°C scenario, demonstrating the shift in transition risk analysis to scenarios which imply alignment with the objectives of the Paris Agreement, as well as the 2°C used as the basis for high transition risk scenarios in 2019. All methodologies supplement this with a 3°C or 4°C scenario to provide a comparison with the 'business-as-usual' or 'stated policies' approach, though Carbon Tracker focuses on oil & gas transition risks by using the IEA's STEPS scenario (~2.7°C) as a proxy for 'business-as-usual' by assessing the proportion of company expenditure that goes ahead under the STEPS scenario at the asset level but falls outside lower demand scenarios.

IEA scenarios are used by many methodologies, including 2DII, Carbone 4, Carbon Tracker, Planetrics, ClimateWise, Moody's Investor Services (MIS) and South Pole, as the IEA provides arguably the most granular scenarios for carbon intensive sectors, such as oil and gas, electricity, power generation, heavy manufacturing and automotive. Given the IEA's consistent under-estimation of renewable energy growth and high reliance on CDR, a number of providers use IEA scenarios as a basis for their own bespoke approaches – for example, Carbone 4 uses IEA SDS as a basis for modelling the electricity sector only.

NGFS scenarios will become increasingly important and Oliver Wyman's Transition Check Tool has integrated these scenarios in its initial release, building on Oliver Wyman's collaboration with PIK and IIASA in UNEP FI's first and second phase TCFD pilot. NGFS scenarios have also been integrated into Oliver Wyman and S&P Global Market Intelligence's Climate Credit Analytics.

Forecast Policy Scenario, based on PRI's Inevitable Policy Response (IPR) is adopted by Vivid Economics and Planetrics alongside IEA and IPCC scenarios to inform its 1.5°C transition risk tool.

Bespoke approaches are used in both of Oliver Wyman 's tools, by MSCI-Carbon Delta, in collaboration with PIK, IIASA and GCAM, by Carbone 4, and by Verisk, while Baringa Partners offers bespoke approaches in addition to standard scenario sets. Ortec Finance have developed 3 transition pathways similar to the NGFS scenario set including orderly and disorderly Paris aligned transitions and a business-as-usual, equivalent to a 'hothouse' world. The macroeconomic consequences, including GDP, inflation and sectoral GVA, of these scenarios are taken from Cambridge Econometrics' E3ME model, and cover countries, sectors and asset class risk return expectations, through a top-down approach.

It must be noted that many methodologies still employ scenarios, both sector specific such as the IEA scenarios or the IAMs, which continue to model relatively late emission peaks and CDR. This implies that many risk analyses are still building in a later transition, but with a much steeper decarbonisation and reliance on unproven decarbonisation technologies. Employing more ambitious 1.5°C aligned scenarios that do not rely on CDR, requires confronting technological and societal transformation in a more rapid and ordered manner. The continued use of 2°C scenarios or <2°C scenarios with a heavy reliance on CDR suggests a lack of confidence in the ability of economic governance institutions, businesses and society to confront the low-carbon transition in the medium to long term. Even the IEA's latest Net-Zero Emissions by 2050 scenario estimates that about 1,150 Mt of CO2 would have to be removed by 2030, using technology that does not yet exist.

Further information on scenario selection can be found in :

- *Pathways to net zero: Scenario architecture for strategic resilience testing and planning (Energy Transition Advisors for PRI, 2020)*
- *Navigating Climate Scenario Analysis (IIGCC, 2019)*

3.3 Hazards

As in the 2019 Changing Course report, the focus here is on two types of transition hazards:

i. **Policy** – changes in the counterparty's policy and legislatory environment, for example through direct costs such as carbon pricing, taxation or cap-and-trade, or indirect costs such as changes in subsidies, the introduction of renewables obligations, etc.
ii. **Technology** – changes in the availability and relative costs of technology, for example the lowering costs of renewable technologies and energy storage and the high costs of fossil fuel extraction from shale reservoirs, tar sands or deep offshore fields.

Market hazards are not included in this review, as it is assumed that the market is largely shaped by policy and technology, though recently markets have shifted independently of technology or policy due to the global pandemic, which impacted the demand for fossil fuels in certain sectors. Such changes in demand through changes in behaviour, lifestyle or economic model could be taken into account in these methodologies. Some methodology providers are accounting for pandemic or public health shocks in their risk assessment in response to the considerable demand shock in 2020.

All methodologies employ sector scenarios or integrated assessment models (IAMs) that automatically account for both policy (carbon prices) and shifts in technology, so almost all the methodologies take into account policy and technology hazards. The only exception to this is South Pole's Risk Screening Tool, which is a 'quick' assessment tool assessing only carbon price. South Pole do provide a more comprehensive assessment tool that also covers technological change, the Climate Risk Deep-Dive Assessment.

3.4 Assessment methodologies

Determining financial risk at the sector and firm level, from climate scenarios and associated socioeconomic pathways is dependent on the approach the methodology takes. The methodology has to assess a range of variables and assumptions that affect the economic impact at the macroeconomic or sectoral level and translate those impacts at the firm-level and subsequently estimate the financial impact to the financial institution.

This report bases its methodological assessment on the framework developed in the 2019 Changing Course report, which looks at each methodology's scope and breadth of assessment. The scope of an assessment is across four principal impact channels:

i. **Macro-environment** – economic trends at the macro-level tend to be the starting point for top-down analyses. Policy and technology changes at the country and sector level could impact macroeconomic indicators such as economic growth, the balance of trade and exchange rates, particularly in the case of disorderly transitions or price shocks.

ii. **Supply chain** – policy or technology shifts could see impacts on the upstream or downstream supply chain of counterparties, for example through changing costs of electricity generation or increased demand for certain products such as electric vehicles.
iii. **Operations and assets** – this impact channel directly affects the operations of counterparties, i.e. scope 1 emissions.
iv. **Market** – for emissions-intensive industries, most transition impact will be through the scope 3 emissions of consumers, so for coal mining or oil & gas production, policy or technology changes will lead to changes in market demand.

This overview also looks at three levels of assessment:

i. **Exposure** – determined by location and sector, and therefore exposure to climate policy or technology respectively.
ii. **Sensitivity** – determined by a counterparty's emissions intensity per unit of production and therefore how far it will be affected by a change in costs, or in supply chain terms, by a supplier's emissions intensity. This also affected by the counterparty's ability to absorb costs or to pass them on to consumers.
iii. **Adaptive capacity** – determined by a counterparty's ability to shift away from high emissions technology or suppliers (input substitution), or to develop new technologies or business models through R&D and strategy respectively.

Most of the described methodologies are based on deterministic modelling – where they differ is in how the economic modelling is approached: either bottom-up, which builds the economic impacts up from the firm level, or top-down, which directly models economic impacts at the macroeconomic or sector level. Bingler & Colesanti Senni give a good description of how these methodologies work (pp. 16-20; 2020). Stochastic modelling is integrated into some of the methodologies, such as Ortec Finance's ClimateMAPS, which takes deterministically modelled GDP, inflation and sector GCA shocks from its econometric model and feeds into their stochastically determined financial model.

Bottom-up methodologies provide a more granular assessment with arguably more accurate near-term results. They also tend to provide more detailed information at the firm level and through the supply chain. Such approaches include Baringa Partners' Climate Change Scenario Model, Carbone 4's Climate Impact, PwC/CO-Firm's Climate Excellence, Planetrics' Climate Risk Toolkit, Verisk's Transition Risk Tool and MIS' Carbon Transition Assessment and V.E's Carbon & Energy Transition metrics.

Top-down approaches measure emissions against the global carbon budget as country level emissions data is often more reliable and consistent than firm-level emissions data. Additionally, top-down approaches capture more readily the networked effects of interacting climate risk drivers, including policy, technology and physical risk. Ortec Finance's ClimateMAPS is an example of this approach.

Most of the covered assessment methodologies are able to provide macro-economic level analysis. The only tool not to cover this aspect at all is Carbon Tracker's 2 Degrees of Separation tool which is focused on granular firm-level transition risk analysis in the oil & gas sector. A majority of the methodologies are able to capture sensitivity and adaptive capacity at the macro-level, including Ortec Finance's top-down analysis and Vivid Economics and Planetrics who incorporate top-down macroeconomic assessment into their tool through the Vivid Economy-Wide (ViEW) model, while Baringa Partners' model allows for sector-level impact modelling in addition to their bottom-up analysis. Oliver Wyman and S&P Global Market Intelligence's Climate Credit Analytics also captures top-down macroeconomic impacts alongside its bottom-up analysis.

All methodologies are able to measure the transition risk to counterparty **operations** and to the **market**, while **supply chains** tend to be better modelled by those methodologies with a bottom-up approach that has been extended along upstream and downstream value chains. Top-down approaches can model supply-chain effects at a macro-level, through international trade impacts, for example. Often, however, **supply chain risk, otherwise known as second-order or indirect risk, is modelled using proxies such as vulnerability indicators**. It must be noted that this level of assessment is only as good as the visibility of a company along its upstream and downstream supply chains, while sector-level estimates of indirect risks are likely to increase the error of risk estimates.

In terms of methodologies' **depth of assessment**, exposure and sensitivity to transition risks are modelled across the board, though South Pole's 'light-touch' methodology only covers exposure and not sensitivity or adaptive capacity. Sensitivity tends to be modelled across the board by cost-pass through only. Only Oliver Wyman and the PwC/CO-Firm's models account for a counterparty's ability to absorb costs or to outperform peers (Bingler & Colesanti Senna, 2020).

Adaptive capacity is less well covered, though methodologies have improved over the past year on this score. Adaptive capacity in supply chains, operations and markets is necessarily modelled at the firm level through bottom-up approaches, as it is necessary to either understand the firm's technological and business strategies, or capacity to substitute away from high emissions inputs. Adaptive capacity in supply chains is perhaps the greatest challenge to methodologies given the need to model upstream and downstream. Currently six of the assessed methodologies are able to provide this level of analysis, though a number of other providers are developing this capacity over the coming year.

Transition opportunities are an important aspect of any transition assessment and a number of the methodologies covered here are able to model either patent data, including Carbon Delta's CVaR model, Planetrics' Climate Risk Toolkit and V.E's energy transition and governance data. Oliver Wyman's model is able to assess the capabilities of banks to respond to technological change through Transition Check, as well as in their collaboration with S&P Global Market Intelligence's Climate Credit Analytics. Top-down approaches can also identify sector-level opportunities, for example where, for example, transition technologies may drive sector GVA growth. This is perhaps the key element in a climate risk analysis enabling banks and investors to identify sectors likely to grow as a result of the economic transition, as compared to current focal sectors.

It is important to note that climate risk analysis must be distinguished from alignment, impact or target-setting tools, which have slightly different goals. We continue to include 2DII's PACTA, though in the framing of its recently released Stress Test Module, which was developed in partnership with the Bank of England and has been used to pilot a climate stress test methodology for UK-based insurers and was recently developed and further applied by EIOPA in their climate risk sensitivity analysis. Unlike a risk analysis tool, however, this impact approach focuses on a base case and high transition risk temperature scenarios – 3°C and disorderly <2°C. Other PACTA modules are focused on portfolio alignment for banks and investors and are not included in this overview, though measuring alignment of a portfolio can provide a useful proxy for transition risk.

3.5 Outputs

The majority of methodology providers are able to provide quantitative financial metrics and have expanded the range of outputs they are able to provide in order to meet the needs of different financial institutions – Baringa Partners, South Pole and Ortec Finance have indicated their flexibility in developing a range of financial output metrics. Moody's and Ortec Finance can also provide a range of climate-adjusted macroeconomic indicators using their top-down macroeconomic approach, including climate-adjusted GDP, interest & inflation rate expectations, risk-return/asset class, credit spreads, risk premia, etc. Value at Risk (VaR) from climate change is a widely used output metric used by MSCI-Carbon Delta, Ortec Finance, Planetrics and Verisk, which measure the financial impact of the climate transition against a baseline. South Pole's Risk Screening Tool provides a PRR metric, while Carbon Tracker's oil & gas sector focus provides an estimate of capital expenditure at risk outside the sector carbon budget. Verisk's Transition Risk analysis also provides metrics oriented towards the insurance industry: for example, the Risk Premium Rating.

Some methodologies provide semi-quantitative outputs such as Carbone 4's Carbon Impact Analysis, which provides an overall rating and alignment with 2°C trajectories risk rating (A to E), as well as an assessment of forward-looking company strategy (++ to –), based on quantified induced and avoided emissions, as well as forward-looking emissions. MIS' Carbon Transition Assessment Tool and Verisk provide semi-quantitative emissions intensity scores (0 to 10). 2DII's PACTA Stress Test Module estimates a Loss in Predicted Value, which assesses the level of exposure of equity and corporate bond portfolios to Paris-aligned transition pathways.

Increasingly, methodologies are adopting temperature alignment scores. These semi-quantitative outputs provide an indication of a portfolio's or loan book's implied impact on global warming. This metric is currently being explored by the TCFD Secretariat as an addition to the TCFD recommendations in order to gradually move financial institutions from risk assessment to active portfolio management to align portfolios with international climate objectives. Carbone 4's methodology implicitly assesses climate impact, while other service providers have added implied temperature scores to their services, including Baringa Partners, Moody's (V.E), MSCI-Carbon Delta, Planetrics, Ortec Finance through their ClimateALIGN tool. 2DII's PACTA methodology implicitly calculates the delta with a 2°C scenario, so can be said to calculate a metric alignment. One methodology that is not included in the current assessment as it is not a tool for calculating climate risk *per se*, is *Right.based on science*'s XDC tool, which directly calculates the temperate alignment score for a portfolio.

3.6 Resolution

This is where the difference of top-down vs bottom-up approaches can really come into focus. Bottom-up approaches are generally more granular, but as uncertainties around asset and firm level data increase over the medium to long term, top-down approaches, with their sector overview, may be more credible at these longer timescales. Furthermore, bottom-up approaches are likely to be more readily deployable by larger financial institutions with the reach and means to access more granular data or those institutions with an intimate knowledge of their investment portfolio. Top-down and bottom-up approaches can be complementary allowing for strategic asset allocation through top-down approaches and stock or investment level decision-making supported by bottom-up approaches.

High resolution, bottom-up approaches with facility and firm level analysis include Baringa Partners, Climate Credit Analytics, MSCI-Carbon Delta, Planetrics, Vigeo-Eiris, South Pole, Verisk and PwC/CO-Firm. Carbon Tracker's analysis assesses oil and gas production at the field level to estimate the extent of asset stranding. Carbone 4 assess impact at the firm level, rather than at the facility level. Top-down methodologies, such as Ortec Finance and PACTA can provide granularity at the company, sector and country levels.

3.7 Validity

Given the complexity of climate scenarios, socio-economic models and translating these model outputs into consequences for financial firms and their clients, each tool has its own set of assumptions and simplifications. This inevitably leads to variations in the calculation of financial risk metrics for a given input, so it is important for financial institutions to understand how the models work or at the very least to have confidence in the validity of the tools they are using.

In terms of full public access, only ClimateWise, 2DII and Climafin, as externally funded projects, have made their full source code publicly available. Ortec Finance is engaged in an initiative led by the Linux Foundation to make an open-source version of ClimateMAPS that will be made available on the OS-Climate platform, while their ClimateALIGN is based on the SBTi-FI developed open-source temperature scoring tool. In the majority of cases where access to the model is restricted, it is important to ensure validity through peer review or, at the very least, to understand the scientific basis of a methodology through its source references. Service providers may make elements of the methodologies available to clients under Non-Disclosure Agreements in order for users to have an understanding of key assumptions and parameters and how metrics are calculated.

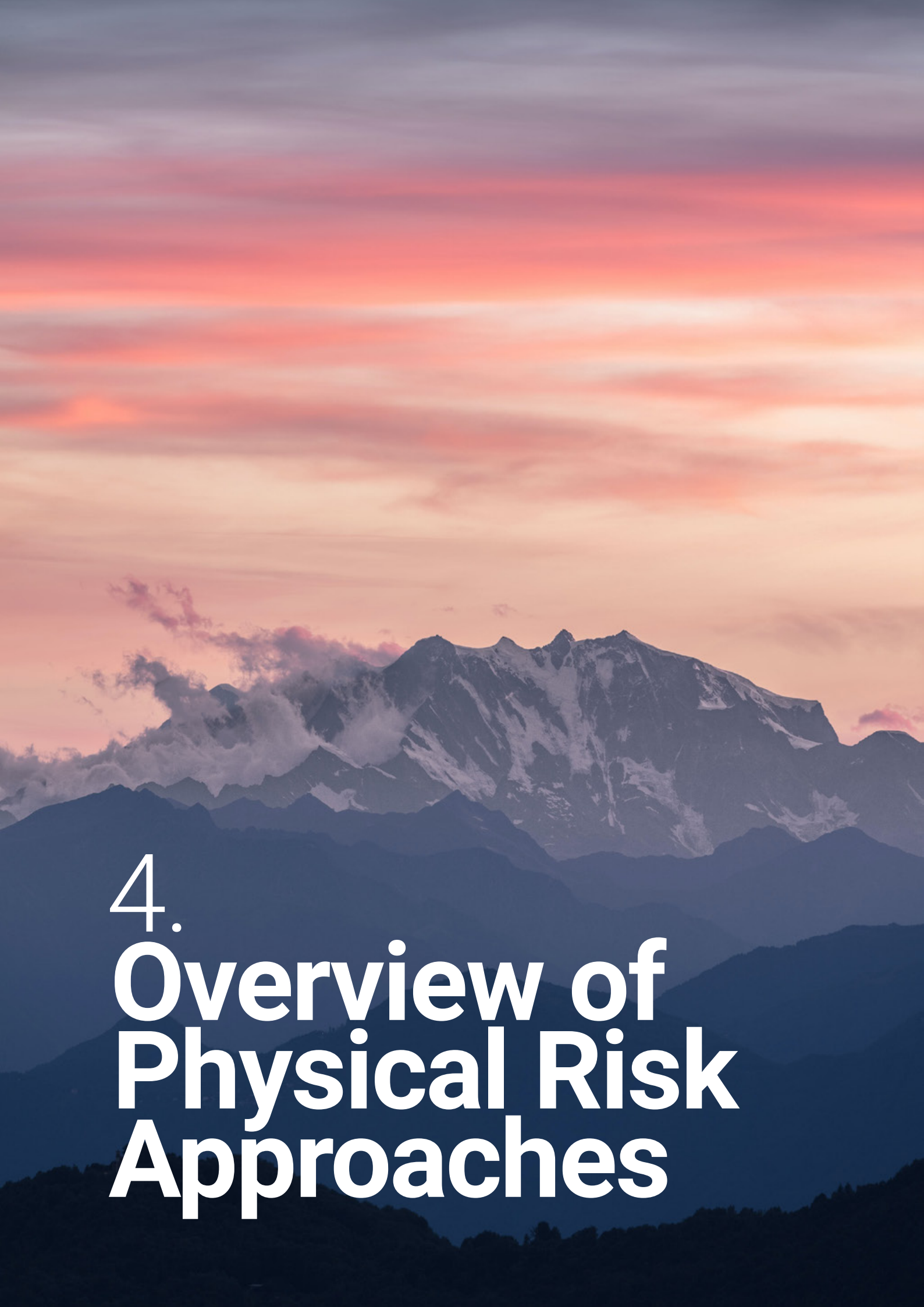
3.8 Usability

Further to the scope of last year's Changing Course report, we provide a brief overview of some additional criteria, including accessibility and coverage, and time horizon.

Accessibility: The majority of these methodologies are fee-based, except for 2DII's and CISL's tools. Oliver Wyman's Transition Check is free for UNEP FI members, while the results from Carbon Tracker's tool are free for all, though PRI members have access to greater functionality. PACTA's Stress Test Module is free to explore and use on transition-monitor.org, as well as access to PACTA's alignment tools for investors and banks. The Cambridge Institute of Sustainability Leadership's ClimateWise tool can provide a free, open-source introduction to scenario analysis. Finally, Carbon Tracker's oil & gas focused tool is free to use for PRI members at 2degreesseparation.unpri.org/.

Coverage: Almost all tools are described as 'global'. Ortec Finance's Climate MAPS, which nominally covers 29 countries worldwide, does integrate global interaction and impacts given its top-down approach, and other countries can be added into the model on a bespoke basis. ClimateWise, which currently only covers the EU, US and India, is looking to scale up its offering to China and Australia in 2021.

Horizon: The time horizon of the methodology varies between methodologies and care needs to be taken that the methodology chosen provides an adequate balance between short-term validity in terms of the estimated uptake of transition-aligned policies and technologies and the investment horizon required by the financial institution. The majority of methodologies provide horizons to 2030-40, with Planetrics and ClimateWise also providing nearer term outputs to 2025. Carbone 4 impact analysis has a near term horizon of 2025. Longer-term horizons are also provided by Oliver Wyman, Baringa Partners, PwC/Co-Firm and Planetrics (2050), Ortec Finance (2060, with narrative outlooks to 2100), Verisk (2064), Climafin (2080) and South Pole and The Climate Service (up to 2100).



4. Overview of Physical Risk Approaches

4.1 Introduction

This section provides an overview of nineteen physical risk tools and analytics and reproduces the comprehensive overview in Acclimatise's *Charting a New Course* report (2020) developed for UNEP FI's TCFD Banking Pilot Project Phase II. The reproduction of this work in this report is firstly for completeness, as many financial institutions will want to assess both their transition and physical risk exposure. Furthermore, a number of providers offer both transition and physical risk methodologies and are aiming to provide combined risk assessments over the coming year. For a thorough and complete overview of physical risk tools and analytics, therefore, it is strongly recommended to also refer to *Charting a New Course*.

Secondly, in order to reflect the sector-wide scope of this report we have included a number of other service providers, including RMS and Verisk. These are firms who have traditionally provided historic risk assessments for (re-)insurance services and engineering projects and who are increasingly scaling their offerings to forward-looking climate change-related risk assessment for the wider finance sector. Their expertise lies largely on the analysis of acute physical risk, though they are developing expertise on chronic risks, such as RMS' collaboration with the Natural Capital Alliance on drought scenarios for Brazil, Mexico, the US and China. Given their recent entry into the sector of climate risk assessment for financial institutions (beyond underwriting), their offering is best suited to products directly associated with physical assets such as mortgages, real estate and project finance, where their analytic approach can provide highly granular analyses. Other service providers have been able to develop a framework to update these natural catastrophe models for climate change – ClimateWise, for example have demonstrated this approach for property portfolios.

Like the transition risk overview in chapter 3, the set of service providers listed and reviewed in this section is certainly not exhaustive, but we have attempted to include the principal commercially available methodologies.

For a detailed overview of the physical risk tools and analytics and a set of case studies by banks using a selection of the methodologies, it is strongly recommended to refer to *Charting a New Climate* (UNEP FI, 2020). Hereunder are a few additions to the commentary provided in the previous report.

			Provider																		
			427 (1)	427 (2)	ACC	ACC-WTW	C4 (1)	C4 (2)	CFIN	CW	MSCI	OF (1)	OF (2)	RhG	RMS	SP (1)	SP (2)	TCS	VE-PL	VR	XDI
Scenarios	<2.0°C (RCP 2.6)				✓	✓			✓		(✓)[i]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	2.0°C (RCP 4.5)		(✓)[i]		✓	✓	✓	✓	✓	✓	(✓)[i]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	3.0°C (RCP 6.0)				✓	✓	✓		✓		(✓)[i]	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	>4.0°C (RCP 8.5)		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time horizons	Baseline / historical				✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Near term (2025-2040)		✓	✓	✓	✓			✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Medium term (2050)		(✓)[i]		✓	✓	✓	✓	✓	✓[ii]		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Long-term (2100)		(✓)[i]				✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Physical Hazards	Chronic		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Acute		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Risk analysis	Level of analysis	Asset	✓	✓	✓	✓	✓	✓		✓			✓	✓	✓		✓	✓	✓	✓	✓
		Firm	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓
		Sector	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓			✓	✓	✓	✓
		Country	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓			✓	✓	✓	✓
		Portfolio	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓		✓	✓	✓	✓	✓
	Impact Channel	Macroenvironment		✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	
		Supply chain		✓	✓	✓	✓		✓			✓	✓		✓	✓	✓	✓	✓	✓	✓
		Operations and assets	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Markets and customers		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
	Method	Physical Exposure	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Vulnerability indicators		✓	✓		✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓
		Physical impact modeling	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Financial modeling	✓	✓		✓			✓			✓	✓	✓	✓		✓	✓	✓	✓	✓
Physical Hazard Type	Flood, coast		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
	Flood, inland		✓	✓	✓	✓	✓	✓	✓	✓	(✓)[i]	✓	✓		✓		✓	✓	✓	✓	✓
	Extreme weather		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
	Extreme heat		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓
	Extreme precipitation		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓	✓	✓
	Landslide				✓	✓	✓	✓				✓	✓						✓	✓	✓
	Drought		✓	✓	✓	✓	✓	✓			(✓)[i]	✓	✓		✓		✓	✓	✓	✓	✓
	Water scarcity		✓	✓	✓	✓	✓	✓									✓	✓	✓	✓	
	Wildfire		✓	✓	✓	✓	✓	✓	✓		(✓)[i]	✓	✓		✓		✓	✓	✓	✓	✓

		Provider																		
		427 (1)	427 (2)	ACC	ACC-WTW	C4 (1)	C4 (2)	CFIN	CW	MSCI	OF (1)	OF (2)	RhG	RMS	SP (1)	SP (2)	TCS	VE-PL	VR	XDI
Asset classes	Equity	✓	✓	✓	✓	✓	✓	✓		✓	✓			✓	✓	✓	✓	✓	✓	✓
	Bonds, Corporate		✓	✓	✓	✓	✓	✓		✓	✓			✓	✓	✓		✓	✓	✓
	Bonds, Government	✓		✓	✓	✓	✓	✓			✓		✓	✓		✓		✓	✓	✓
	Loans, Corporate		✓	✓	✓	✓	✓	✓			✓			✓		✓		✓	✓	✓
	Loans, Project	✓		✓	✓	✓	✓	✓			✓		✓	✓		✓		✓	✓	✓
	Mortgages	✓		✓	✓	✓	✓				✓	✓	✓	✓		✓	✓	✓	✓	✓
	Real Estate / Real Assets	✓		✓	✓	✓	✓	✓	(✓)[iii]	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
User inputs	Counterparty name		✓	✓	✓	✓	✓	✓		✓	[v]	[v]	✓	✓	✓	✓	✓	✓	✓	✓
	Location	✓		✓	✓		✓		✓	✓	[v]	[v]	✓	✓		✓	✓	✓	✓	✓
	Value of asset			✓	✓		✓		(✓)[iv]	✓	[v]	[v]	✓	✓	✓	✓	✓	✓	✓	✓
	Characteristics of asset	✓		✓	✓		✓			✓	[v]	[v]	✓	✓		✓		✓	✓	✓
Validity	Open-source	(✓)[vi]						✓	✓		(✓)[viii]				(✓)[ix]	(✓)[ix]		(✓)[ix]		
	Peer-reviewed	(✓)[vii]		✓	✓			✓	✓		✓	✓		✓	✓	✓	✓	(✓)[x]	✓	✓
	Source references	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Outputs	Quantitative	✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
	Semi-quantitative		✓		✓		✓		✓				✓	✓		✓				
	Non-financial metrics	✓		✓		✓	✓		✓		✓	✓		✓		✓	✓	✓		✓
	Financial metrics	(✓)[i]	✓[xi]		✓			✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 5: Overview of physical risk assessment tools and analytics

Abbreviation	Service Provider	Tool
427 (1)	Four Twenty Seven	On-demand physical climate risk scoring application
427 (2)	Four Twenty Seven	Physical climate-risk scores for publicly listed companies
ACC	Acclimatise	Physical climate risk heatmapping tool
ACC-WTW	Acclimatise-Willis Towers Watson	Sector deep-dive assessments tool
C4 (1)	Carbone 4	Climate risk impact screening (CRIS)
C4 (2)	Carbone 4	Infrastructure and real estate portfolio assessment tools
CFIN	Climate Finance Alpha	Physical risk toolbox
CW	ClimateWise (CISL)	Physical risk framework
MSCI	MSCI-Carbon Delta	Climate Value-at-Risk (CVaR)
OF (1)	Ortec Finance	ClimateMAPS
OF (2)	Ortec Finance	ClimatePREDICT
RhG	Rhodium Group	Valued asset-level physical risk data
RMS	RMS	Climate risk models and consultancy service
SP (1)	South Pole	Risk screening tool
SP (2)	South Pole	Climate risk deep-dive assessment
TCS	The Climate Service	TCS Climanomics
VE-PL	Planetrics	PlanetView
VR	Verisk Analytics	AIR
XDI	XDI Systems (physical risk only or in partnership with Baringa for physical & transition)	

Notes

i. Under development for 2021
ii. Up to 2080
iii. Infrastructure / real assets only
iv. Optional (but preferable)
v. Top-down approach does not need company/asset information
vi. Methodology available for users
vii. Elements of the methodology are peer-reviewed
viii. Open-source version will be available on OS-Climate platform
ix. Methodology, not source code
x. Within Vivid Economics' academic network
xi. Leveraging Moody's Analytics' Public Expected Default Frequency structural credit risk model, 427's physical climate risk scores for listed companies can be translated into credit metrics such as probability of default term structures, expected loss estimates, credit spread effects, price effects, and value-at-risk. This is currently offered as consultancy services and will be offered in future as an on-demand analytics product.

4.2 Scenarios

All methodologies surveyed adopt an RCP 8.5 (4°C by 2100) scenario to measure the maximum physical risk. There has been discussion as to whether RCP 8.5 can still be considered as a business-as-usual scenario, given the advances in scenario modelling and the trajectory of the energy transition since AR5 was published in 2014 (Hausfather & Peters, 2020; Shwalm, Glendon & Duffy, 2020). A recent study has marginally narrowed the range for global temperature rise by 2100 to a "likely" (66% confidence) range of 2.6-3.9°C, but this is not enough to shift the Business-as-usual case to RCP 6 (Sherwood et al, 2020).

Unusually, MSCI-Carbon Delta employs a stochastic approach to estimating physical risk, based on the 50th and 95th percentile expectancy of a business-as-usual risk distribution, rather than comparing a RCP8.5 scenario against a <2°C objective RCP 2.6 scenario. It is arguable as to whether this approach accounts for more extreme physical risks in the event of tipping points or climate shocks.

4.3 Acute and chronic risks

The inclusion of a number of risk assessment firms with experience working in the (re-)insurance industry, such as RMS and Verisk, opens up the risk assessment space to firms that have a history of developing highly granular physical risk models with a focus on acute hazards such as extreme weather, inland and coastal flooding, wild-fires, landslides, etc. With the rise in demand for climate risk assessment, these firms are rapidly developing forward-looking climate scenarios, which provides them with a distinct competitive advantage over other firms that have developed physical climate risk assessments for the financial sector, whose strengths lie more in modelling forward-looking chronic risks and in translating these models into output data of use to financial firms.

Chronic risks are a particular challenge. Approaches to chronic risk have focused either on quantitative analysis such as RMS' collaboration with the Natural Capital Alliance on drought and water scarcity, or on qualitative evaluation based on a comprehensive literature review, for example, by Ortec Finance to assess the impacts of precipitation changes and temperature rise, on industrial, labour and agricultural productivity. One area where chronic impacts are perhaps less of a challenge is in coastal flood risk due to sea level rise. However, sea-level rise has other effects including salination of agricultural land, which is less well modelled.

4.4 Secondary risks from climate change

One area for improvement in physical risk models is assessing the impacts from secondary climate-change driven effects, whether socio-economic, such as migration and conflict, or environmental, such as public health shocks. These secondary impacts are difficult to model given the human behaviour element of socio-economic shocks, and the unpredictable nature of public health impacts. However public research funding is being directed towards modelling limited climate change-induced impact scenarios, such as the CASCADES project. This EU-financed initiative will model trade and supply chains, analysing the impact of acute and physical climate change-related hazards on agricultural production, energy and commodity markets. Combined with "macro-economic modelling, qualitative political analysis and strategic policy simulations", this will enable an assessment of areas of critical concern and potential solutions for Europe and beyond.[3]

3 cascades.eu/

5. Beyond 2020

This review of the available methodologies for physical and transition risk assessment will hopefully be of benefit to financial firms embarking on climate-related risk assessment in order to meet the requirements of a TCFD-aligned climate risk disclosure. As highlighted previously, more in-depth information is available on physical risk methodologies and data sources from UNEP FI and on transition risk methodologies from ETHZ.

5.1 Developments in regulation

Policy makers and regulators are increasingly highlighting the threats from climate change and are pointing the way towards mandatory climate risk through the development of guidelines and standards. In section 2.1.1, a brief overview shows how central banks, regulators and policy makers are responding to climate risk, with New Zealand the first country to announce mandatory climate risk disclosure. Within the next year the European Union can be expected to release an update to the Non-Financial Reporting Directive (NFRD), which is likely to direct member states to implement climate-risk reporting regulation for financial institutions, and the UK's Joint Government Regulator TCFD Taskforce has released a strategy and roadmap to mandatory disclosure by 2025 at the latest, with many requirements in place by 2023 (HM Treasury, 2020).

Central banks and regulators will increasingly pilot and subsequently impose climate stress testing on banks. As described in section 2.1.2, a number of central banks in western Europe have already piloted climate stress tests and some service providers are moving to support the development of these stress tests, such as 2DII in Switzerland and Japan. As central banks move away from piloting individual scenarios, they will increasingly gauge sensitivity by stress testing against a bank of multiple climate scenarios. 2DII have also suggested that stress testing may move away from sector-level shocks to "technology-oriented" shocks, e.g. to renewable energies or to coal power.

Service providers are increasingly pooling resources or are being integrated into larger financial service providers. Trucost, an ESG risk consultancy not covered in this review, was acquired already in 2016 by S&P Global Indices. Over the last year, MSCI purchased Carbon Delta; Willis Towers Watson acquired Acclimatise; 427 and Vigeo-Eiris have come under the umbrella of Moody's Analytics; while 2DII and Carbon Tracker are increasingly collaborating. Firstly, this process of consolidation will allow climate risk specialists greater access to company data and resources to develop their risk tools. Secondly, greater integration will also improve access and usability: for example, Carbon Delta's data will be integrated into MSCI's ESG Manager platform before the end of 2020, while V.E and Four Twenty Seven data is made available on Moody's CreditView.

5.2 Developments in technology

Climate-related risk assessment is still only in its infancy and tools or methodologies are being constantly updated to allow for more granular analysis that takes into account a broader, more plausible set of scenarios, access to more granular datasets. Commercial providers that require a fee to access have a particular incentive to improve their risk forecasts. Below are some of the most important forecast developments:

Most of the service providers are moving away from the use of one scenario provider, if they have not already done so. Up to now, many models have relied on one scenario type, particularly IEA given its focus on high carbon emissions sectors. However, IEA scenarios have consistently had to be updated to account for low emissions technologies developing at a faster rate than predicted by the IEA and this is encouraging a move towards integrating either multiple or bespoke scenarios. For example, South Pole have indicated that they will broaden the scenarios available on their tool, while Moody's ESG Solutions (incorporating Four Twenty Seven and V.E) have indicated that they will expand their range of GCMs from 5 to 18, while also including additional scenarios. Oliver Wyman's online Transition Check tool launched with the three main NGFS scenarios, building on their previous use of PIK, IIASA, GCAM scenarios, but the online scenario module will, over time, integrate other scenarios including IEA, IRENA, OECM, etc. The increasing use of Shared Socioeconomic Pathways (SSPs) is allowing service providers to better model socio-economic inputs and impacts – The Climate Service is already using SSP3-60 and -45.

A number of scenario developers have already developed a bespoke range of transition scenarios, often at sector level, based on existing climate models to improve methodological accuracy or to model alternative transition or demand shocks, including Carbone 4, MSCI-Carbon Delta, Planetrics and Ortec Finance. Baringa Partners also offer bespoke options as well as industry standard scenarios. Bespoke approaches, as well as the use of opaque risk assessment methodologies may reduce the ability of financial institutions or financial regulators to understand the parameters or assumptions used in risk analysis.

Increasing demand for standardisation may move developers towards the use of reference scenarios. This would help to address growing concerns over the transparency and comparability of climate risk assessments (Bingler & Colesanti Senni, 2020). The NGFS reference scenarios, released earlier in 2020, are aiming at standardisation and have already been adopted by Oliver Wyman in their Transition Check tool, released September 2020. It must be noted, however, that the NGFS scenario sets need to be further developed to improve granularity at the sector and regional level, as well as integrating other market drivers such as technological change and alternative policy responses (Pierfederici, 2019).

Transition and physical risk methodologies are being increasingly combined in order to provide financial institutions with an overall picture of climate-related risks for each scenario. Some providers have already achieved this in-house, such as Ortec Finance. Others are pooling resources such as Baringa Partners, who have built on their experience in the energy sector to develop a transition risk tool, and are partnering with physical risk specialists, XDI, to provide a holistic climate risk analysis. Bottom-up assessment methodologies are perhaps more complex to integrate, but many of the service providers covered in this report are moving in this direction, including The Climate Service.

Physical risk models will be able to aggregate greater sources of data, with the use of geospatial and remote sensing data, AI and data mining. Artificial Intelligence will be of increasing importance in accessing data from various sources. For physical risks this could include 'vision learning' from geospatial data. This will also help to expand the range of physical hazards covered – Four Twenty Seven for example will expand their offering to include landslides and wildfire smoke. Jupiter Intel, not included in this current overview, has built a model for physical risk assessment up to 2100 that is constantly updated from real-time satellite and senor data. In terms of transition risk, data mining will enable banks to assess climate risks to a wider range of counterparties, including SMEs.

Increasing granularity of physical risk analysis. Given the increased access to data discussed above, it is likely that physical risk analyses will become far more granular, allowing more accurate risk analysis. Extreme weather and climate hazards are highly location dependent, especially acute risks such as coastal and fluvial flooding and wildfires. Several service providers are scaling up their resolution, including risk specialists such as RMS and Verisk, and XDI who can differentiate changes in impact at up to 1m scale.

Data is likely to become easier to access and in a format more easily usable by financial institutions, as corporates increasingly report on climate risk and respond to data requests, while a number of research projects, including ClimINVEST, are developing open source access to physical risk data, such as the EU's Copernicus Climate Change Service (E3CS). The OS-Climate platform (os-climate.org) initiated by the Linux Foundation, is also aiming to make relevant data publicly available, as well as providing some open-source analytical tools. Meanwhile increasing data availability and higher granularity will reduce errors in risk measurement, making it more likely that financial institutions are able to provide consistent and market-ready disclosures. This will allow analyses to move away from qualitative and exposure-based assessments to more quantitative vulnerability-focused assessments.

5.3 Challenges in 2021

Aside from the regulatory developments described above in 2021, we can expect financial institutions to be faced with the following challenges:

Increasing standardisation and mainstreaming: Industry reporting standards CDSB, CDP, SASB, GRI, and IIRC are moving to align over the coming year and integrate the recommendations of the TCFD, and there will almost certainly be wider uptake of NGFS reference scenarios. Standardisation may follow the guidelines in ISO 14097, the international framework for assessing standards assessing and reporting investments and financing activities related to climate change. Financial institutions will also increasingly want to integrate climate risk into their financial and economic decision-making tools, rather than relying on independent 'black-box' models from climate risk specialist firms.

Presidential transition in the United States: The election of Joe Biden in November will undoubtedly signal a dramatic change in climate policy with the President aiming to: (i) invest up to $2tn on low-carbon energy, (ii) re-join the Paris Agreement, and (iii) achieve net-zero emissions by 2050. Regarding climate risk reporting, the Vice-President, Kamala Harris, is a supporter of climate risk disclosure, e.g. of Sen. Elisabeth Warren's Climate Risk Disclosure Act and Sen. Brian Schatz's Climate Change Financial Risk Act. The change in direction is reflected in the Federal Reserve Board's November 2020 report, which highlights, for the first time, the threat to financial stability posed by uncertain future climate change impacts, and the lack of knowledge on financial sector exposure. The report recommends that, "increased transparency through improved measurement and disclosure could improve the pricing of climate risks" (FRB, 2020).

Methodologies should all take into account carbon lock-in or 'expected greenhouse gas emissions', otherwise approaches that only look at present carbon emissions will ignore the risk of surpassing carbon budgets. This issue has been highlighted in research on climate risk assessment and alignment by financial institutions (Caldecott, 2020; Bingler & Colesanti Senni, 2020) and has been integrated by a number of the methodologies assessed here, including Baringa Partners, PwC, Planetrics, Ortec Finance and 2DII account for this among the models highlighted here.

Knock-on impacts of climate risk are also under-assessed by the existing set of tools and methodologies. Secondary effects of climate change including knock-on economic impacts, public health shocks or migration caused by the physical impacts of climate change have not been adequately modelled by existing methodologies, which may constitute a considerable blind spot in current climate risk methodologies. While there is no evidence for a link between the CoVID-19 pandemic and climate change, it is estimated that climate change will increase the range and survival of vectors that transmit disease and public health will be impacted by higher temperatures, water scarcity and extreme climatic events (Costello et al, 2009).

Integrating biodiversity risk is the next major environmental risk analytics challenge for financial institutions. With the 15th Conference of the Parties of the Convention on Biodiversity taking place this year (CBD, COP15) and the global extinction of flora and fauna worldwide accelerating, UNEP FI, UNDP, WWF and Global Canopy have launched the Taskforce on Nature-related Financial Disclosures (TNFD) together with a working group of around a dozen banks and investors. While this Taskforce was not initiated by the Financial Stability Board as was the case for the TCFD, it is hoped that the momentum of COP15 and widespread awareness of the links between climate change and biodiversity may help TNFD to develop into an industry standard for financial institutions to monitor their impact on biodiversity. Ideally, climate and biodiversity risks should be considered together in the same assessment framework, as climate change will have significant impacts on biodiversity, while biodiversity is a crucial factor in mitigating and adapting to climate change.

Abbreviations

2DII	2 Degrees Investing Initiative
AR5	5th Assessment Report (IPCC)
BCBS	Basel Committee on Banking Supervision
BES	Biennial Exploratory Scenario (Bank of England)
CBD	The United Nations Convention on Biological Diversity
CDR	Carbon Dioxide Removal
CDSB	Carbon Disclosure Standards Board
CET1	Common Equity Tier 1
CISL	Cambridge Institute for Sustainability Leadership
COP	Conference of the Parties (UNFCCC)
CVaR	Climate Value-at-Risk
DNB	Den Nederlandsche Bank
E3CS	EU Copernicus Climate Change Service
ESG	Environmental, Social and Governance
ETHZ	Swiss Federal Institute of Technology, Zurich (Eidgenossische Technische Hochschule Zürich)
FSB	Financial Stability Board
GCAM	Global Change Analysis Model (University of Maryland)
GCM	General Circulation Model
GDP	Gross Domestic Product
GRI	Global Reporting Initiative
GVA	Gross Value Added
IAM	Integrated Assessment Model
IDDRI	Institute for Sustainable Development & International Relations (Institut de Développement Durable et de Relations Internationales)
IEA	International Energy Agency
IIASA	International Institute for Applied Systems Analysis
IIGCC	The Institutional Investors Group on Climate Change
IIRC	International Integrated Reporting Committee
IPCC	Intergovernmental Panel on Climate Change
IPR	Inevitable Policy Response (PRI)
IRENA	International Renewable Energy Agency
MAS	Monetary Authority of Singapore
MIS	Moody's Investor Services
NFRD	Non-Financial Reporting Directive
NGFS	The Network for Greening the Financial System
OECM	One Earth Climate Model
PACTA	Paris Agreement Capital Transition Assessment
PIK	Potsdam Institute for Climate Impact Research (Potsdam Institut für Klimafolgenforschung)
PRI	Principles for Responsible Investment

PwC	PricewaterhouseCoopers
RCP	Representative Concentration Pathway
SASB	Sustainability Accounting Standards Board
SDSN	Sustainable Development Solutions Network
SME	Small and Medium Enterprises
SSP	Shared Socioeconomic Pathways
TCFD	Task Force on Climate-related Financial Disclosures
TFCR	Task Force on Climate-related Financial Risks (BCBS)
TNFD	Task Force on Nature-related Financial Disclosures
UNDP	United Nations Development Programme
UNEP FI	United Nations Environment Programme Finance Initiative
UNFCCC	UN Framework Convention on Climate Change
VaR	Value-at-Risk

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