UN environment programme

finance initiative

2024 Climate Risk Landscape Report

April 2024

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The project has been supported throughout the year by a group of 29 banks and investors convened by UNEP FI

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Acknowledgements

The authors would like to thank all individuals who supported the development of this report and all the providers who shared information and insights. We are particularly grateful to the following solution providers for the time they invested in our working group activities.

The authors would also like to express their gratitude to the following solution providers for their contributions to this report:

- 15Rock
- 2 Degrees Investing Initiative
- Climatig
- Insig AI
- Intensel
- JBA Risk Management
- Ortec Finance
- Riskfootprint™
- Riskthinking.AI
- WayCarbon
- Willis Towers Watson.

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Suggested citation: UNEP FI (2024). *2024 Climate Risk Landscape Report*. Geneva.

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Abbreviations and acronyms

AI	Artificial Intelligence
API	Application Programming Interface
ASA	Advertising Standards Authority
AR6	Sixth Assessment Report
CCKP	Climate Change Knowledge Portal
CMA	Competition & Markets Authority
COP28	The 28th United Nations Climate Change Conference
CSRD	Corporate Sustainability Reporting Directive
CVaR	Climate Value at Risk
EBA	European Banking Authority
ECB	European Central Bank
EFRAG	European Financial Reporting Advisory Group
ENCORE	Exploring Natural Capital Opportunities, Risks and Exposure
ESG	Environmental, Social, and Governance
ESRS	European Sustainability Reporting Standards
EU	The European Union
FCA	Financial Conduct Authority
FTC	Federal Trade Commission
GEMs	General Equilibrium Models
GFANZ	Glasgow Financial Alliance for Net Zero
GHG	Greenhouse gases
GRI	Global Reporting Initiative
G-SRAT	Global Systemic Risk Assessment Tool
IFRS	International Financial Reporting Standards
IFRS S1	IFRS S1 General Requirements for Disclosure of Sustainability-related Financial Information
IFRS S2	IFRS S2 Climate-related Disclosures
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
ISSB	International Sustainability Standards Board
KPIs	Key Performance Indicators
LLM	Large language model
Lloyds	Lloyds Banking Group
MiFID	Markets in Financial Instruments Directive
ML	Machine learning
NAB	The National Australia Bank
NGFS	Network for Greening the Financial System
NGO	Non-governmental organisation
NLP	Natural language processing
NZDPU	Net-Zero Data Public Utility
OECD	Organisation for Economic Co-operation and Development

PCAF	Partnership for Carbon Accounting Financials
PVaR	Physical Value at Risk
PwC GmbH WPG	PricewaterhouseCoopers GmbH Wirtschaftsprüfungsgesellschaft
SDG	Sustainable Development Goals
SEC	U.S. Securities and Exchange Commission
SFDR	Sustainable Finance Disclosure Regulation
SMEs	Small and medium-sized enterprises
TCFD	Task Force on Climate-Related Financial Disclosures
TNFD	Taskforce on Nature-related Financial Disclosures
TPT	Transition Plan Taskforce
TVaR	Transition Value at Risk
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP FI	United Nations Environment Programme Finance Initiative
UNEP-WCMC	The UN Environment Programme World Conservation Monitoring Centre
United Kingdom	United Kingdom of Great Britain and Northern Ireland
USA	United States of America
USD	U.S. Dollar
VaR	Value at Risk
WEF	World Economic Forum
WRI	World Resources Institute
WWF	World Wildlife Foundation

Executive summary

The United Nations Environment Programme Finance Initiative (UNEP FI)'s Climate Risk and Task Force on Climate-related Financial Disclosures (TCFD) programme takes a leadership role in developing good practices to identify, measure, disclose, and manage climate risk in the financial sector. Working with over 100 banks, insurers, and investors since 2017, the programme has created numerous tools, frameworks, and guides to accelerate the implementation of these good practices.

Initially helping its members implement the Financial Stability Board's TCFD recommendations, the programme now also provides insights on legal risks, climate stress testing, climate scenarios, climate tools, and other related areas. To this end, UNEP FI's Climate Tools for Risks and Opportunities Working Group has engaged in a series of thematic research and piloting exercises. These efforts have resulted in the development of comprehensive publications that serve as a vital resource for financial institutions, introducing and comparing both physical and transition risk assessment tools and their underpinning methodologies (UNEP FI, 2022).

The working group's primary objective is to foster market transparency and alleviate information asymmetries in the climate tool universe. It strives to empower financial institutions to become informed consumers of climate-related data, solutions, and services, thereby enhancing their capabilities in climate risk management and facilitating a transition towards sustainability. This report is an outcome of the working group's annual projects. Not only does it incorporate the latest observations in the climate risk landscape, but it also provides a practical blueprint for financial institutions to strategically utilise these tools.

Main progress and observations in this climate risk landscape report include:

Enhanced synergistic collaboration through partnerships across industries

Emerging functionalities for regulatory compliance and stress testing requests

Increased integration of Artificial Intelligence (AI) technologies in climate tools

Open-source innovation & enhanced data access through collaborative platforms by data and tool providers

Enhanced data input, refined assumptions, diverse functionalities, and coverages toward comprehensive analysis

Key challenges remaining in the market include:

Challenges related to **sector-specific analysis**, unlisted assets analysis, and supply chain assessment from the complex nature of climate assessments

Access and affordability challenges in climate tools that lead to imbalanced global tool adoption and poor resource efficiency

Limitations with climate modelling and realistic assumptions that tend to ignore or simplify the dynamic effects of physical and transition risks on the economy

Imbalances in regional resource availability that can result in underuse of climate tools, potentially leading to the oversight of climate risks in emerging markets

Concerns arising from **risks associated with AI** usage in climate-related assessments

Elevated environmental, social, and governance (ESG) risk factors and the need for comprehensive environmental risk assessments to address more holistic risk landscape

The suggested **best practices for tool utilisation** include the following:

Accessibility across departments

Make climate tools and their results readily accessible to all relevant departments, such as customer engagement, ESG & sustainability, risk management, legal, and compliance teams

Integration with existing solutions and metrics

Integrate climate tools with current accounting and risk management systems and metrics for ongoing, updated risk assessments

Holistic risk evaluation

Conduct a thorough evaluation of the institution's risk profile, considering the additional implications of climate risks to support effective decision-making

Capacity-building and internal tool development

Begin by assessing open-source data and platforms to pinpoint critical hotspots; then integrate external climate tools as foundational resources, while developing internal capacities and custom tools tailored to the institution's specific needs

Introduction

The year 2023 broke records for the hottest day for a staggering 116 days in a row and marked the warmest year on record (Poynting & Rivault, 2024). According to the World Economic Forum (WEF), extreme weather events rank as the second most critical risk on a two-year horizon. Over the next decade, they emerge as the top risk (see Figure 1), highlighting the growing need for effective climate actions (WEF, 2024).

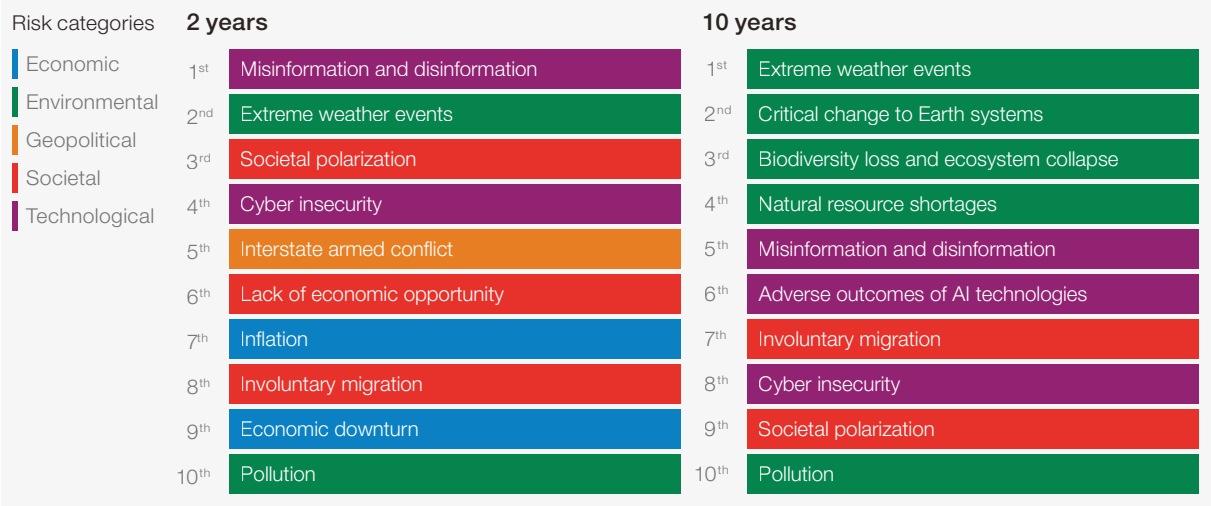

Figure 1: Global risks ranked by severity over the short and long term, (WEF, 2024).

As the urgency to address climate change intensifies, financial institutions are increasingly recognised for their pivotal role in integrating climate change-related risks into their strategic frameworks. The financial sector's significant influence on economic activities—principally, through funding decisions, investment strategies, and risk management—positions financial institutions as key drivers in steering the global economy toward sustainable practices and resilience against climate impacts. This sense of urgency has accelerated the need for financial institutions to accurately assess and respond to the financial implications of climate change, which manifest in a multitude of forms.

The complexity of climate-related risks necessitates the use of advanced tools for thorough assessment and effective management. In response, the market for climate risk assessment tools has expanded, offering financial institutions a broad spectrum of options. These tools are crucial for financial institutions to align their strategies with unique investment objectives and environmental commitments, allowing them to safeguard their portfolios while fostering sustainable development.

The 2024 Climate Risk Landscape Report, building on the foundational work of previous UNEP FI publications, serves as a comprehensive resource for financial institutions navigating the dynamic climate risk tool market. Following this brief introduction, it provides an in-depth look into the evolving regulatory environment and market context in Chapter 2. Subsequent chapters, including Chapter 3 and Chapter 4, then delve into the main advancements and challenges that have emerged in the field since 2023.

In Chapter 4, the report examines the strategic utilisation of climate tools within financial institutions, highlighting how these tools extend beyond mere compliance with climate-related disclosure standards. It shows how they are instrumental in decision-making processes, potentially redefining climate-related factors from risk centres

to profit centres within financial institutions. This transformative potential underscores the importance of effectively integrating these tools into financial institutions' operational frameworks. Additionally, Chapter 5 provides blueprints, best practices, and case studies to aid financial institutions in their journey to effectively leverage climate risk assessment tools. This guidance is designed to help financial institutions navigate the complexities of the climate risk landscape, enabling them to make informed decisions that align with sustainability goals and contribute to the global agenda for a sustainable economy.

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SECTION 1:

Setting the scene: Context of this landscape report

1.1 UNEP FI's existing work about the climate tools industry

UNEP FI has taken a proactive role in enabling financial institutions to navigate the complex landscape of climate risk tools. Several key publications have emerged from its Climate Tools for Risks and Opportunities Working Group. The first Climate Risk Landscape Report, published in 2021, gave an overview of the main climate risk tool providers in the market. This was followed in 2022 by the Climate Risk Tool Supplement, which presented a series of case studies jointly delivered by banks and vendors. This supplement offered insights into the actual experiences of financial users while piloting different tools. It also provided tool vendors with targeted feedback for future enhancements. Building on these foundational works, UNEP FI published the 2023 Climate Risk Landscape Report and its accompanying Technical Supplement report during 2023. These publications have not only equipped financial institutions with an up-to-date overview of existing tool vendors and their unique workstreams regarding climate risk and opportunity assessment; they have also provided a comprehensive roadmap for choosing and utilising the array of commercially available and open-source tools.

With the ambition of increasing market transparency and bridging the gap between financial institutions and climate tools industry, UNEP FI's 2023 Climate Risk Programme continues this in-depth research, with global vendors and international financial institutions deeply involved in the working group activities. Tool demonstrations have been arranged among 19 vendors, as presented in Figure 2 below. This current 2024 Climate Tools Landscape report is the general outcome of the yearly working group. It focuses on dissecting the latest trends, methodological advancements, and approaches that vendors use to tackle common challenges in climate risk assessment process. This report also provides practical steps for basing decisions on the analysis results and integrating these tools into the existing systems of financial institutions.

To supplement these efforts, UNEP FI has also launched a Climate Risk Tool Dashboard. This interactive database enhances the readability of climate risk tools by providing a detailed overview of dozens different tools as of now, including features such as scope of coverage, metrics, methodologies, and assumptions. The dashboard is designed to be updated continually, with input from UNEP FI's Climate Tools for Risks and Opportunities Working Group and the vendor community. This ensures that it remains a current and reliable resource. Since the initial release in June 2023, the database has been updated quarterly in Q3 and Q4 2023 with enrichments of more granular information, more developed and self-explanatory filers, and a physical risk assessment piloting exercise. These efforts collectively aim to empower financial institutions to be informed and effective consumers of climate risk tools, thereby fostering a more resilient and sustainable financial sector. In Q1 2024, UNEP FI initiated a proof-of-concept exercise with over 20 climate tool vendors, utilising a strategically designed dummy portfolio. The exercise focused on generating economic metric results at the property level and aggregating these to form a comprehensive view at the portfolio level. To ensure a certain level of comparability among the different vendors' submissions, the definition of requested metrics, scope of perils, economic metrics, and parameters will be harmonised. The outcomes of this exercise are presented as they stand in the Climate Risk Tool Dashboard, providing unbiased

information to the public. This will assist users in selecting physical risk assessment tools that best meet their specific needs for engagement.

Figure 2: Climate tool providers that joined UNEP FI's 2023 tool demonstrations, (UNEP FI, 2024).

1.2 Regulatory environment developments

With 2023 having six record-breaking months and two record-breaking seasons in global surface air temperature (Copernicus Service, 2023), the urgency for enhanced transparency in climate-related risks and for greater resilience and adaptability have become paramount. The year saw significant progress in global standards and regional practices for climate-related disclosures, stress testing, and greenwashing, highlighting the need for additional transparency and bolstered resilience in the financial system.

Recent years have seen concerted efforts toward **global standardisation and the alignment of climate-related disclosure frameworks**, aiming to ensure that companies integrate comprehensive and relevant details in their reports to enable stakeholders to make well-grounded decisions. In June 2023, the International Sustainability Standards Board (ISSB) released its inaugural sustainability disclosure standards, including IFRS S1: General Requirements for Disclosure of Sustainability-related Financial Information, and IFRS S2: Climate-related Disclosure Standard. The ISSB, which operates under oversight from the IFRS Foundation, will take over TCFD monitoring from 2024. This move will help simplify the so-called 'alphabet soup' of disclosure initiatives for companies and investors. The new framework is set to become the global baseline for climate-related disclosures starting January 2024. Notably, the ISSB Standards integrate the four core recommendations and 11 recommended disclosures published by the TCFD. In addition, the ISSB's collaboration with the Global Reporting Initiative (GRI) (ISSB, 2023a) and

the European Commission and European Financial Reporting Advisory Group (EFRAG) enables the ISSB to build its requirements so that they are interoperable with the GRI standards and the European Sustainability Reporting Standards (ESRS) for reporting (ISSB, 2023b). This will serve to reduce the disclosure burden for companies.

In parallel, His Majesty's Treasury in the United Kingdom of Great Britain & Northern Ireland (United Kingdom) initiated a Transition Plan Taskforce (TPT) in April 2022 to **design and disclose transition plans for firms**. The TPT has a two-year mandate to convene academia, regulators, and non-governmental organisations (NGOs) to develop its view on best practices for transition planning and associated metrics. The taskforce draws upon ISSB recommendations for templates and guidance on setting metrics and targets. It also draws on the components identified by the Glasgow Financial Alliance for Net Zero (GFANZ) of a good transition plan. In this way, the outputs of both initiatives lock together to form an integrated approach to transition planning. Figure 3 illustrates the transition plan disclosure landscape and shows how preparers of transition plans may draw on the resources of the TPT and GFANZ to support reporting against the ISSB Standards. In October 2023, the TPT launched its 'gold standard' disclosure framework for companies and financial institutions to tackle climate change. This Disclosure Framework provides the basis for companies to set out credible and robust climate transition plans as part of annual reporting on forward business strategy. The Framework will support the creation of consistent, comparable company reports, and reduce the level of complexity faced by firms disclosing climate-related information. In addition, it is designed to be consistent with, and build on, the final IFRS S2 issued by the ISSB (TPT, 2023). The TPT is also developing sector specific guidance for preparers to interpret the disclosure framework for their sector and forward pathway on transition plans, with final version to be published in spring 2024 (TPT, 2023).

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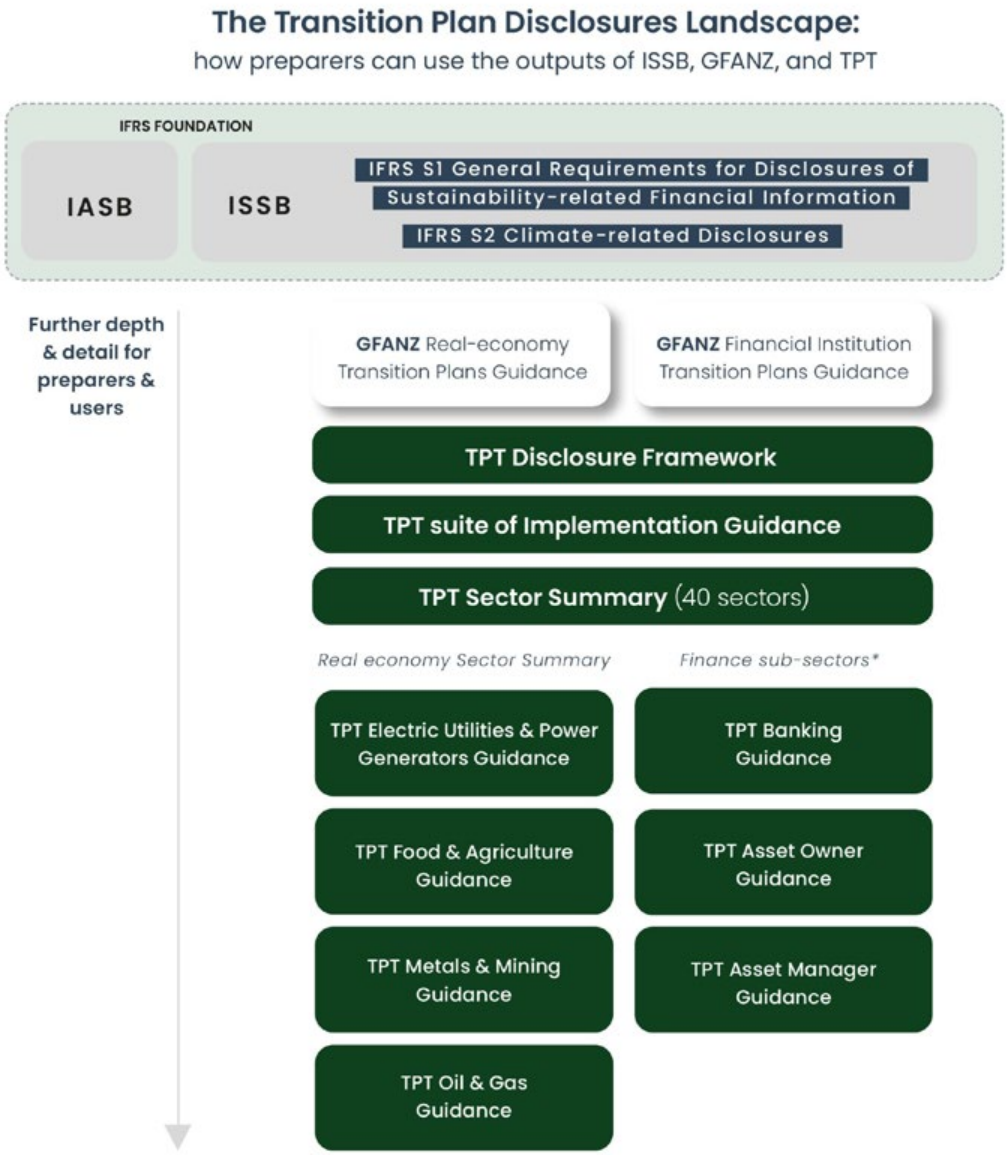

Figure 3: The Transition Plan Disclosure Landscape: how preparers can use the outcomes of ISSB, GFANZ, and TPT, (TPT, 2023).

Amid the progress in these disclosure framework and standards, significant regulatory developments have been witnessed not only in major developed economies like the European Union (EU), the the United States of America (USA), and the United Kingdom, but also in nations such as Switzerland and Brazil. This progress persists despite the challenges posed by legal pressures and political actions in some jurisdictions, which aim to slow down or limit the efforts towards climate regulation. Within the EU, the European Commission adopted a proposal in 2022 for a directive on corporate sustainability due diligence to foster sustainable and responsible corporate behaviour and to anchor human rights and environmental considerations in companies' operations and corporate governance. Under the directive, certain large companies need to have a plan to ensure that their business strategy is compatible with limiting global warming to 1.5°C, in line with the Paris Agreement (European Commission, 2022). In January 2023, a new framework for environmental, social, and governance (ESG) disclosures came into effect

under the Corporate Sustainability Reporting Directive (CSRD). The CSRD significantly increases the number of disclosures companies have to make about 'material' sustainability matters in addition to some base level disclosures. Specifically, companies that must report under CSRD have to undertake a 'double materiality assessment' to identify which sustainability matters are most material to the organisation and its stakeholders. This is being rolled out in phases for different types of entities. In October 2023, the European Commission adopted the first set of European Financial Reporting Standards (ESRS) by delegated regulation. Whilst the CSRD sets out reporting requirements and obligations, the ESRS provide the framework and methodology for reporting. As of January 2024, the ESRS applies to 50,000 companies. From 2028 onwards, meanwhile, non-EU companies operating in Europe must also report their impacts using the ESRS or equivalent standards (EFRAG, 2023). In addition, the EU Taxonomy (EUR-lex, 2020) establishes a framework for categorising economic activities as sustainable, which is applied within CSRD.

In the United Kingdom, the Financial Conduct Authority (FCA) mandated TCFD/ISSB-aligned reporting for large asset managers and owners, effective by June 2023. Premium-listed companies started publishing TCFD/ISSB reports in 2022, with standard-listed companies set to join them in 2023. From 1 June 2023 onwards, the mandatory disclosure applies to most financial institutions as well as smaller managers and asset owners (FCA, 2023). In the USA, the Office of the Comptroller of the Currency, Board of Governors of the Federal Reserve System, and the Federal Deposit Insurance Corporation also collectively announced principles for climate-related financial risk management for large financial institutions in October 2023. These are designed to support the identification and management of climate-related financial risks by financial institutions with more than USD$100 billion in total consolidated assets (OCC, 2023). In March 2024, the Securities and Exchange Commission (SEC) adopted rules to enhance and standardise climate-related disclosures by public companies and in public offerings. The final rules require larger public companies in the USA to disclose risks that climate disasters pose to their businesses, as well as greenhouse gas emissions from their own operations or energy use if this information is financially material to investors. Compliance dates for the rules will be phased in for all registrants, with the compliance date dependent on the registrant's filer status (SEC, 2024).

Other countries have also witnessed notable **progress in climate and sustainability-related disclosures**. For example, Brazilian financial institutions are required to disclose social, environmental, and climate-related risks and their governance and management annually; the Brazilian Securities and Exchange Commission has also established ESG regulations, requiring its registrants to report whether they follow the TCFD/ISSB or other climate-related disclosure frameworks, or to justify why they do not do so (Clyde & Co, 2023). Figure 4 provides a non-exhaustive list for climate-related regulatory and implementation of TCFD recommendations in 2023, as summarised by the Financial Stability Board (FSB, 2023).

Brazil: Financial institutions are already required to provide qualitative disclosures based on the TCFD Recommendations under a proportionality perspective according to the segmentation of the local financial system. Quantitative disclosures will adopt a similar approach.	**Türkiye:** In June 2023, the Public Oversight, Accounting and Auditing Standards Authority of Turkey decided to adopt the ISSB Standards. In January 2024, Türkiye Sustainability Reporting Standards were released, regulating the scope of application of Climate-related Disclosures.	**Switzerland:** The TCFD's climate-related financial disclosures have been made mandatory for larger companies across all sectors of the economy from 1 January 2024. Companies will be expected to implement the legislation starting in 2025 for the financial year 2024.
Japan: The Sustainability Standards Board of Japan (SSBJ) is developing standards for sustainability-related disclosures based on IFRS S1 and IFRS S2. The Financial Services Agency is considering to designate the SSBJ's standards within the regulatory framework.	**Hong Kong:** The Hong Kong Stock Exchange published in April 2023 a consultation paper proposing to mandate all listed companies in Hong Kong to provide climate-related disclosure in their ESG reports and announced that the implementation date will be 1 January 2025.	**Saudi Arabia:** Various ministries and government agencies, including SAMA, are currently coordinating their policy initiatives with a view to working towards a common sustainability disclosure requirement at the national level. A specific timeline is to be determined.
South Africa: In August 2023, following the Prudential Communication 10 on climate-related risks, South Africa's Prudential Authority has issued two proposed guidance notes on climate-related disclosures for banks and insurers.	**Singapore:** The Singapore Exchange introduced requirements for issuers to incorporate climate-related disclosures based on the recommendations of the TCFD. Climate reporting is mandatory for all issuers on a 'comply or explain' basis for the financial year of 2022.	**New Zealand:** Effective 1 January 2023, New Zealand's standards require mandatory climate-related disclosures for approximately 200 entities, including equity and debt issuers and large financial organizations such as banks and insurers.

Figure 4: 2023 TCFD/ISSB-aligned regulations and actions in major economies, (FSB, 2023).

Financial institutions are exposed to climate risks through their loan book, insurance underwriting activities, and asset holdings. As such, financial supervisors have started to **look at the resilience of the financial system towards climate risks with requirements of climate stress tests**. For example, the European Central Bank (ECB) has carried out a climate risk stress test of 104 significant institutions as part of its annual stress test in 2022, focusing on banks' progress towards developing climate risk stress-testing frameworks, their capacity to produce climate risk factors and climate risk stress test projections, and the key risks faced by banks in terms of transition risks and acute physical risk events. The results indicate that banks still do not take climate risks adequately into consideration in their internal models and stress testing, although the situation has improved since 2020. Although the results have yet to have a marked impact on capital

guidance for banks, they are set to be considered in the pending Supervisory Review and Evaluation Process. The ECB has set the end of 2024 as the deadline for banks to meet the supervisory expectations concerning climate and environmental risks (ECB, 2022).

The United States Federal Reserve also conducted a pilot climate scenario analysis exercise in 2023, involving six of the nation's largest banks. The Fed provided climate scenario narratives that banks then used to analyse the impact on their portfolios and business strategies. The United States Federal Reserve then reviewed those findings with the firms to help them build up their ability to manage climate-related risks (Reuters, 2022). The Hong Kong Monetary Authority undertook a similar pilot exercise on climate risk stress test to assess the climate resilience of the banking sector in its jurisdiction. The exercise also sought to facilitate the capability building of participating authorised institutions in measuring climate risks. As compared to the pilot exercise, the Hong Kong Monetary Authority has made several major enhancements to the Climate Risk Stress Test framework in respect of climate scenarios, assumptions, assessment approaches and reporting requirements. (HKMA, 2023). In New Zealand, a climate stress test for the country's five largest banks took place in 2023, which replaced their annual bank solvency stress test. The banks were requested to perform the stress tests under the 'Too Little, Too Late' scenario, and present severe but plausible climate-related challenges spread over a 28-year period (Reserve Bank of New Zealand, 2023). Together, these examples strongly indicate that financial institutions, especially banks, should now look to respond to stakeholder expectations to run further internal climate stress tests and move beyond their first-generation efforts (Deloitte, 2023).

More generally, an uptrend in regulations against greenwashing practices has been observed in major economies. One of the first movers was the United Kingdom's Competition & Markets Authority (CMA), which launched a sector-by-sector review of misleading environmental claims in 2022. The CMA is currently expanding the investigation to greenwashing around "household essentials", including food, drink, toiletries, and cleaning products. The goal of the initiative is to determine the factual accuracy of claims about products and services that are being marketed to consumers as green or eco-friendly (CMA, 2023). The Advertising Standards Authority (ASA), the United Kingdom's independent regulator of advertising across all media, also takes a keen interest in green claims and regularly rules that green claims breach the country's self-regulatory advertising codes. In June 2023, the ASA updated its advertising guidance, including a general overview of the principles that underpin the rules for misleading corporate claims to environmental or social responsibility (ASA, 2023). In the USA, meanwhile, the Federal Trade Commission's (FTC) reviewed the Guides for the Use of Environmental Claims in December 2022, which was last updated in 2012. The changes include new guidance concerning marketers' use of product certifications and seals of approval. The updates also incorporate the act of defining materials and energy sources as "renewable", as well as the deployment of "carbon offset" claims. The FTC plans to update its Green Guides to reflect developments in consumers' perception of environmental marketing claims, while also hosting workshops to examine claims on recyclability (FTC, 2023).

In addition, the European Parliament formally endorsed its provisional agreement with the Council on the Directive Empowering Consumers for the Green Transition through Better Protection against Unfair Practices and Better Information in January 2024. The

directive will protect consumers against misleading 'green' claims, including about unfair claims about carbon offsetting. It will also clarify the traders' liability in cases of information (or lack of information) on early obsolescence, unnecessary software updates or the unjustified obligation to buy spare parts from the original producer (European Council, 2024).

In Asia, meanwhile, the Monetary Authority of Singapore has launched the Singapore-Asia Taxonomy for Sustainable Finance (Singapore-Asia Taxonomy), which sets out detailed thresholds and criteria for defining green and transition activities that contribute to climate change mitigation across eight focus sectors[1] (MAS, 2023). Last but not least is the Australian Securities and Investments Commission, which has made the identification of misleading conduct in relation to sustainable finance (including greenwashing) as a top priority of 2024 (ASIC, 2023).

These regulatory advances underscore the critical role that climate tools might be able to play in validating green claims and screening greenwashing risks, bridging between regulatory expectations and market practices. The progress of greenwashing tools will be discussed further in Section 2.3.

The 28th United Nations Climate Change Conference (COP28) in Dubai, United Arab Emirates, also saw progress towards a global consensus about climate action. An agreement was reached that signalled the "beginning of the end" of the fossil fuel era by laying the ground for a swift, just, and equitable transition, underpinned by deep emissions cuts and scaled-up finance (UNFCCC, 2023). Parties were encouraged to accelerate "ambitious, economy-wide emission reduction targets" in their next nationally determined contributions. The agreement also clarified the need to more than double current levels of adaptation finance in order to meet urgent and evolving demand (COP28, 2023). This global consensus sets the stage for governments and policymakers to intensify their efforts to address climate change. For financial institutions, these developments signal the likelihood of heightened compliance requirements and reinforce the necessity to adapt rapidly to a changing regulatory landscape influenced by climate imperatives.

1 The eight focus sectors are: Energy, Real Estate, Transportation, Agriculture and Forestry/Land Use, Industrial, Information and Communication Technology, Waste/Circular Economy, and Carbon Capture and Sequestration.

SECTION 2:

A changing terrain: The evolving climate risk assessment landscape

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As the climate risk assessment landscape undergoes swift and significant transformation, the climate tool market has experienced profound advancements in recent years. This chapter aims to encapsulate these shifts by outlining five prevailing trends that are currently shaping the industry. Additionally, it will delve into the innovative functionalities that have been introduced in climate tools to meet the evolving demands of this rapidly advancing field.

2.1 Enhanced synergistic collaboration through partnerships across industries

As featured in UNEP FI's 2023 Climate Tools Landscape report, the trend of climate tools integration through increased mergers and acquisitions has vastly transformed the climate tools market. In the rapidly evolving landscape of this market, users have seen robust collaborations spanning not only among tool vendors but also across diverse industries. These changes should serve to elevate the ultimate quality of the services provided.

In the realm of tool vendors, integration remains a prominent theme. Notably, MSCI's acquisition of Burgiss in August 2023 broadens the former's scope significantly. MSCI already provided data on approximately 73,000 entities, including 55,000 private firms. Post-acquisition, its coverage has extended to include more than 7,000 private investment funds operating across 195 countries and spanning private equity, real estate, debt, infrastructure, and natural resources. This move aligns with MSCI's goal of strengthening its multi-asset class portfolio (MSCI, 2023a). Additionally, MSCI's acquisition of Trove Research expanded its climate solutions to provide transparent voluntary carbon markets insights, including data into corporate transition plans, the quality of existing carbon credits, and the carbon credit pricing outlook. Similarly, ICE acquired Black Knight back in September 2023, thereby considerably enhancing its offerings in sustainable finance solutions for the mortgage sector (ICE, 2023a). The move followed Moody's decision to purchase RMS in 2021. In the years since, major investments by Moody's have enabled it to integrate RMS's climate change science and physical risk capabilities into its own financial intelligence and integrated risk management solutions. This set up Moody's to launch enhanced physical risk analytics with Climate on Demand Pro in 2023 (Moody's, 2023a).

Simultaneously, tool providers are forming strategic alliances based on complementary strengths. For example, Morningstar's Sustainalytics has been involved in a significant partnership with XDI since 2022. Leveraging XDI's expertise in statistical and probabilistic modelling, Morningstar enhances its Physical Climate Risk Metrics through its solution Climate Risk Engines (Morningstar, 2022). In the same year, meanwhile, Planetrics/McKinsey and Moody's Analytics announced a partnership across physical risk, transition risk, and credit risk (McKinsey, 2022). Similarly, OS-Climate, a prominent open-source tools and data community of practice, has initiated various tool development projects in collaboration with Jupiter, Imperial College, and the World Resources Institute (WRI) (OS-Climate, 2022). In a separate move, Moody's Analytics and Lloyd's of London (a marketplace for insurance and reinsurance) announced a collaboration to develop a solution to help quantify greenhouse gases (GHG) emissions across insurance managing agents' underwriting and investment portfolios. The solution, which was announced

in 2023, aims to facilitate managing agents in meeting expected regulatory reporting requirements (Lloyds, 2023).

Beyond intra-vendor collaborations, tool vendors are also forming alliances with other stakeholders such as data providers and service providers in the climate risk and opportunity domain. Data integration emerges as a primary area of synergy. To illustrate, ICE's Physical Climate Risk tool incorporates hazard maps from JBA Risk Management. In a similar manner, WTW leverages its global brokerage expertise to create advanced physical climate analytics tools, combining climate science, risk engineering, and comprehensive data from broking databases. Meanwhile, Ortec Finance integrates an economic scenario generator calibrated on historical financial datasets from providers like Bloomberg, MSCI, and ICE, with company-specific ESG data from ESGBook. In addition, vendors also collaborate with each other to enhance their solutions. As an example, PricewaterhouseCoopers GmbH Wirtschaftsprüfungsgesellschaft (PwC GmbH WPG) cooperated with Jupiter Intelligence for the assessment of physical risks and impacts on assets. There is also a prevalent trend to incorporate open-source data such as national gross domestic product totals, inflation rates, and population metrics from the World Bank (UNEP FI, 2023a). Worth highlighting is the proactive engagement of many tool vendors with consulting firms or professional service entities. This collaboration ensures comprehensive solutions backed by strategic insights and management expertise. An illustrative example is provided by XDI's regular collaborations with industry leaders such as Ernst & Young, KPMG, Oliver Wyman, Marsh McLennan, Baringa, and any other specialised teams that clients opt to bring onboard.

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2.2 Emerging functionalities for regulatory compliance and stress testing requests

Amid the regulatory and disclosure context for climate-related risks and opportunities discussed in Chapter 1, financial institutions face increasing pressure from regulatory requirements, including mandated reporting. As illustrated in Figure 5, a UNEP FI survey reveals that regulatory compliance and stress testing emerge as the primary internal operational priorities for a majority within the banking sector. To fulfil these needs, the climate tool marketplace is introducing the following features:

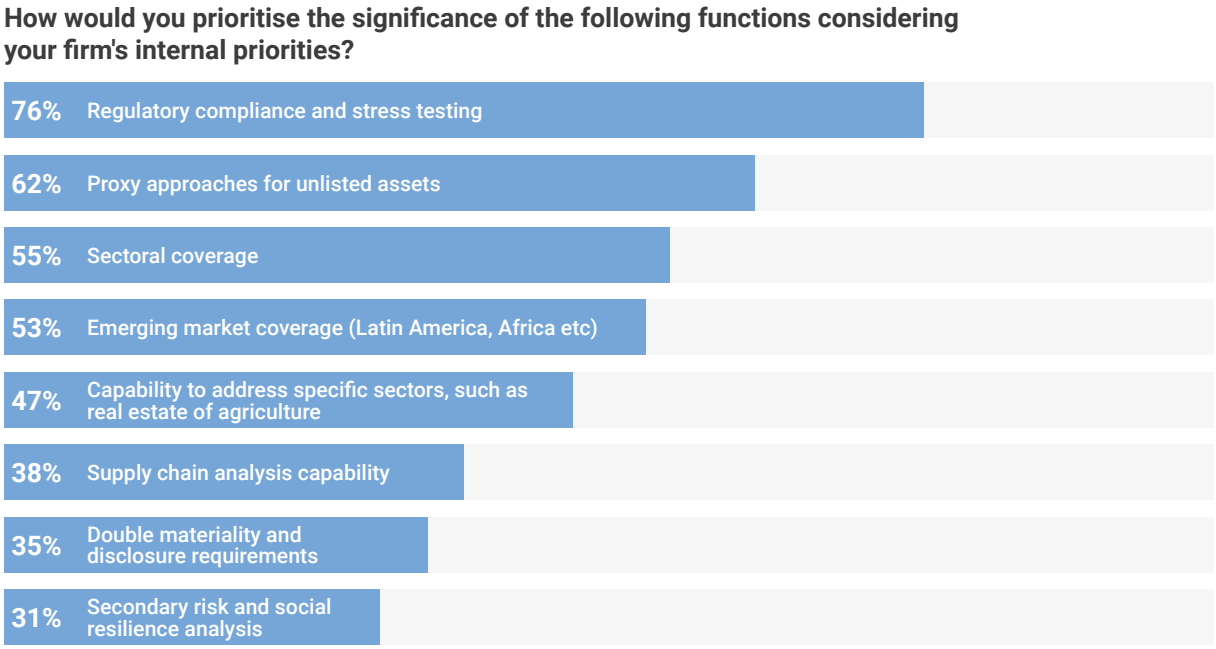


Figure 5: Regulatory compliance and stress testing as the top priority for UNEP FI members, (UNEP FI, 2023).

Introduction of modules that evaluate a firm's alignment with framework objectives. UNEP FI's latest release of the Climate Risk Tools Dashboard has captured the trend. In the Q1 release 2024, 40 out of 58 climate tools incorporated in the online database indicated that they provide related functions or services to address the regulatory requirement frameworks to which clients might be subject. Major disclosure frameworks include **the IFRS S2 Climate-related Disclosures / TCFD, the EU Taxonomy, the SEC climate proposal, and CSRD**. When it comes to climate stress testing, 33 out of 58 vendors indicated their capability to run forward-looking climate analysis and provide a range of climate and financial projections that would support clients' compliance to financial regulators' stress testing requirements. This section below highlights a few examples of how these capabilities are playing out in practice.

Jupiter Intelligence, for instance, has analysed the specific scenarios, time horizons, and physical hazards that companies should disclose to investors under the EU Taxonomy and CSRD. Additionally, it has discussed its matching of these elements in the solution that it provided. For example, the tool provider scenarios are consistent with Intergovernmental Panel on Climate Change (IPCC)'s Sixth Assessment Report (AR6),

which is in line with the EU Taxonomy statement. As Figure 6 indicates, Jupiter also matches its metrics up to EU Taxonomy parameters for physical hazards. For example, the tool provider captures changing air temperature, heat stress, and temperature variability through the use of ten designated metrics. These include days exceeding historical (1986–2005) 99th percentile temperature, days exceeding 35°C and 38°C, and annual heating/cooling degree days (Jupiter Intelligence, 2022), among others. PwC GmbH WPG also indicates how its Climate Excellence is in line with regulatory expectations, including, but not limited to, the ESRS E1–9 AR 72 regarding the information on real estate assets at material transition risk. For project/asset finance, its outputs can also be used as a basis for, and are in line with, EU Taxonomy Do No Significant Harm assessment approaches. The ESG Assessment solution by Moody's has employed standardised, traceable, and defined ESG metrics. In addition, Moody's has powered through a double materiality to help clients understand their ESG performance, streamlining the process of compliance with disclosure regulations (Moody's, 2023b). In addition, tool providers cater to sustainability-related disclosure requirements by other regulators, such as the Pillar 3 disclosures on ESG risks by the European Banking Authority (EBA) (EBA, 2022). Solutions such as Munich Re's Locational Risk Intelligence Platform (Munich Re, 2024), ISS ESG's EU Taxonomy Alignment Solution (ISS ESG, 2024a), and the EBA Pillar 3 ESG Solution (ISS ESG, 2024b) help ensure that financial institutions' ESG risk-related reporting is aligned with EU Taxonomy and EBA's Pillar 3 reporting requirements. MSCI's Sustainable Reporting Services also supports clients in meeting regulatory and reporting requirements aligned with TCFD, the EU's Sustainable Finance Disclosure Regulation (SFDR), the EU Taxonomy, the Markets in Financial Instruments Directive (MiFID) II, and EBA Pillar III (MSCI, 2024a) disclosures.

Directly quantified by Jupiter metrics	Risk drivers available	Not available, rationale provided

	Temperature-related	Wind-related	Water-related	Solid-mass related
Chronic	Changing temperature (air)	Changing wind patterns	Changing precipitation patterns and types (rain, hail, snow/ice)	Coastal erosion
	Changing temperature (freshwater)		Precipitation and/or hydrological variability	Coastal erosion
	Changing temperature (marine water)		Ocean acidification	Soil erosion
	Temperature variability		Saline intrusion	Solifuction
	Heat stress		Sea-level rise	
	Permafrost thawing		Water stress	Avalanche
Acute	Heat wave	Cyclone, hurricane, typhoon	Drought	Landslide
	Cold wave/frost	Storm (blizzards)	Heavy precipitation (rain, hail, snowice)	Subsidence
	Wildfire	Storms (dust)	Flood (coastal, fluvial, pluvial)	
		Storms (sand)	Flood (groundwater)	
		Tornado	Glacial lake outburst	

Figure 6: Overview EU requirements and Jupiter data support in identifying climate hazards, (Jupiter Intelligence, 2022).

Morningstar's Sustainalytics has developed a Global Standards Screening module to assess companies' compliance with the United Nations' (UN) Global Compact Principles and provides information on related standards such as the Organisation for Economic Co-operation and Development's (OECD) Guidelines for Multinational Enterprises and the UN Guiding Principles on Business and Human Rights, as well as their underlying conventions (Morningstar, 2023). Sustainalytics also has an EU Taxonomy Solution that assesses companies' eligibility and alignment with the climate change mitigation and adaptation objectives, supplementing reported data with estimations. As illustrated by Figure 7, the assessment is performed on Sustainalytics' activity-based research at company level, with accompanying breakdowns of company involvement in Taxonomy-eligible activities (Morningstar, 2023).

Figure 7: EU Taxonomy alignment assessment framework, (Morningstar, 2023).

Climate stress-testing capabilities are designed to navigate scenarios, accounting for financial and credit implications under requested conditions. Vendors such as S&P Global, XDI, and ICE provide functionalities that assist financial institutions with climate stress tests that regulators are increasingly expecting from financial institutions, especially linked to the latest IFRS S2 recommendations. For example, S&P Global's Climate RiskGauge supports climate-related stress testing at both a single counterparty and portfolio level, as well as incorporating TCFD/ IFRS S2 recommendations on forward-looking scenario analysis. As seen in Figure 8, its stress testing methodologies consider multiple company responses, while also capturing both risks and opportunities as requested by Bank of England. The approach reveals how these factors impact credit score changes, probability of default, projected market valuations, and other financial metrics for IFRS report guidelines (S&P Global, 2021). In a similar way, ICE provides climate data and analytics at both company and portfolio levels, aiding a wide array of financial institutions to conduct climate stress testing. Its services include offering climate data that align with the investment portfolios and loan books of banks, as well as facilitating climate stress testing and scenario modelling. These models leverage reference scenarios from entities like the Network for Greening the Financial System (NGFS) and IPCC and cover a broad spectrum of both listed and unlisted assets. This enables financial institutions to seek solutions that are tailored to their specific requirements.

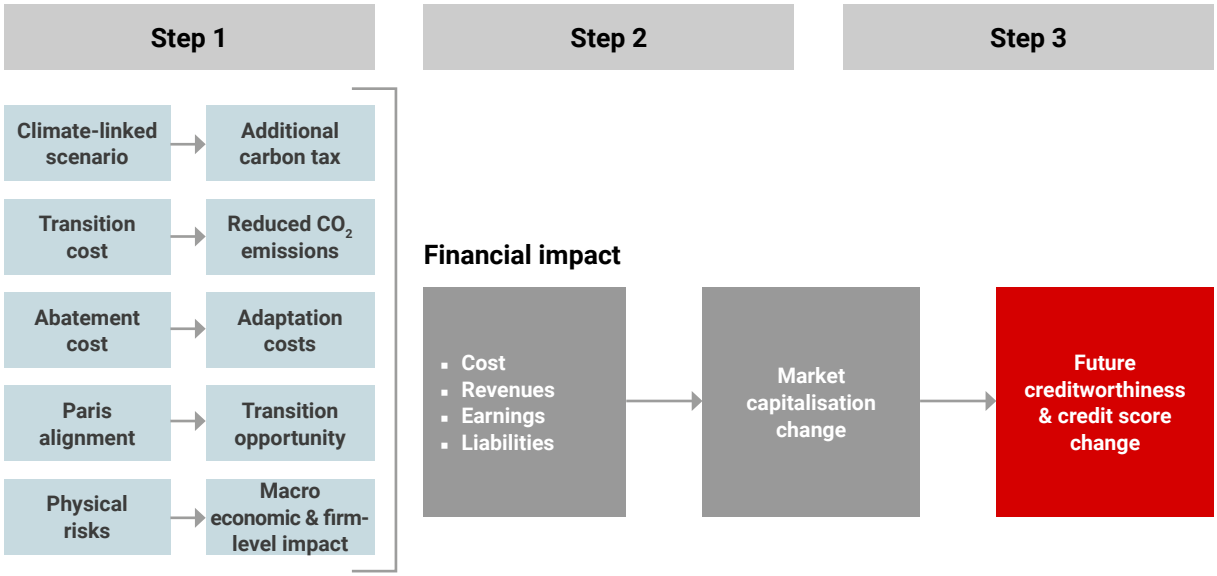


Figure 8: Climate RiskGauge climate stress testing methodology, (S&P Global, 2021).

To capture the broad scope of potential climate costs, which could be used for compliance to regulatory stress test requirements, tool providers utilise Climate Value at Risk (CVaR) models. For example, MSCI's CVaR model forecasts financial costs and profits of climate risks for different future scenarios until 2100. To accommodate users' data needs for cost evaluation in shorter time horizons, MSCI develops new Multi-Horizon CVaR outputs. The new outputs complement the standard CVaR model and provide specific cost evaluations pertaining to a range of time horizons, including one year, three years, five years, 10 years, 20 years, and 30 years in the future. Combining with other models such as MSCI's Climate-Adjusted Probabilities of Default model as seen in Figure 9, users could translate CVaR financial shocks into CVaR-driven credit shocks (MSCI, 2023b). Another example of this approach is provided by WTW, which uses a CVaR model to offer both bottom-up and aggregate results from assets, segments, entities, and portfolios. WTW's model considers Physical Value at Risk (PVaR) and Transition Value at Risk (TVaR), integrating both physical and transition risks in its quantification of the combined financial impact as the percentage of cashflow affected from climate change. All in all, the CvaR model could usefully inform financial institutions in their reporting and disclosures, as well as in their internal and regulatory stress testing exercises.

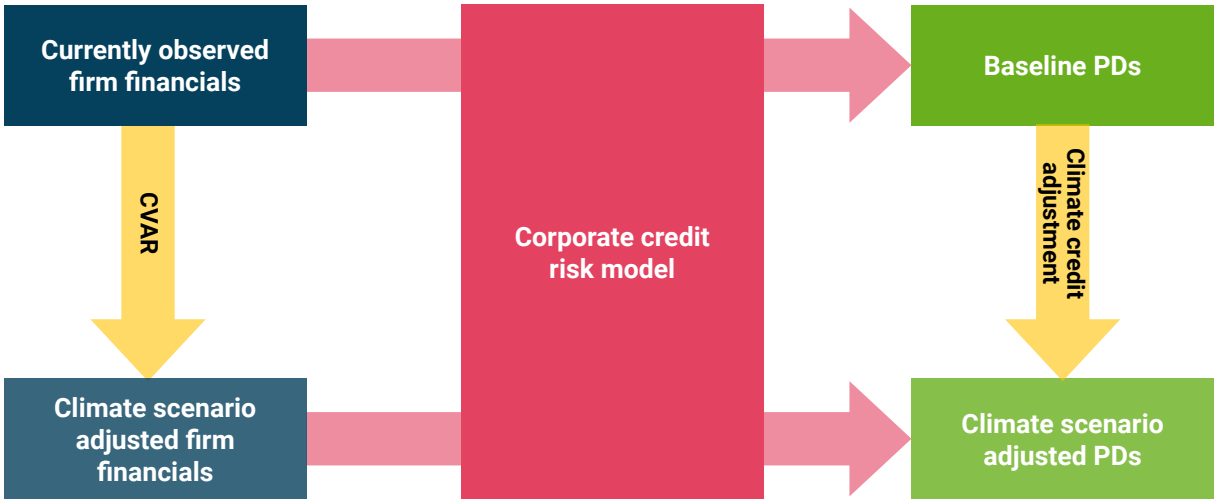


Figure 9: Translating CVaR-driven financial shocks to the credit space, (MSCI, 2024b).

XDI has also been collaborating with regulators and governments to perform scenario analysis and stress testing, not only in developed countries but also in emerging markets. It has already supported Reserve Bank of Australia in its research, for instance, providing climate hazard data to capture the physical climate risks to residential housing (RBA, 2023). The vendor also works with large banks and companies globally, notably in China, Southeast Asia, and Europe. Its world-first comparison of every sub-national jurisdiction's physical climate risk indicates that provinces in China and the USA lead the global ranking for physical risk from climate change and extreme weather. Two of China's largest regional economies—Jiangsu and Shandong—top the ranking in first and second place, respectively. Over half of the provinces in the ranking's top 50 are located in China (XDI, 2023).

2.3 Increased integration of artificial intelligence technologies in climate tools

The integration of artificial intelligence (AI) into climate risk assessment is a defining trend driven by a technology innovation wave witnessed by the climate tool universe. AI's role is multifaceted. Among other novelties, it enables climate tool providers to maximise existing data and information, offer capabilities for identifying high-risk zones, better craft adaptation strategies, and even predict natural disasters such as floods and wildfires with remarkable accuracy (Rutenberg et al., 2021).

The advent of these tools carries substantial implications for risk analysis. For example, where data gaps exist, the integration of AI into the climate data space can offer potential solutions to long-standing issues. When data are either unavailable or inaccurately recorded, AI can supplement these deficiencies with precision-driven predictions. Even in cases involving data without any historical precedent, AI modelling could provide valuable projections (Carlin, 2023). With AI, for instance, it becomes feasible to forecast future sea levels by extrapolating current data sets. The AI-driven approach, particularly reinforcement learning, strengthens policy decisions and equips researchers to design accurate economic climate models (NGFS, 2021).

Within this context, the landscape of climate fintech is evolving quickly, bringing forth companies equipped with **innovative tools that bridge data gaps and enhance the precision of risk assessment.** For example, a climate tool vendor featured in the Climate Tools Database, Riskthinking.AI, utilises AI algorithms to research the complex network structure between private or public parent companies, subsidiaries, and the full constellation of physical assets owned by each node in the corporate network. Another noteworthy contributor is Intensel, an Asia-based vendor, which employs AI across a multitude of hazard types. It also uses AI-powered model to compute the correlating energy use with temperature increases and to approximate the location and specifications of physical assets. Many organisations are exploring the potential of AI at present. A notable case in point is the Tech for Climate Adaptation initiative. Led by the World Economic Forum (WEF), the initiative is examining how data-driven and digital technologies, including AI, can offer critical tools and resources to assist climate adaptation. In its latest report, for example, the initiative explore the potential of using AI to fill data gaps, conduct weather and climate modelling, and undertake climate risk analytics (WEF, 2023b).

Another notable development is the use of **advanced satellite technology** to augment the capabilities of these tools, with companies such as CLIMATIG conducting physical risk assessments at a detailed 10-meter resolution. Complementing this, some risk assessment platforms are integrating FEMA maps. The latest generation of these maps deliver geospatial hazard data for North America with remarkably brief time lags. Furthermore, most tool vendors are streamlining the user experience by offering cloud-based, real-time dashboards and portals, which adds yet another layer of convenience and efficiency.

AI technology usage is now also featuring in the **assessment of climate reporting quality and the enhancement of companies' transition plans**. The World Wild Fund for Nature (WWF) recently launched an AI-backed tool, ChatReport, for example. The tool helps investors assess whether the science-based targets of companies' transition plans are robust whether they provide a credible pathway to achieve net zero by 2050. Importantly, its use of AI to help identify inconsistencies and possible greenwashing in transition plans enables the tool to be deployed at scale. WWF envisions that it will serve as a first screening tool to "red flag" companies whose transition plans lack ambition, feasibility, or credibility (WWF, 2023). Insig AI, an AI-based tool vendor, has developed a Transparency & Disclosure Index to measure how well companies report governance and sustainability information. The solution deploys a best practice framework informed by the ISSB Standards and related regulations. Insig AI combines machine learning (ML) and natural language processing (NLP) to enable the granular filtering, search, and comparison of what companies have disclosed about specific sustainability issues across reports, as well as providing year-on-year benchmarking against industry peers. Its research platform and the reports that it generates permit close analysis of company disclosures that, in turn, sheds light on transparency, sectoral trends, and indicators for greenwashing risk based on keywords (Insig AI, 2023).

Another tool vendor, 15Rock, also developed modules to **assist climate reporting and target setting**. Its Athena platform is particularly notable in this respect. This AI-powered, climate risk tool assists companies to recognise, evaluate, and control climate-related risks, including transition risks such as alterations in policy, technological breakthroughs, and changes in consumer preferences. In regard to reporting, Athena asks promoted questions and gathers data relevant to TCFD/ISSB. It also helps set targets, track progress, and implement effective strategies to reduce emissions (15Rock, 2023).

MSCI likewise leverages AI to facilitate data acquisition processes. AI is used mainly for: (i) information detection, which involves initiating data collection when relevant signals or events are identified across various sources; and (ii) data extraction, which focuses on retrieving factual information from these identified sources or signals.

Moody's Score Predictor Solution comprises an example of a similar approach. The tool uses an ML system trained on the historical record of reported emissions for large-cap corporates to estimate the Scope 1, 2, and 3 emissions of any corporate entity.

The increasing use of AI techniques such as ML in the enhancement of report reliability will unlock additional market insights. In turn, this will equip investors and other stakeholders with critical information that helps them to streamline their decision-making processes. In this way, they will be better positioned to seize the emerging opportunities, while at the same time mitigating the risks that are being created by the transition to a low carbon economy.

2.4 Open-source innovation and enhanced data access through collaborative platforms by data providers and tool vendors

The increasing accessibility of data from governments, universities, and NGOs is revolutionising how corporations approach climate-related challenges. Enhanced by the rise of open-source climate tools, there is now a rich amount of information readily available. Although primarily available at national or global levels, these tools still serve as essential preliminary filters that enable users to gain an initial understanding of climate-related risks in the regions in which they operate. They are crucial in offering both a general overview and specific insights of potential risks and impacts related to climate anomalies across various scales and sectors.

In response to the pressing need for comprehensive risk analyses, recent years have seen **the development of various tools that focus on physical risks**. One notable example is the World Bank Group's Climate Change Knowledge Portal (CCKP), a hub for climate-related information, data, and tools. The CCKP contains climate, disaster risk, and socio-economic data sets, as well as synthesis products such as the Climate Risk Country Profiles. These are all built and packaged for specific user-focused functions in a particular country or sector. As shown in Figure 10, the portal currently presents aggregated climate data at various scales, including national, sub-national, and watershed levels. In addition to climate data, the World Bank also provides a comprehensive collection of ESG data through the Sovereign ESG Data Framework and similar related resources. Led by researchers at the University of Oxford and its partners, the Resilient Planet Data Hub provides open climate risk data and tools such as the Global Systemic Risk Assessment Tool (G-SRAT). The G-SRAT also displays risk from climate hazards at a global scale and includes data on hazards, vulnerability, and exposure under different future climate scenarios. With a global map and satellite view, the online platform currently allows users to overlay various natural hazards, ranging from river/coastal flooding and drought through to extreme heat, earthquakes, and cyclones. It also enables users to visualise exposure-related data attributes such as population, infrastructure, and buildings. In addition, the tool provides vulnerability indicators such as the Human Development Index and travel time to healthcare facilities across countries and regions. Based on these insights, it then visualises the final risk level in terms of population exposure and infrastructure risk, and presents a regional summary. Although financial institutions cannot derive financial or economic metrics or results from these platforms, they provide **a high-level overview for hotspot identification and resilience building.**

Figure 10: CCKP's global map view and country profile page for selected regions, (CCKP, 2023).

For its part, WWF has developed The Risk Filter Suite, including modules of Biodiversity Risk Filter and Water Risk Filter. Designed as a **corporate and portfolio-level screening and prioritisation tool**, the innovation enables companies and investors to assess and respond to their biodiversity and water risks both now and in the future. WWF's suite of tools provides global coverage across all industry sectors and, as such, is best suited for organisations that have location-specific data available or that have a large portfolio of sites/assets to analyse (e.g., company operational sites and supplier sites). These tools are therefore primarily used by medium to large-sized companies that have robust value chain information available for analysis. The tool does not yet include ways to assess risk given individual company management actions or practices. It cannot therefore be used as a tool for impact quantification, nor can it provide quantified assessments of financial risk (WWF, 2023). Similar in approach is the Exploring Natural Capital Opportunities, Risks and Exposure (ENCORE) initiative. Developed in collaboration between UNEP FI, UNEP WCMC, and Global Canopy, ENCORE serves as a screening tool for financial institutions to take their first steps towards understanding their dependencies and impacts on nature for different sectors and sub-industries (ENCORE, 2024).

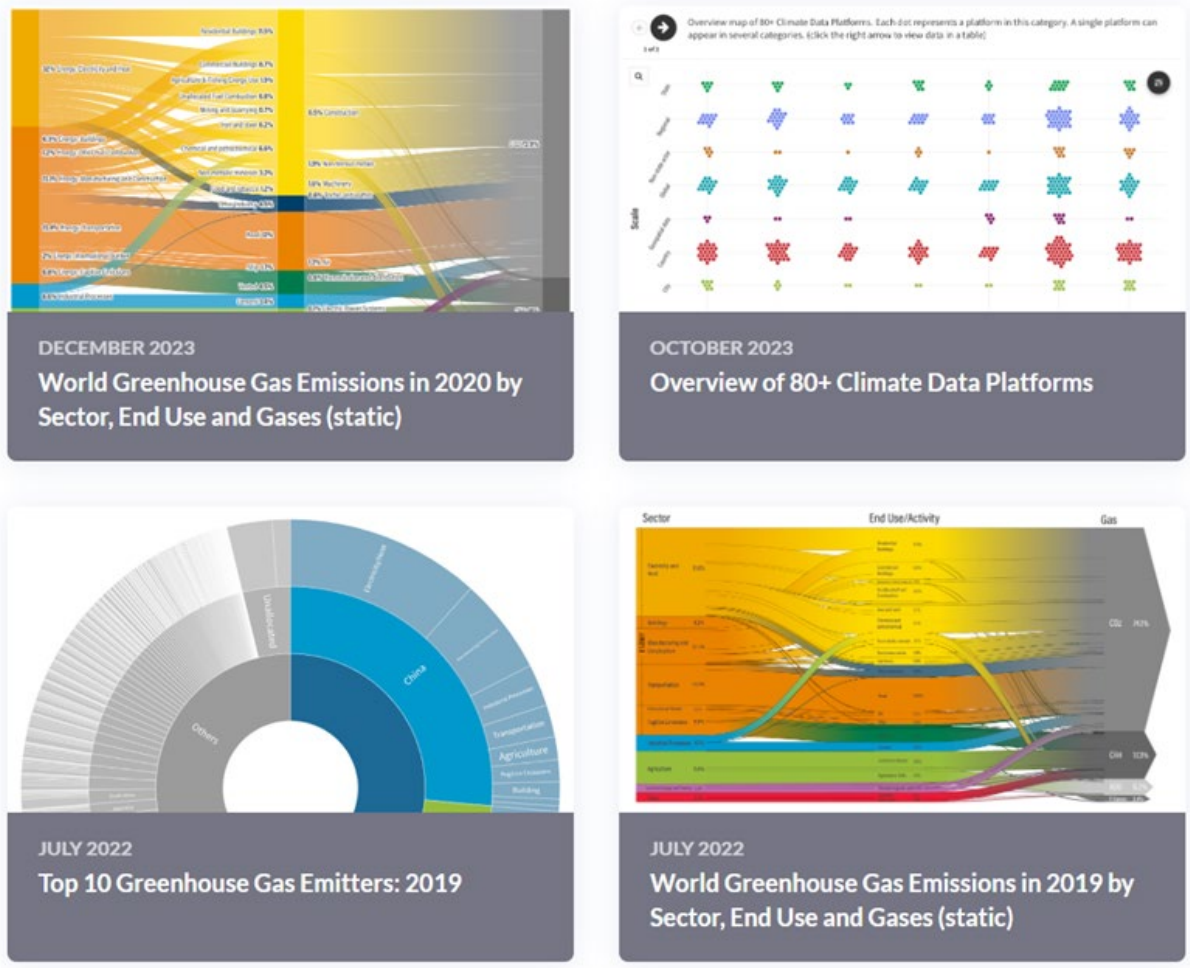


Figure 11: WRI Climate Watch modules and visualisation, (WRI, 2023).

WRI has also developed a series of open-source tools that can **help monitor and understand climate-related physical risk and transition risks**. On the transition risk side, Climate Watch is a tool developed to track and compare countries' GHG emissions data, Nationally Determined Contributions, long-term strategies, and net-zero targets, as Figure 11 indicates. Systems Change Lab is another tool that aims to spur action at the pace and scale needed to limit global warming to 1.5 °C and halt loss of biodiversity while also building a just and equitable economy. It does so by tracking global progress for more than 70 transformational shifts across all major economic systems. In a similar vein, WRI has also co-developed with users a free online tool called AgriAdapt that helps agricultural funders, processors, distributors, government agencies, and other "missing middle" links of agricultural value chains to better identify and understand their climate change risks. AgriAdapt provides global, map-based, and crop-specific data for agricultural supply chains. The information ranges from changing land-use suitability through to projected shifts in temperature and rainfall patterns. The tool's "Analysis" section permits aggregated analysis of the selected layers in specific geographic points selected by the user. Specific crop pages provide tailored narratives for selected crops (currently, coffee, cotton, and rice). These narratives use data to tell the story of how climate change affects different parts of the value chain. The goal is to inform medium and longer-term climate adaptation decisions regarding the best types of crops to grow, plus the most appropriate location timing for their production. The tool also presents

ways to increase climate resiliency when processing, distributing, and storing crops, ultimately enhancing the climate resilience of people working in the most vulnerable parts of these supply chains. The addition of an adaptation solutions menu as a new tool feature is planned for November 2024. On the physical risk side, the WRI Aqueduct Water Risk Atlas provides similar tools for decision makers on water-related risks, including floods, droughts, and water stress.

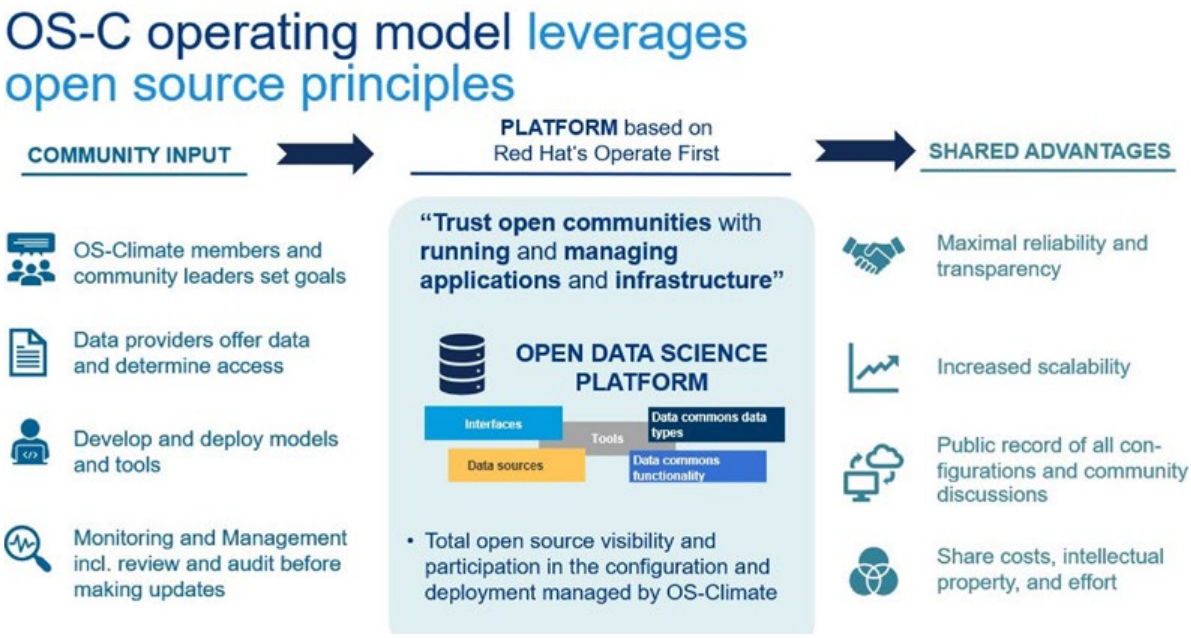


Figure 12: OS-C as a community of practice and action, (OS-Climate, 2023).

Data sharing concerning climate risk is also evolving. This brings particular benefits to unlisted companies, small and medium-sized enterprises (SMEs), and financial institutions in emerging markets. Despite previous reluctance due to engage with security and competition concerns, **new frameworks and partnerships are emerging to catalyse change, fostering a conducive environment for collaboration and data sharing** (Ballard, 2023). As Figure 12 illustrates, initiatives such as OS-Climate demonstrate the potential of community-based collaboration among a diverse range of stakeholders, emphasising the production of high-quality, transparent, and accessible data and tools in alignment with global reporting standards. All stakeholders involved in reducing climate risk, including companies (despite being potential market competitors), can work together on the "pre-competitive" layer of technology and standards that they all need. This prevents "wheel re-invention" and frees up resources to accelerate innovation. By enhancing models and use cases, OS-Climate aims to help firms increase knowledge and capabilities internally (OS-Climate, 2023). When collaboration between different data and tool providers deepens, it could create more room for users to benefit from enhanced data and could generate models that fit their needs better. For example, through OS-Climate's physical risk building blocks, which are both open-source and modular, users are allowed to utilise both open hazard and vulnerability models as well as plug-in commercial models as needed. This synergy fosters a more adaptable and comprehensive framework, enabling users to tailor their analysis and decision-making processes with greater precision and relevance.

Specifically in respect to **open-source data related to net zero and GHG emissions**, the Climate Data Steering Committee developed the Net-Zero Data Public Utility (NZDPU) in 2023. This resource aims to create an open, free, and centralised data repository that will allow all stakeholders to easily access key climate transition-related data, commitments, and the progress of businesses and financial institutions toward those commitments. At present, the NZDPU covers 382 companies by IFRS Foundation's Sustainable Industry Classification Systems from 31 jurisdictions. The data attributes of a sample company are illustrated in Figure 13. These cover emissions disclosures, historical emissions, emissions reduction targets, and target progress, among other data points (NZDPU, 2023).

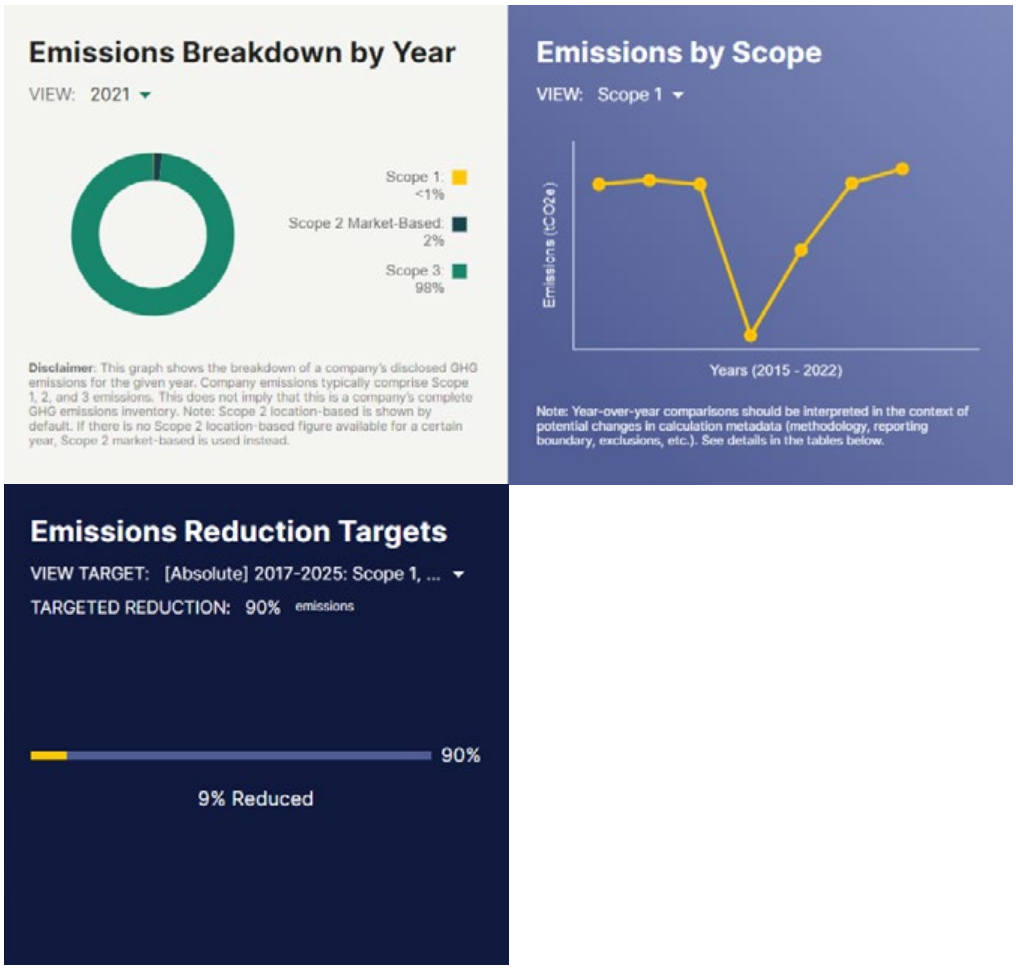


Figure 13: Data visualisation of a sample company covered by NZDPU, (NZDPU, 2023).

Commercial tool vendors like Moody's and MSCI are also contributing significantly to this evolving landscape by **establishing support hubs for the tool user and developer community**. This approach fosters an enabling environment for knowledge exchange, as well as the exploration of a plethora of data through the use of extensive databases and resources. The creation of such an environment helps accelerate the development of advanced and sophisticated climate tools. An illustrative example is MSCI's ESG Ratings & Climate Search Tool. As illustrated in Figure 14, this public search tool permits users to search over 2,900 companies for a range of useful data, such as Implied Temperature Rise, decarbonisation targets, and alignment to Sustainable Development Goals (SDGs)

(MSCI, 2024c). In parallel, Moody's is creating Application Programming Interfaces and developer hubs to ensure that climate risk data can be easily digested by customers and are suited to their workflow needs (Moody's, 2024).

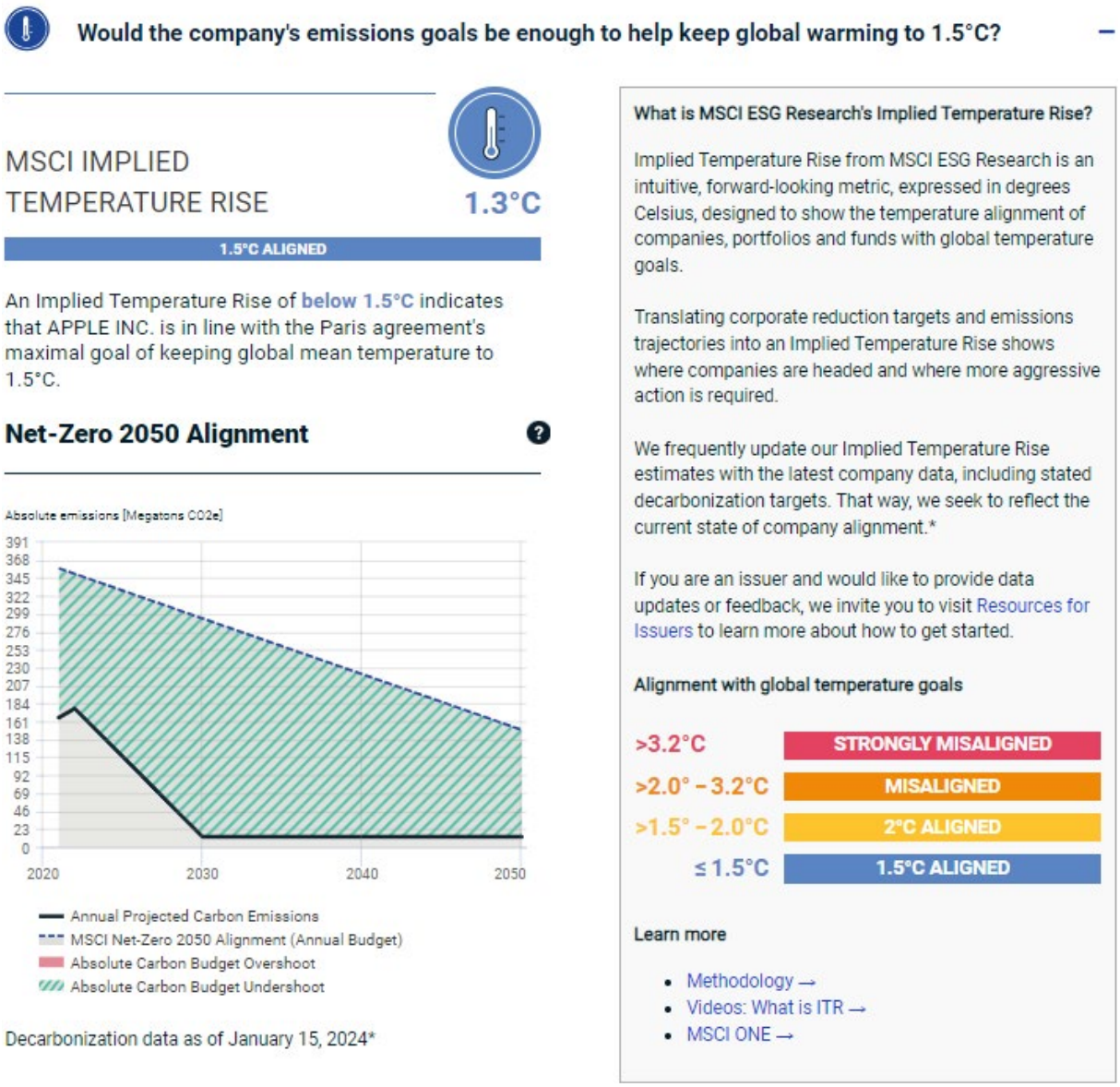


Figure 14: Search tool that allows public searches of climate and ESG data by MSCI, (MSCI, 2024c).

In addition, solution providers are leveraging AI to provide comprehensive reports in order to assist institutions with their climate disclosure. For example, 15Rock offers a free AI-driven tool backed by auditable climate data that supports climate reporting, target-setting, and progress tracking (15Rock, 2024). All in all, this evolving trend not only comprises a convergence of technologies, but also represents a harmonious integration of diverse resources, insights, and innovations. By harnessing these advanced tools and collaborative platforms, organisations can manage climate risks more effectively, thereby fostering resilience and sustainability in their operational landscapes.

2.5 Enhanced data input, refined assumptions, diverse functionalities, and coverages toward comprehensive analysis

The evolution of climate tools offerings has an intensified focus on the precision of data inputs, the breadth and granularity of assumptions, and the continual refinement of product modules. The industry's trajectory towards delivering more profound insights has been shaped by these enhancements.

Many tool vendors **established systems to be stricter with data quality and input validation.** ICE adopts a quality assurance process to ensure the accuracy of its emission data, as shown in Figure 15. The human quality assurance steps are combined with a modelled statistical outlier assessment to create a process in which data points are efficiently flagged for the team's action, thereby reducing the effect of possibly spurious outliers. ICE also generates inferred emissions data for companies that do not publicly disclose or provide incomplete emissions disclosure. To achieve this, it uses its 10-year history of reported Emissions Data and granular industry-level information, together with company-specific data. This enables it to generate inferred emissions data for Scope 1 and Scope 2 emissions, as well as for each category of Scope 3 emissions. Its user interface identifies whether the data provided is directly reported or inferred (ICE, 2023b). To improve data quality, ICE consistently enhances its data validation processes. This includes the regular implementation of stricter criteria for the acceptance of companies' emissions targets, plus the expansion of the coverage of scope 3 emissions and net-zero objectives. At the same time, tool providers are actively developing new functionalities building upon existing methodologies. As an example, MSCI assists clients in performing internal validation of metrics, such as CVaR, based on regulation guidance set forth by the United States Federal Reserve, the EBA, and the ECB.

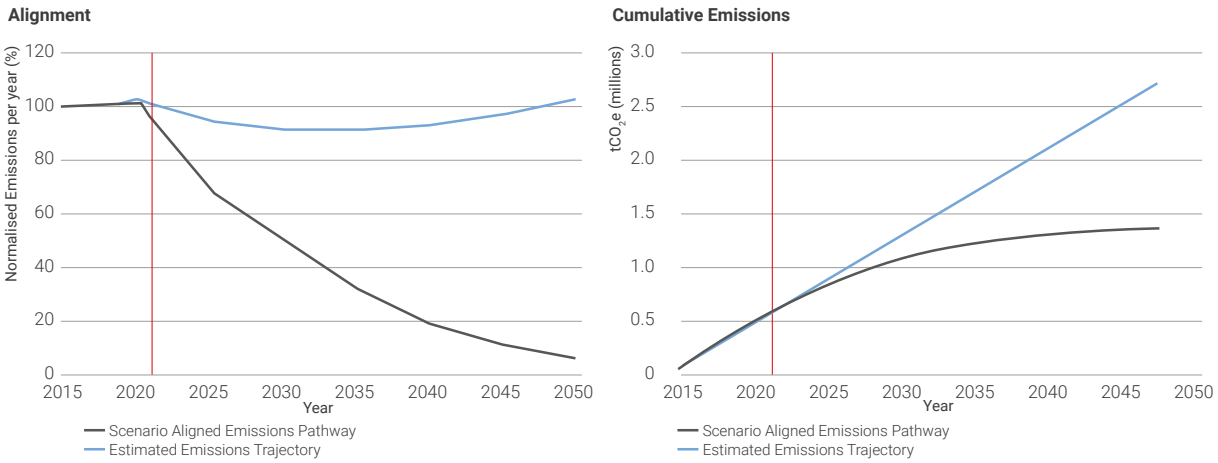


Figure 15: Forward-looking analytics supporting climate stress testing, (ICE, 2023b).

Morningstar, another integrated risk tool vendor, has added a **transition plan evaluation function** to Sustainalytics' Low-Carbon Transition Ratings product. Instead of automatically accepting the self-disclosed targets from counterparties and assuming these are going to be achieved, the vendor assesses the robustness of targets before using the disclosed data in further analytics on a company's carbon transition performance.

Morningstar also has a dedicated TCFD/ISSB module showing the scope and quality of an issuer's TCFD/ISSB disclosure. The module looks beyond historical emissions and stated net-zero commitments by providing a deep assessment of companies' actions, including their implemented policies, governance systems, and investment plans (Morningstar, 2023). ISS ESG has a similar verification process for self-reported data collected from individual companies, with data discarded if their reporting is shown to be of a low quality (ISS ESG, 2023).

Furthermore, tool vendors are integrating **more sophisticated elements and assumptions into their risk and opportunity assessments**. BloombergNEF's TRACT, for instance, emphasises that transition risks are not synonymous with carbon risks due to the non-universal nature of carbon pricing. It recognises that the majority of transition risks emanate from shifts in demand for commodities and products, influenced by consumer adoption, climate policies, and technological innovation (BloombergNEF, 2023). In WTW's case, it recognises that carbon prices do not often directly feed into asset valuations and therefore takes into account a broader spectrum of climate-related factors than simply the implementation of carbon pricing. Any factor that could affect demand, costs, margins, and pricing—and thus influence company cash flows and, consequently, asset valuations—is considered in its approach. Tool providers like PwC GmbH WPG are also integrating granular assumptions such as indicators of demand and price shifts into their assessment processes. This allows users to adjust their adaptation assumptions based on varying counterparty actions. Another example includes Moody's climate-adjusted credit risk analytics, which not only assess impacts of carbon prices but also company-level and sector-level demand dynamics, such as inter-firm competition modelling.

The NGFS scenarios has explored the development of short-term climate scenarios to complement its existing scenario framework of long-term climate scenarios. It has also examined their ability to provide assumptions on climate risks at higher frequency and the interaction of these risks with business-cycle shocks. Five different climate scenario narratives are proposed to underpin the short-term dynamics associated with different transition and physical impacts, as seen in Figure 16 (NGFS, 2023). Many tool providers are capturing the latest progress and are incorporating the new narratives in their upcoming enhancements.

Scenario	Narrative
Highway to Paris	Elevated levels of uncertainty related to fossil energy supply lead governments to implement an ambitious mitigation pathway in a timely and anticipated fashion. There is a boom in green public investment leading to a rapid reallocation of capital and across sectors as well as internationally via cross-country capital flows and lending patterns. Technology shocks lead to a faster-than-anticipated transition, inducing disorderliness. Green prudential policies prevent financial turmoil albeit with losses in some sectors due to stranded assets. **In line** with reaching net zero by 2050.
Green bubble	Elevated levels of uncertainty related to fossil energy supply limits governments in their ability to implement ambitious mitigation policy. Green regulation overtakes government policies in driving the transition, leading to a glut of green private investment and the build-up of a green credit bubble. A sunspot (i.e., an unrelated random event) leads to the burst of the bubble, a sharp rise in risk premia and a confidence crisis. **In line** with reaching net zero by 2050
Sudden wake-up call	Elevated levels of uncertainty related to fossil energy supply limits governments in their ability to implement ambitious mitigation policy. Driven by an event that triggers a sudden change in public opinion (e.g. a severe natural disaster), an unanticipated and accelerated transition occurs.[a] The abrupt policy change sets off shock waves through the economy and financial system: stranded assets in polluting sectors cause severe financial stress which propagates internationally via capital, trade and financial flows. **In line** with reaching net zero by 2050.
Low Policy Ambition and Disasters	Severe acute physical disasters hit exposed jurisdictions. Investors price in a sizeable risk premium, which freezes private investment, and reduce their exposure to the jurisdictions and sectors whose assets are at greatest risk of disaster losses. Households consume less and save more due to the increase in uncertainty and insurance costs increase. **NOT in line** with reaching net zero by 2050.
Diverging realities	The world as a whole aims to avoid the worst impacts of global warming. However, severe natural disasters in the EMDEs and LICs and a lack of external financing lead to recovery traps, i.e., a lack of fiscal space for affected regions to transition. Meanwhile, the disruption of transition-critical mineral supply chains originating in disaster-prone regions hampers the speed of the global transition.[b] The sudden realization that the global transition is too slow to avoid a Hot House World leads to a sudden re-assessment of future physical impacts globally. As a result, risk premia rise sharply. **NOT in line** with reaching net zero by 2050.

a For instance, the natural disaster in Fukushima lead to a 180-degree turn-around in Germany's nuclear energy policy under Chancellor Merkel

b An alternative narrative would be that geopolitical tensions instead of natural disasters clog up supply chains. However, the impacts might be observationally equivalent-leading to a spoke in commodity prices and a sharp increase in risk premia once the realisation that the transition is ineffective hits investors

Figure 16: New NGFS short-term scenarios, (NGFS, 2023).

The market has also seen the emergence of **complementary tools embodying diverse philosophies in climate-related risk assessment**. RiskFootprint™, which is featured in UNEP FI's climate tools dashboard, focuses exclusively on evaluating natural risks and associated losses at status quo, offering stakeholders a comprehensive overview of natural perils and property resilience (RiskFootprint, 2023). In contrast to forward-looking solutions, this approach aids stakeholders in making well-informed decisions regarding their real estate assets. Riskthinking.AI, another tool provider, employs stochastic models that takes multiple factors into account in order to provide a range of outcomes. The approach underscores the significance of considering uncertainty in climate risk assessments, proposing that the current emphasis on precision (such as highly resolved projections for 2050) may be oversold in light of inherent uncertainties and data limitations (Riskthinking.AI, 2023). In summary, the collective move towards higher accuracy, enhanced granularity, and more comprehensive assumptions will surely help tool users to navigate the multifaceted dimensions of climate-related risks and opportunities, fostering a more informed and responsive approach to climate-related challenges across various use cases.

Given that addressing data limitations is paramount for financial institutions engaged in climate-related analysis, the market is also seeing **vendors intensifying efforts to enhance data availability across diverse regions and asset classes, with a spotlight on emerging markets and private entities.**

In the context of emerging markets, the prevalent data scarcity poses substantial challenges to effectively discerning and mitigating climate risks. Likewise, private entities and SMEs often lack access to the high-quality data available to their larger counterparts. Amplifying data acquisition in these regions is imperative to mitigate risks and foster sustainable development. Data accessibility for unlisted assets and SMEs also helps establish the resilience and sustainability of the financial ecosystem.

A notable 41 per cent of vendors featured on UNEP FI's Climate Risk Dashboard cater to companies in Latin America, Asia-Pacific, and Africa, offering both transition and physical risk assessments. Emergent tech start-ups and vendors in these regions not only bring in-depth insight into localised risks but also provide more location-specific details about adaptive capacities. For instance, Brazil's WayCarbon has asserted its presence across Latin America, where it collaborates with the Federation of Brazilian banks, focusing on energy sector risk evaluations. Furthermore, Swiss Re boasts a global reach, highlighting regional coverage in areas such as EMEA, Australia, and Malaysia. Similarly, Intensel leverages its presence in Hong Kong and Singapore to demonstrate expertise in Asian markets, extending its services to physical assets in key geographies such as mainland China and Vietnam (UNEP FI, 2023). BloombergNEF covers over 40,000 companies across the globe, highlighting its capability in India and mainland China, as indicated by Figure 17 below. In addition, S&P Global also offers a range of datasets that allow users to gain insights into environmental data and analytics across different asset classes, time horizons, and regions (S&P Global, 2024).

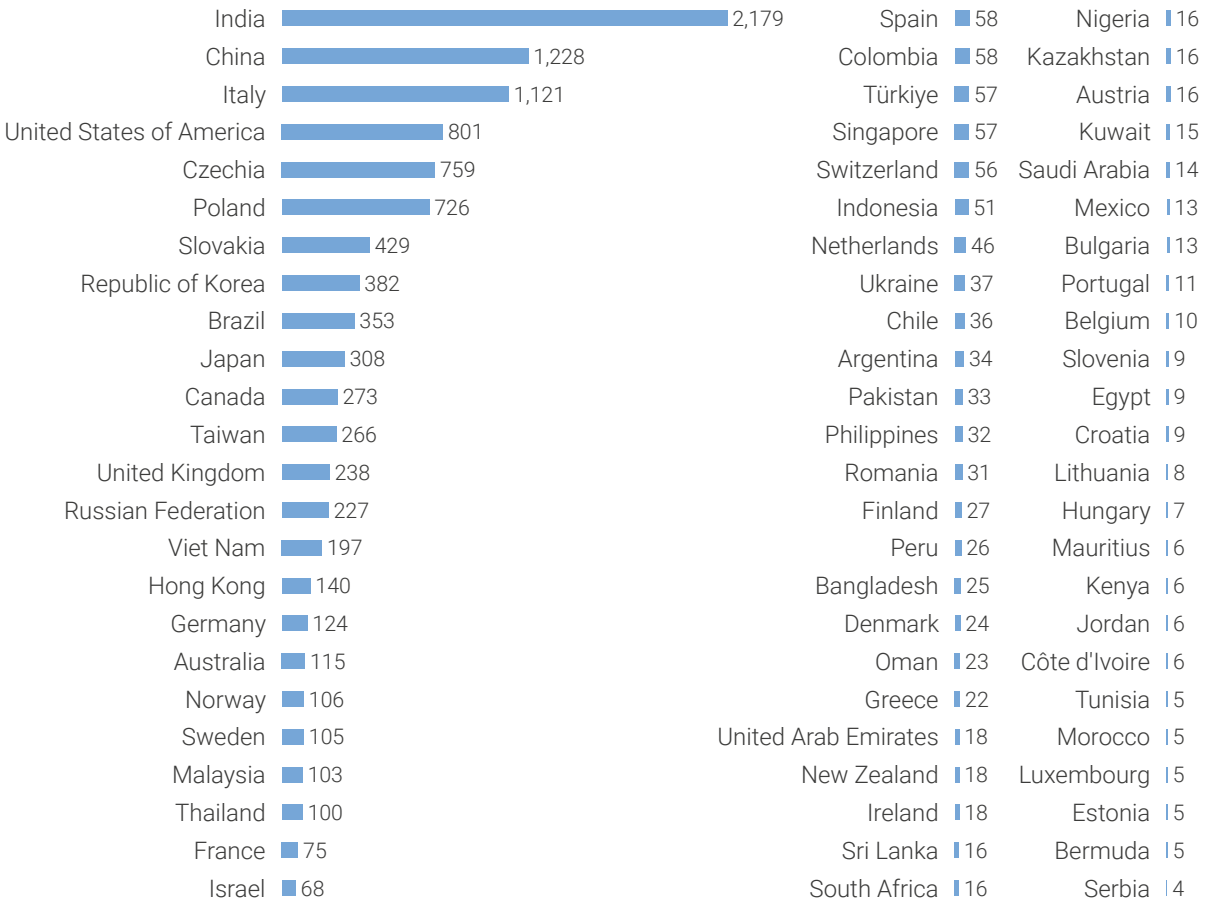


Figure 17: Company counts by market of incorporation, (BloombergNEF, 2023).

Out of 58 vendors incorporated in the Climate Risk Dashboard, 18 offer coverage for unlisted assets in their physical analyses. OS-Climate clarifies that its method of bottom-up measurement does not discriminate between listed and unlisted assets; with the geolocations and ideally some asset characteristics available, its approach remains consistent. S&P Global holds expansive coverage of approximately 2.2 million entities, both public and private, accounting for 99 per cent of global market capitalisation.

SECTION 3:

Enhancing utility: Optimising third-party tool functionalities for meeting financial institutions climate-risk assessment needs

unsplash.com/@unstable_affliction

Climate risk assessment is inherently challenging due to the uncertainty related to climate change. This forward-looking process involves complex steps to translate climate risks into financial or economic impacts. Consequently, while climate tools, are useful, they have inherent limitations in this context. This chapter will discuss some challenges that financial institutions are seeing in the risk assessment process, highlighting calls for the climate tools industry to provide further support and enhancements for end users.

3.1 Common challenges in climate risk assessment process

Given the complex nature of climate assessments, which frequently depend on approximations, there are inherent challenges in the methodologies currently employed. Financial institutions often encounter common obstacles as they strive to comprehensively assess the risks and opportunities related to climate change. Some key challenges include, but are not limited to, the following:

- **Sector-specific analysis**: Some sectors, such as the agricultural and real estate sectors, present a distinct set of complexities in risk assessment due to their sensitivity to climate variables and dependency on geospatial locations. For example, it can be challenging to map out the locations of all farms, factories and infrastructures for an agricultural company and translate local hazards of individual assets to holistic financial metrics and counterparty-level implications.
- **Evaluating unlisted assets**: Risk assessments for unlisted assets and SMEs could be difficult to address, mainly due to data gaps and unavailability. These limitations could restrict the breadth and accuracy of climate-related risk assessments and projections, including areas that might be specifically vulnerable to climate change.
- **Supply chain analysis**: Comprehensive evaluation of supply chains remains challenging, especially when considering the interdependencies and potential for cascading impacts.

To address these hurdles, vendors have innovated and adapted in various ways. Enhanced tools are being offered to address challenges around supply chain analysis. An example is MSCI's tool, GeoSpatial, which leverages large datasets to provide users with asset-level data and analysis, such as physical risk exposures and impact assessments, for a range of assets that may be affiliated to a company in different ways (MSCI, 2024d). There are also targeted solutions on specific sectors. PwC GmbH WPG, for example, has developed its Climate Excellence for real estate, aiming to address specific topics such as: the returns, value, and investment costs at the portfolio and building level; assets carbon dioxide emissions and energy consumption; and renovation plans to make the buildings fit for a net-zero future (PwC GmbH WPG, 2023). The mechanisms and findings of this separate tool are then integrated into the firm's regular analysis for other financial institutions. Similarly, ICE provides specialised analysis tackling sector- and geographic-specific inferences for unlisted assets. In addition, it has developed a Supply Chain Risk Dashboard (ICE, 2023c), a tool for calculating and assessing the carbon footprint and emission intensity of a company's supply chain using data such as supplier expenditure. In the absence of direct data for certain physical assets, vendors sometimes leverage information from neighbouring locations and building structures

as proxies. As for unlisted assets, some tool providers, such as MSCI, provide portfolio foot-printing solutions covering a range of assets including private equity (MSCI, 2024e). Others, such as WTW, offer asset-level commodity models that capture structural changes in commodity markets as part of the transition to a low-carbon economy. There are also tool providers that turn to proxies, using information from listed counterparts, sector-wide data, or geographic markers to estimate potential risks. XDI's cross-dependency analysis considers the interdependency of assets across a certain area that are essential to the proper functioning of a site or city, such as water supplies, data lines, access roads, and power supply lines, as Figure 18 shows (XDI, 2019).

However, despite the implementation of these strategies, the need exists for solutions that are more robust and sophisticated. Thus, vendors must adequately communicate the proxies and approximations that they employ, ensuring that clients fully understand the methodologies used. Collaborative testing of approximation and extrapolation methods with both peers and clients is essential for continuous improvement. Most importantly, collaboration—both within the industry and with external partners—can pave the way for innovative strategies that address the root challenges of climate risk assessment.

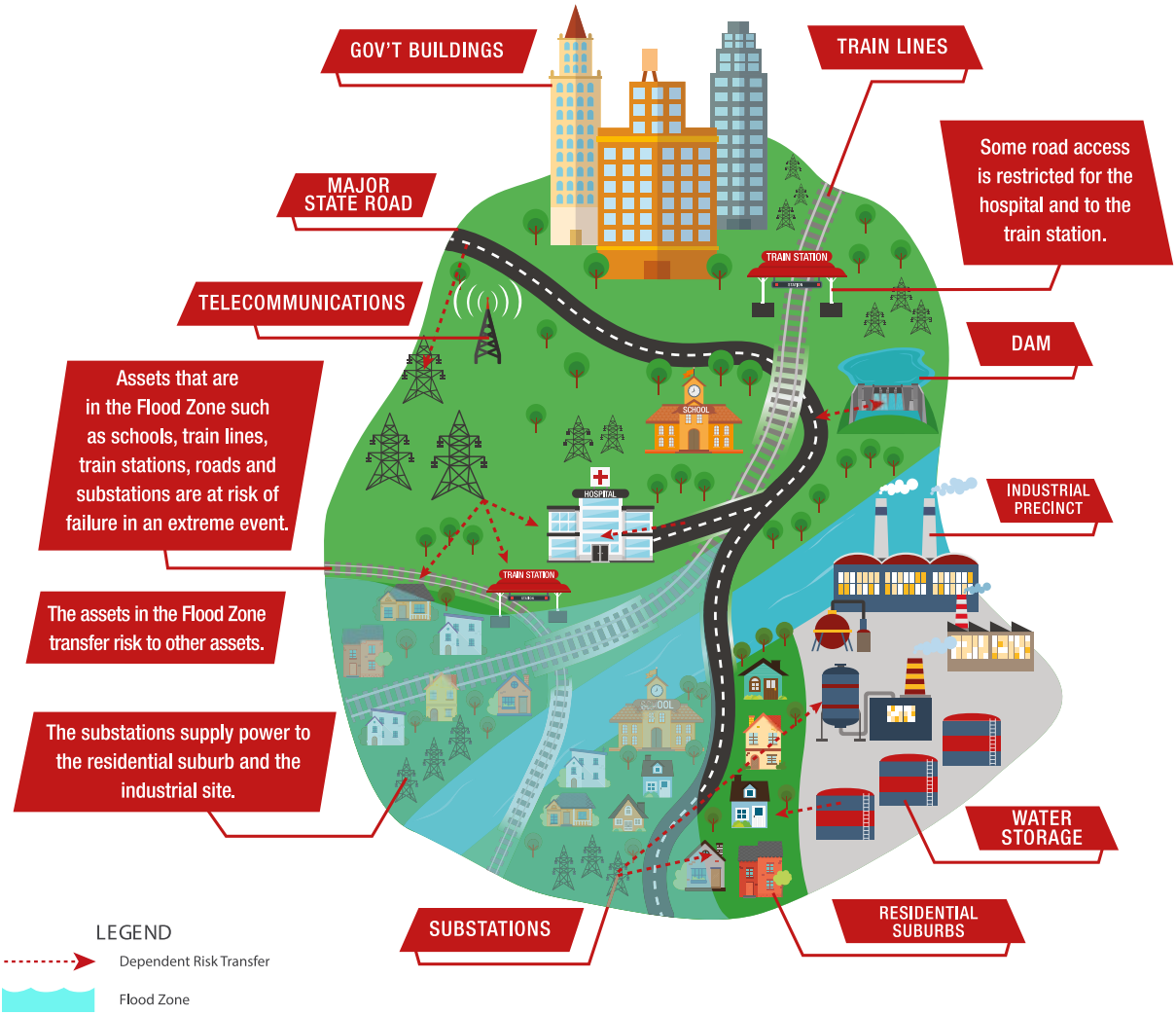


Figure 18: Cross-dependencies of infrastructure from XDI Sydney project, (XDI, 2019).

In addition, many financial institutions grapple with the "so what?" aspect, questioning the practical application of climate risk assessment outcomes. This includes translating results from stress tests and climate assessments into actionable strategies. Addressing this requires a comprehensive, organisation-wide approach to the use of climate tools, as is explored in further detail in Chapter 5 of this report.

3.2 Access and budgetary challenges in climate tools and data acquisition

Access to robust climate data and reliable climate assessment tools is essential for financial institutions to effectively gauge risks and capitalise on opportunities within an ever-changing climate landscape. Institutions equipped with an advanced, customised climate tool may be better able to anticipate future extreme events in the cities where they operate and identify the potential disruptions to their supply chains. With such foresight, they can adopt proactive strategies, such as securing insurance, in order to mitigate potential damages. However, procuring these developed tools and the necessary data often requires time, budget, and expertise, which can represent a substantial commitment of resources.

Financial institutions might face challenges in identifying both effective and cost-efficient climate data sources and tools. To make well-informed decisions, they need to understand the underlying assumptions of these tools. Doing so typically necessitates specific expertise, training, and investigation. Additionally, comparing different providers to find the right balance between the scope of services and cost involves a significant investment of time.

Feedback from a UNEP FI survey also reveals concerns among financial institutions regarding pricing transparency and value for money. Some institutions express a preference for specific tool functionalities instead of bundled subscriptions, as illustrated by Figure 19 below. While open-source database and tools could serve as a valuable and accessible option, their capacity to provide detailed, institution-specific financial analyses and practical integration into risk assessment processes is still under continuous development. In scenarios where climate data are freely available and open-source, users may still face challenges in finding and using such data effectively. These challenges might stem from the structure and format of the data. Additionally, comprehensive and clear documentation is crucial to guide users on how to effectively leverage these resources, ensuring their full potential is realised.

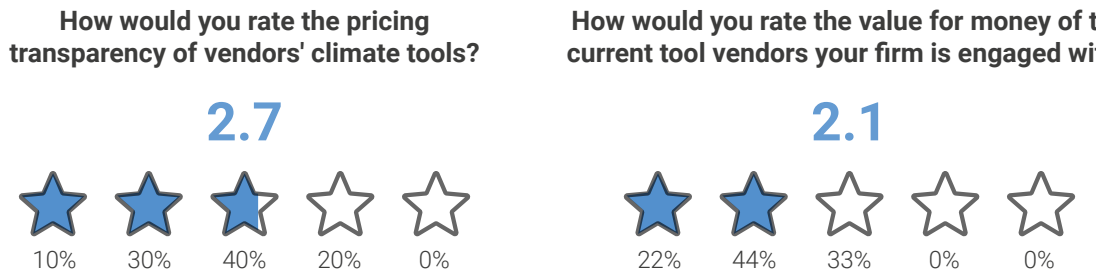


Figure 19: Financial institutions' feedback on pricing and value for money of climate tools, (UNEP FI, 2023).

While larger enterprises may have the flexibility to allocate substantial budgets, time, and expertise in climate-related analysis (Frank & Chegwidden, 2022), SMEs, especially those in emerging markets, are often constrained by resource limitations in accessing climate tools and databases. Differences in resource availability and priorities for resource allocation can also create an imbalance of data coverage and adoption of climate risk assessments amongst sectors and regions. Considering the vulnerability among regions to the impacts of climate change (FSB, 2020) and given the pressing need for emerging market participants to tackle climate risks (IISD, 2023), addressing the affordability and budgetary issues is crucial.

Further to budgetary concerns and restrictions, access to high-quality, reliable, and comparable climate data is also needed by financial market participants to effectively assess and price climate-related risks. The United Nations Environment Programme (UNEP) highlighted the lack of systematic methodology and comprehensive data to accurately identify practices as significant gaps in the realisation of the Sustainable Development Goals (UNEP, 2015). Although the increasing trend of integrations, mergers, and partnerships amplifies service vendors' capabilities and offers a one-stop solution for financial institutions, it could also lead to the centralisation of climate data. This could potentially limit access for end users (Schletz et.al., 2022). In situations where climate data serve as a public good (particularly during extreme weather events like impending cyclones), it is important to make relevant critical data sufficiently accessible to safeguard public safety and welfare. The transformation to a sustainable financial system is essentially a matter of public choice that should be made across stakeholders and a growing portion of the financial system.

In an ideal world, comprehensive climate-related data and developed climate solutions should be made fairly accessible and put to good use in an equitable and trusted manner so as to enable sustainable development and the achievement of net-zero emissions. OS-Climate recently onboarded the IRIS Tropical Cylcone model from Imperial College, which exposes open data in a format optimised for the processing of a high volume of assets. In reality, it is expected that the pricing of related climate solutions would reflect the resource invested into creating and maintaining these offerings. Recognising this, it is essential to ensure that those most in need are not priced out of accessing vital data necessary for effective climate risk assessment, mitigation, and adaptation. Market participants in the private sector are already actively engaging with under-resourced communities to address their needs for climate risk assessment, mitigation, and adaptation. One example includes The Jupiter Promise, which is a programme initiated by

Jupiter Intelligence to assist these communities in understanding and quantifying risks for informed climate adaptation strategies (Jupiter Intelligence, 2024). The public sector also plays a critical role in this context by helping orchestrate funding and closing accessibility gaps, thereby promoting a more inclusive and equitable approach to tackling climate challenges worldwide.

3.3 Limitations with climate modelling and realistic assumptions

Current climate-related risk analyses have been criticised for their tendency to underestimate or simplify the dynamic effects of physical and transition risks on the economy. This problem is largely caused by the disconnect between climate scientists, economists, and model users in financial services (Trust et al., 2023). A particularly significant challenge is the ability to quantify the risk of armed and social conflicts, along with the political and economic repercussions of forced migration due to rising temperatures. Whereas simplified modelling of risk analysis often makes sense, such simplification does not apply to climate-related risks due to the complex spatial and temporal dynamics involved. With the global scale of climate change and its diverse temporal and spatial implications, oversimplified risk analyses are inadequate as they undervalue financial dangers. This is especially the case when these risks threaten entire ecosystems through cascading or threshold effects.

Adding to this complexity, current research indicates the likelihood of the global temperature increase reaching 2˚C by 2050, given the current carbon dioxide concentrations and the latest calculations of Charney (fast-feedback) equilibrium climate sensitivities (Hansen et al., 2023). This potential discontinuities between 1.5˚C and 2˚C scenarios could make predicting outcomes of climate change's impacts exceedingly challenging.

The core objective of these models is to assess the implications of climate change and associated mitigation measures on corporate financial health. It is paramount that they mirror real-world situations closely (Bowdrey and Hidi, 2022). An important mitigating factor, however, is the reliance of risk assessments on historic data as this leads to uncertainty about the thresholds for many biophysical and earth systems processes as well as the diverse reactions across physical systems, ecosystems, and the economy. Cascading disasters can occur as natural disasters can heighten the risk of other disasters. For example, droughts can cause wildfires and further damage to biodiversity, which subsequently result in a range of negative social impacts. Critical (and sometimes overlooked) risks often arise from the complex interplay of climate change with other factors, such as variations in spatial impacts, demographic shifts, economic uncertainties, and differences in political landscapes. Feedback processes are often the source of heavy-tailed distributions and are therefore closely linked to so-called "black swan" events, which exceed the expectations normally associated with a particular situation and result in potentially severe consequences. Figure 20 below shows the kind of channels of interaction that are often missing from analyses and thus represent a source of potentially overlooked or underestimated risks (Rising et. al, 2022).

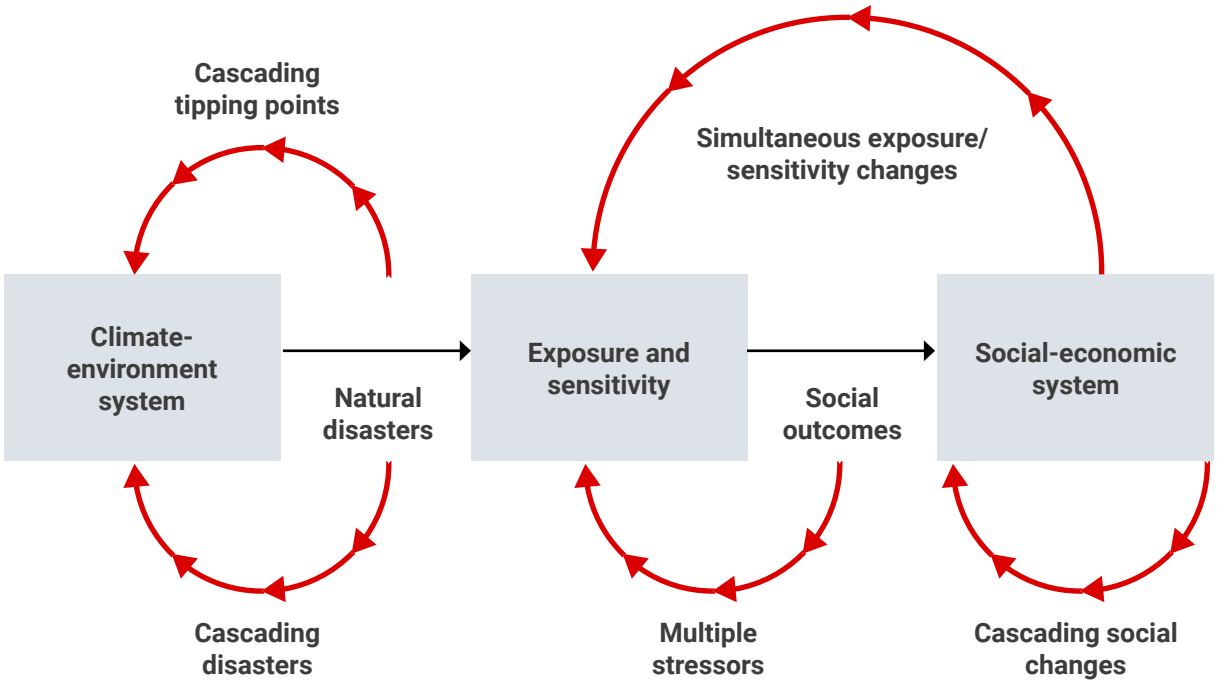


Figure 20: Stylised channels by which risks can interact and compound, (Rising et. al, 2022).

Existing climate models may use misleading assumptions. For example, some climate models have been criticised for being potentially misleading due to a lack of comprehensive consideration of the potential consequences of climate change and the possible advantages that a net-zero transition could bring about. This may be due to the inability of some models to accurately capture developments in alternative energy and their tendency to overlook complex feedback loops in the innovation process that can lead to institutional and behavioural changes, discoveries, and economies of scale (Stern, 2016). On the other hand, some of these models—notably, general equilibrium models (GEMs)—often project all actors as economically rational and judge the economy as already deploying assets in an optimal way. As the economics literature clearly shows, this is rarely the case due to factors such as bounded rationality and imperfect information (Bowdrey and Hidi, 2022). Yet the premise of rationality can result in models projecting a decrease in growth as a consequence of the transition to clean energy, owing to the (mistaken) assumption that assets have already been utilised optimally and ignoring the possibility of green initiatives actually driving growth. Since climate risk tools are intended to support decision makers, it is important that models provide meaningful insights for corporations and do not leave out critical information.

The potential limitations of climate modelling can be addressed by taking on board the following considerations. On the one hand, climate tool providers should consider fully utilising the latest technologies, including machine learning to address these challenges (Zennaro et al., 2021). AI solutions, as already discussed in Section 2.3, have been relevant in the design of climate risk tools that account for risk interaction. They show the potential of filling potential data gaps and can also help identify exposed assets and rate their vulnerability. In addition, they can offer insights by comparing large amounts of data to detect potential trends and correlations.

In addition, tool creators should stay abreast of evolving scientific insights and embed more accurate assumptions. This is especially the case in light of recent advancements such as the IPCC's AR6's narrowing down of climate sensitivity metrics and its insights around the amplifying effects of feedback loops such as cloud feedback and "bio geophysical" and "bio geochemical" feedbacks (Forster, 2021). Climate risk tool developers must therefore pivot towards innovation and adaptability, ensuring that their offerings are both relevant and reliable.

Understanding the limitations of current climate modelling should not be used as an excuse for inaction. As Maslin & Austin (2012) indicates, greater knowledge and improved models will always be desirable, but they are not a panacea for political and public reticence to action on climate change. Challenges in assessing climate risk should not deter efforts towards disclosure or diminish transparency. Despite the uncertainty on the actual estimates, the weight of scientific evidence continues to remind us of climate change's potential to trigger irreversible impacts.

As Trust et al. (2023) note, incorporating more precise estimates of asset impairments into the balance sheets of financial institutions could be a key way for them to effectively act on the results of climate models. Rather than solely relying on models for risk decision-making, it may be beneficial for these institutions to disclose climate risks more openly, thereby enabling the market to make informed decisions with access to transparent data.

3.4 AI and ML application in climate risk assessment: potential benefits and risks

Advanced methodologies including AI and ML show promising potential as discussed in Section 2.3. However, despite emerging economies being an indispensable driving force for related research and innovations, access barriers exist in some regions. To reap the most from this rapid field of development, several obstacles to application and concerns need to be addressed.

The growing focus on AI and ML methods in climate risk assessment could signify a crucial evolution in risk assessment strategies, promising more accurate and dynamic insights into the diversity challenges posed by climate change. These technologies harness the vast and varied expanse of spatial and temporal big data for environmental applications as well as for climate due diligence. As such, they can inform the development of climate risk assessment, particularly in identifying how the complex interplay of factors driving climate risks is approached and analysed. Understanding these potential benefits, organisations and leaders are beginning to turn to AI to fight climate change (Maher et al., 2022).

Some emerging economies are actively driving the development of AI and ML research, positively contributing to the potential use of these technologies to inform climate risk assessments. Iran, China, India, and Malaysia are among those spearheading research in this area, likely driven by their heightened vulnerability to physical risks (Zenarro et

al., 2021). This could contribute to the development and application of AI-empowered climate risk solutions that more closely reflect the unique circumstances and characteristics in these regions.

However, countries in the Global South could be less well-positioned than other regions when it comes to the development and adoption of such solutions. Firstly, infrastructure challenges affecting countries in the Global South could impede both the advancement and application of AI and ML-empowered solutions and models. Limited access to electricity and internet access in some regions (World Bank, 2023) remains an issue despite significant progress in recent years. Secondly, digital skills and capacity-building are limited in the Global South, which contributes to a 'digital divide' (Opp, 2023). These circumstances create barriers to the adoption and effective application of AI and ML climate solutions in these countries. Such gaps in capacity-building and technical training must be filled.

Despite the potential of the deployment of AI in climate risk assessment, there are also challenges associated with its use when combating climate change (Sirmacek & Vinuesa, 2022).

Organisations still seem nervous about integrating new digital technology. While 87 per cent of respondents to a recent survey say that they believe AI represents a helpful potential tool in the fight against climate change, only 43 per cent envision using it in their own climate efforts (Maher et al., 2022). This caution is caused by a combination of factors, including insufficient access to AI expertise, limited tool availability, and reservations about data and analyses yielded through AI-only models.

Another set of challenges stem from concerns of the possible implications from the use of AI and ML technologies. One common concern relates to privacy. AI-based climate tools normally **require internal data input from tool users to function optimally**. Once collected, the storage of such expansive datasets can pose risks. Some common concerns include where the data are stored, who has access to them, and whether the specific data used by these tools are obtained with consent and are anonymised to protect the identities and security of individuals and groups. Besides, AI models do not always **provide clear insight into how they derive particular conclusions**. This lack of transparency can make it challenging for stakeholders to trust the predictions or recommendations made by such tools, especially in high-stakes areas like climate change mitigation. As illustrated in Figure 21, a recent survey by UNEP FI reveals that 35 per cent of financial institutions consider AI only as a complementary tool for climate risk management. Further, 29 per cent are concerned about the potential uncertainties and risks that these algorithms might introduce. Community-based open-source AI, which adhere to the policies non-profit open-source "foundations" such as the Linux Foundation, can help address these issues by providing full visibility not only of the maths and code but also those who developed them.

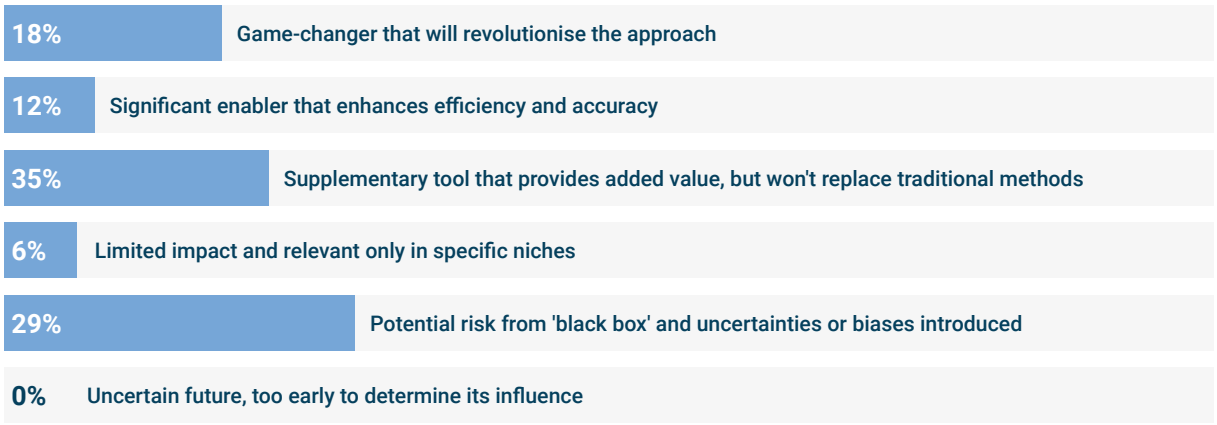


Figure 21: Banks' perspectives on the role of AI in the climate stress testing and risk management process, (UNEP FI, 2023).

In addition, AI and ML systems can be vulnerable to **security-related risks and cyber vulnerabilities**, including data breaches and hacking. As mentioned earlier, AI and ML systems tend to hold and process vast amounts of data for the purposes of both model training and analysis. Moreover, AI and ML models are often interconnected to other systems, including internal personal and business data, as well as external data sources. These could be potential risk drivers. In addition, these technologies are dynamic fields operating in a fast-paced and constantly evolving environment. As such, the technological development itself could potentially outpace security measures and governance frameworks, leaving gaps that could be exploited. This could present a particularly alarming issue given that 'cyber insecurity' already ranks among the top 10 global risks identified by WEF in its aforementioned 2024 report (Figure 1).

Another potential challenge relevant to AI and ML technologies derives from **potential misinformation and disinformation**, which tops the global risks identified by WEF. Most notably, there have been discussions surrounding the concept and possible implications of AI and ML-related 'hallucinations' (Weise & Metz, 2023; IBM, 2024; Google, 2024). This phenomenon pertains in particular to large language models (LLMs) and NLP, which are involved in generative tasks based on deep learning. The term refers to a possible scenario where these systems yield results that contains misinformation or disinformation. Potential examples range from deviations arising from factual inaccuracies, logical inconsistencies, or even potentially the creation of fabricated content. It is feasible that text could be generated that is grammatically correct but logically inconsistent or unrealistic, for instance. These errors could arise due to limitations in the model's training data being incomplete or biased, resulting in the perception of inaccurate patterns or trends.

Meanwhile, debates over the **potential implications of AI technologies ingraining or even worsening inequalities** should also not be ignored. The International Monetary Fund (IMF) warns that AI could affect 40 per cent of jobs globally, disproportionately impacting advanced economies with about 60 per cent of jobs in the USA and United Kingdom at risk (Milmo, 2024). While AI might enhance productivity in some high-skill roles, it threatens to exacerbate income disparities, particularly as higher-wage earners in AI-complementary jobs could benefit more. This could widen the income gap as lower-skill jobs could face displacement. These potential social-related risks associated with AI give grounds for the call of robust social safety nets and retraining programmes.

Addressing the aforementioned challenges requires **multiple action points from tool vendors, data scientists, and the public and private sectors, among other stakeholders**. These complications could be potentially resolved by improvements in the general data available and in model training. However, joint efforts are still required to resolve other issues, particularly in addressing some of the regional differences in the development and adoption of AI and ML-enabled models for climate risk assessments, mitigation, and adaptation.

Increased investment and support for climate risk research in developing markets are pivotal for improving the general data available for analysis and model development. There are **private and public sector collaborative initiatives** that can assist AI and ML development and adoption across the world, including in the Global South, through capacity-building for digital and data skills as well as data access improvements. Examples include the 'AI Innovation Grand Challenge' launched by the UN Climate Change Technology Executive Committee and Enterprise Neurosystem (UNFCCC, 2023). Microsoft has also established an innovative collaboration with the Nigerian government aiming to accelerate digital transformation in the country (Microsoft, 2021). These interventions can guide applications in regions severely impacted by climate change and open doors to market opportunities in these areas. Additionally, tool vendors could also consider actively engaging with local stakeholders from emerging markets for their insights, ensuring tools are both locally relevant and globally effective. This is crucial as developing countries are feeling the disproportionate effects of climate and solutions are needed rapidly. By collaborating with global organisations, universities, and think tanks, climate tool providers can pool resources and knowledge in order to develop solutions tailored for various regions.

3.5 Elevated ESG risk factors and the need for comprehensive environmental risk assessments

It is widely recognised that as long as GHG emissions remain externalities to industrial production and profits, controlling GHG emissions or the resulting temperature rise through free-market mechanisms will remain challenging. Similarly, the treatment of natural resources as 'free' by many industries has led to a lack of proper accounting for the costs of transforming these resources into marketable goods and services (IISD, 2021; SEEA, 2024). The impact of environmental degradation on business practices that rely on the fertility, health, diversity, and synergies of the environment is becoming more evident. While some corporations report on environmental restoration or preservation efforts, these activities often pale in comparison to the implicit value of ecosystem services and nature-based solutions that are typically not reflected on corporate balance sheets.

Thus, the climate risk tool market finds itself at the intersection of pivotal business decisions and environmental responsibility. In this context, there are instances where climate change is viewed through a partisan lens, leading to potential uncertainties relating to climate disclosure regulatory requirements, resource availability, and the incorporation of environmental aspects into business strategies.

Limitations of ESG metrics: The ESG framework, which seeks to encompass a company's overall impacts, has seen extensive debate and discussion regarding its methodologies and interpretations. Such shifts become evident when observing specific instances in the financial world. For example, in May 2022 the S&P 500 ESG Index excluded Tesla (a leading electric vehicle producer) while retaining ExxonMobil (a major fossil fuel company). This oddity arose partly because some ESG ratings compare companies within the same industry and may not always account for Scope 3 emissions (Lyon, 2022). Furthermore, the practice of encompassing diverse characteristics—from labour practices and carbon pledges to diversity trainings and human rights—into singular ratings can potentially create opportunities to game the system. For instance, there are cases where some tobacco companies have received high ESG scores because of their board diversity and social justice efforts, despite their negative health and environmental impacts.

Further compounding the complexity is the nascent state of the regulation of the ESG ratings market. As it continues to develop, investors have expressed concerns primarily about the lack of standardisation and transparency in the ratings. While there are movements in a few countries to regulate ESG ratings, including in the EU, the United Kingdom, Japan, and India, these remain the exception (Capital Monitor, 2023). A recent survey finds that around 88 per cent of investment professionals still incorporate ESG ratings in their decision-making processes; yet potential misinterpretations can influence how climate-related data are perceived and utilised (Tayan, 2022). Notably, SEC examiners are downplaying ESG investing as a focus when inspecting firms for compliance with agency rules after years of listing ESG as a priority. In its 2024 Division of Examinations priorities released in October 2023, for instance, the SEC made no direct reference to ESG. This is despite its listing ESG as an examination focus in its previous three annual reports (Bloomberg, 2023). S&P also dropped ESG numerical scores from its debt ratings in August 2023 due to investor complaints about the feasibility of representing ESG factors as numbers. In addition, it included ESG reporting in a qualitative, as opposed to a quantitative, form (Temple-West, 2023).

Since these publications reflect or influence the views of certain decision makers in the finance sector, vendors should ensure that they are flexible in their approach. Being prepared for market changes that stem from evolving regulatory requirements and changing stakeholder demands is critical to staying ahead and remaining relevant. Providers should offer tools that provide comprehensive understandings and build reliability with decision makers. Further, any shifts in data presentation or methodology need to be communicated with clarity.

Enhancing the social dimension in ESG analysis: The social lens of ESG assesses how a company manages its relationships with its workforce, the societies in which it operates, and the political environment. However, quantifying and understanding these social undertakings can prove challenging for financial institutions. A case in point is the area of diversity, equity, and inclusion. While companies frequently disclose metrics like gender percentages within their workforce or on their boards, such numerical representations form only part of the broader narrative. Relying solely on such quotas can oversimplify the concept of diversity, equity, and inclusion. To get a fuller picture, investors require more detailed information, such as mobility data for women across the

organisation. They also need to see how the company performs on broader diversity, equity, and inclusion measures, such as race, sexual orientation, age, and disability (JP Morgan, 2022).

In the context of climate change, the significance of social aspects cannot be overstated. The 'S' in ESG is pivotal to ensure a just and equitable climate transition, thus ensuring climate action addresses both mitigation and adaptation in ways that are as fair and inclusive as possible, leaving no one behind. Yet, a survey by consultancy firm BCG highlighted some striking disparities. While 90 per cent of respondents believe that social considerations are pivotal in climate actions, for instance, a mere 31 per cent found them to be influential in actual decision-making behaviours (BCG, 2023). As Figure 22 indicates, the 'Just Transition' concept can encompass a wide spectrum and can draw in many related topics. It therefore needs to be tailored to the specific contexts of each region and sector, and must be inclusive of all stakeholders — namely, affected communities, businesses, workers, and vulnerable populations (UNEP FI, 2023). Hence, achieving an industry-wide consensus remains a work in progress.

Figure 22: Wide range of Just Transition topics, (BCG, 2022).

While some initial work is already underway, there is a pressing need for vendors to develop further specific key performance indicators (KPIs) to effectively measure the social impacts of companies' operations. This would provide a clearer picture of a firm's social footprint and ensure that financial institutions embed social considerations into all aspects of the business that connect to climate, while preventing overshadowing the core nature of a company's operations. Enhanced metrics and tools can play a pivotal role in guiding companies towards a truly inclusive and equitable approach to business practices and can facilitate target setting and progress tracking. OS-Climate's Transition Scenario Analysis open-source modelling project, which is led by Capgemini, is one example of a collaborative initiative in which economists, social scientists, intergovernmental organisations, and NGOs could develop the analytic and decision tools needed for a just transition (OS-Climate, 2023).

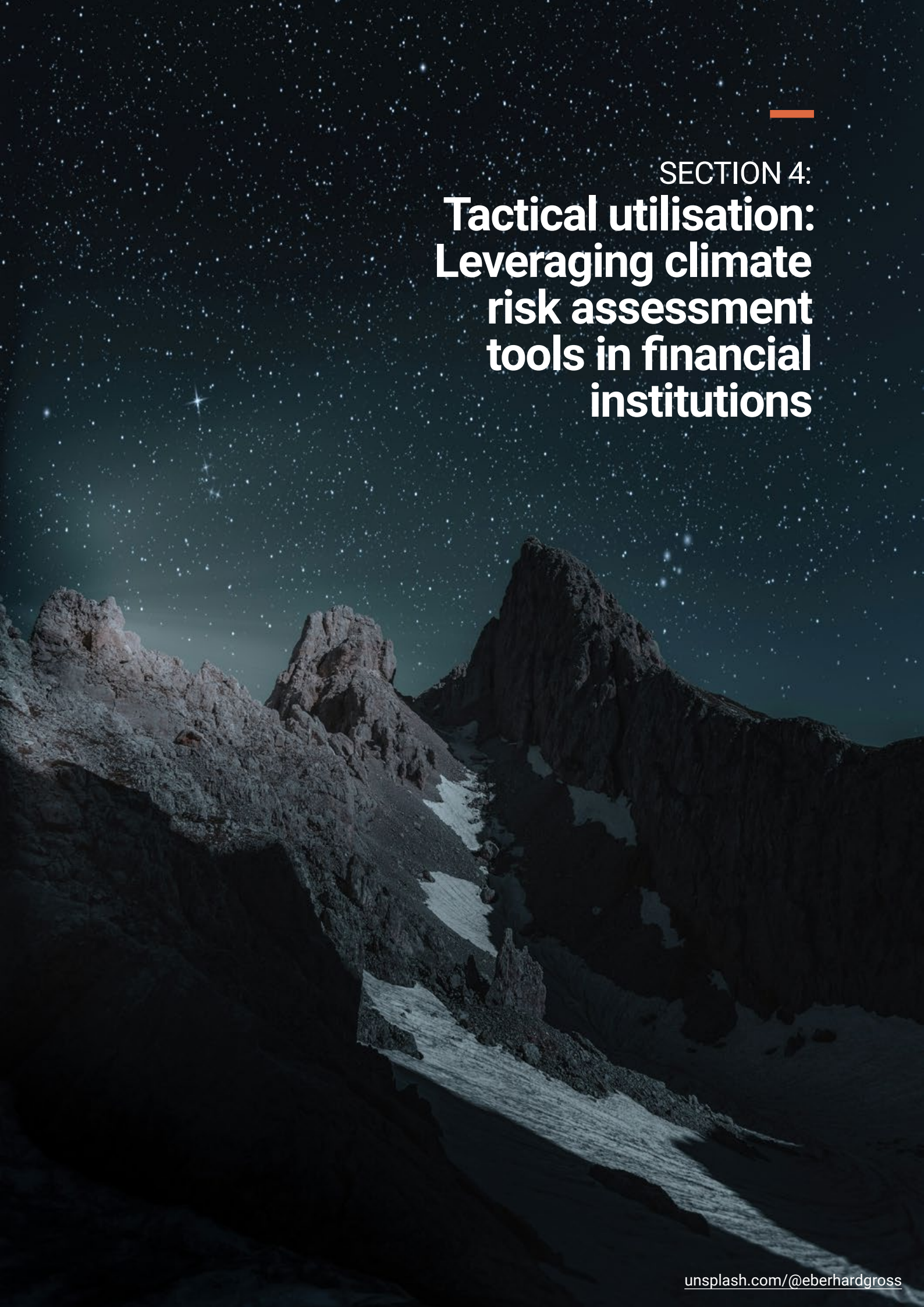
Incorporating nature risks to holistic environmental assessment: According to the Taskforce on Nature-related Financial Disclosures (TNFD), nature is now not only a corporate social responsibility issue but also a strategic risk management issue. Nature loss is closely linked to climate change. Most notable is how changing climate conditions negatively can harm an ecosystem or species. However, some types of nature-related risks can also be unrelated to climate change. Nature-related risk is in many ways a more difficult problem to address than climate change. It has no single unit of comparison, whereas climate-related transition risks could be measured in tonnes of carbon dioxide. Nor does the world does not have a single goal for nature, such as limiting global warming to 1.5°C. This is because the importance of natural elements differs across ecosystems and locations (McKinsey, 2023).

Nature-related risks and opportunities encompass several dimensions. Physical risks refer to physical changes to the planet from the loss of nature, such as the one million species that are currently at risk of extinction. There are also transition risks and opportunities, such as regulations or costs that are introduced because of efforts to mitigate nature loss. Climate risks are now the most significant risks identified by global executives for the next decade. Yet most companies, investors and lenders today do not understand their nature-related dependencies, impacts, risks, or opportunities. As such, they are failing to adequately account for nature in their strategies and capital allocation decisions (TNFD, 2023). Incorporating the nature element into existing risk frameworks is therefore vital for achieving holistic environmental risk assessment and management.

Key differences will require new thinking, data, and tools, and they are vital in helping to integrate nature into risk-management frameworks and disclosure practices. Climate tool vendors, while currently focused predominantly on climate metrics, are uniquely positioned to bridge the gap between nature and climate risks. Tool providers are beginning to respond. Pioneers like AXA Climate, Swiss Re, and PwC GmbH WPG have begun creating solutions that track biodiversity losses. Similarly, Planetrcis/McKinsey has developed a toolkit that translates nature-related transition and physical risks to financial impacts for a universe of listed companies. That said, a significant majority of vendors have yet to integrate nature into their risk assessment frameworks. Potential actions could include: the development of standardised nature-related metrics; partnerships with conservation experts to explore data representation; educational initiatives to enhance user understanding; and customisable tools to address geographically specific nature risks. The imperative now is for vendors to seize these opportunities and craft a more holistic environmental risk landscape. In addition, to respond to the need for holistic risk assessment incorporating environmental risks, UNEP FI has launched its Risk Centre in 2024, aiming to support financial institutions to analyse and manage risks across various sustainability topics.

SECTION 4:

Tactical utilisation: Leveraging climate risk assessment tools in financial institutions



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The Reporting Matters initiative from the World Business Council for Sustainable Development aims to evaluate and improve the effectiveness of corporate sustainability reporting. The general observation is that companies often invest considerable time and money into sustainability reports, but they do not always capture the full benefit of sharing meaningful information (WBCSD, 2023). In this context, climate risk assessment is essential, not just for comprehensive disclosure but also more crucially for informed risk management and strategic decision-making. To achieve this, financial institutions still need to improve their practices when applying climate tool results to decision-making and when integrating tools into governance and risk management systems. On the other hand, it would also be beneficial for financial institutions to foster a deeper level of technical fluency and agency beyond using tools to integrate climate risk and opportunity considerations into strategic planning.

This chapter discusses the potential benefits of harnessing climate tool risk assessment results within a global context. As the world navigates the complexities of climate change, financial institutions are presented with an opportunity to interpret complex data and reflect upon potential strategic avenues and governance adaptations. The section seeks to shed light on how to build a resilient groundwork that is informed and influenced by climate risk assessments. Furthermore, the exploration delves into the potential integration of these risk tools into the established governance and risk assessment frameworks of financial institutions. The section will also touch upon the array of services and support that climate tool vendors might offer in this domain.

4.1 Decision-making grounded in climate risk assessment

In an increasingly volatile climate landscape, astute decision-making lies at the heart of sustainable financial management. Utilising climate risk assessment results effectively is not just about understanding data; it is also about converting these data into actionable insights to fortify financial strategies. Thus, financial institutions will need a structured pathway of decision-making. In addition, climate tool vendors can also provide tailored services and support to play a pivotal role in augmenting this decision-making process.

1. Ensure the trustworthiness of assessment results from the tool

a. Data and Model Validation

Accurate data lay the foundation for actionable insights. Financial institutions should cross-reference data that are generated by tools with trusted external sources and leverage accessible internal data to affirm their accuracy. Furthermore, a thorough review of the underlying models and evaluation methodologies embedded within the tools is crucial to validate the robustness and reliability of the results produced. Ensuring that these models align with financial and scientific rigor provides a solid baseline from which strategic decisions can be made.

b. Assumption Calibration

Assumptions can be calibrated through professional judgments and through alignment with company-specific contexts and realities. This process

enhances the applicability of tool results. It is pivotal that models are fine-tuned to reflect the unique facets that companies operate within, be it industry-specific regulations, geographical considerations, or nuanced market dynamics. In this way, the resulting insights are guaranteed to be genuinely reflective and relevant to the financial institution in question.

2. Ensuring Correct Interpretation and Understanding

Establishing clear pathways for correct interpretation involves engaging with tool vendors for additional support and clarification on results and methodologies. Implementing internal communications and training sessions also ensures that the insights derived are not just well understood but are also translated into informed, strategic actions across all relevant internal sectors.

3. Strategic Decision-Making, Communications, and Reporting

a. Risk Mitigation and Opportunity Amplification in Decision-Making

Integration of a tool's findings into existing risk management frameworks facilitates the minimisation of potential pitfalls while maximising the benefits derived from opportunities identified. Financial institutions must also apply insights from tools in various forward-looking scenarios to gauge potential impacts and inform strategic planning. In this way, they can ensure that identified opportunities are maximised and risks mitigated effectively. Insights derived from tools thereby also serve to refine and optimise existing risk and opportunity scenarios.

b. External Communication

Determining and implementing optimal communication strategies for external stakeholders ensures that all material findings are effectively conveyed to an appropriate extent. Further, aligning the communication of tool results with external reporting frameworks and regulatory requirements enhances compliance and establishes the financial institution in question as a transparent and responsible entity.

c. Internal Communication

Ensuring that results are consistently communicated internally involves the development of standardised reporting formats. This allows for clear sharing of insights and their implications across various internal departments and teams. Consistency in internal communication ensures that strategic decisions are made with a unified understanding of the insights derived.

d. Post-Decision Evaluation and Feedback Loop

Post-decision evaluations provide an avenue for continuous learning and refinement of the decision-making process. Analysing decision outcomes and tracing them back to initial tool results validates the effectiveness and reliability of the tools used, as well as forming a critical feedback loop. This loop serves to perpetually refine the tool application process, optimising it through learnings derived from each iterative cycle of decision-making and outcome evaluation.

In constructing this strategic and structured approach to utilising climate tool risk assessment results, financial institutions enhance their capability to navigate through the intricacies of climate risk management. This helps ensure that the decisions made are both informed and strategically sound.

4.2 Vendor support and services for climate tools

Navigating through the multifaceted realm of climate risk assessments and subsequent decision-making processes, the role of climate tool vendors extends beyond providing software solutions. The breadth and depth of services and support offered by vendors play a crucial role in enhancing the efficacy and applicability of tool-generated insights in the strategic decisions of financial institutions.

Climate tool vendors offer a range of services throughout different phases of engagement. Take Planetrics/McKinsey, for instance: they begin with an onboarding phase that encompasses an introduction to their tool, the process of data input, and the uploading of portfolios to their solution. As financial institutions progress into the analysis phase, most vendors showcase flexibility in their offerings. They provide customisation options in the assessment process. These include creating bespoke scenarios to using proxies for bridging data gaps, adjusting hazard or risk scopes, refining analysis levels and resolutions, delving into individual asset risks, and even tailoring services for niche sectors like unlisted companies or SMEs. Moody's also recognises the importance of technical partnership for customers when adopting climate risk analytics by offering advisory services for onboarding and software integration and model validation.

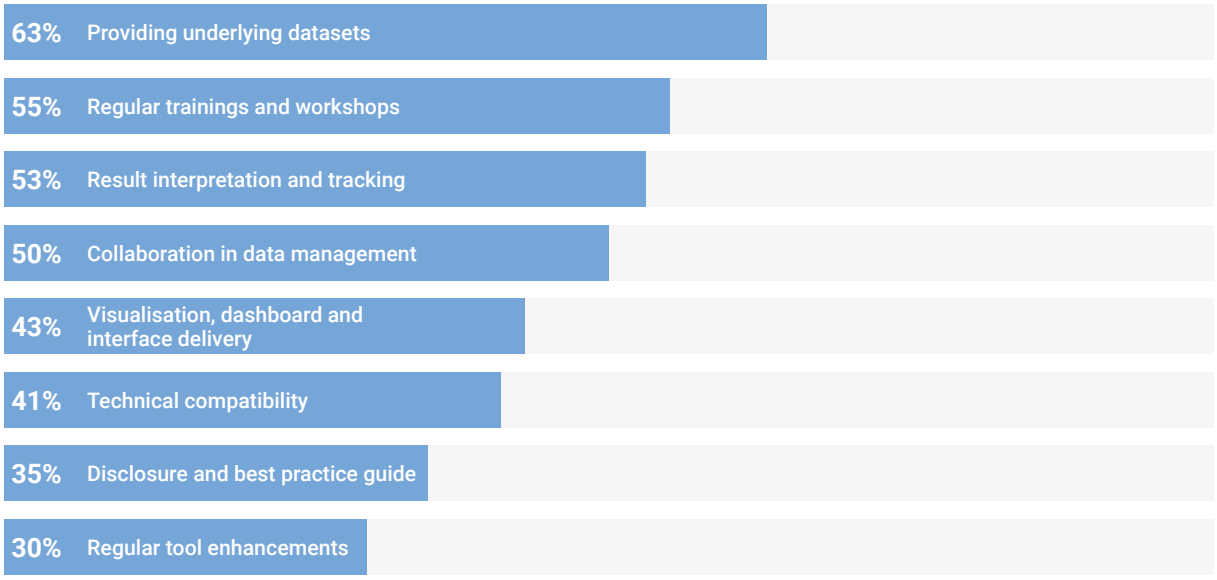


Figure 23: Ranking of prioritised services and support from climate tool vendors, (UNEP FI, 2023).

Once financial institutions are armed with assessment results, many tool providers like South Pole, WTW and PwC GmbH WPG step in with consulting services, focusing in particular around result interpretation and tracking. Professionals can provide a broad range of support from answering questions about SaaS portal to orchestrating customised engagements. These consulting services by vendors can also support financial institutions in making informed investment decisions, linking to subject expertise such

as risk transfer solutions for managing climate-related risks in line with respective risk appetite. As an example, Munich Re draws on its insurance expertise to offer consultancy services to support financial institutions in measuring and managing physical climate risks. In fact, a UNEP FI survey revealed a marked preference among financial institutions for obtaining the underlying datasets for in-depth discussions and referencing, as Figure 23 presents. Responding to such demands, many vendors are offering these datasets.

The XDI Climate Risk Hub

The XDI Climate Risk Hub provides world-leading physical climate risk analysis at your fingertips, so you can access the information you need, when you need it.

API

Allows third parties to centrally and seamlessly integrate our climate risk solutions so that they can understand & report on the physical climate risks associated with a location, asset or portfolio of assets on their own.

Globe

XDI Globe allows you to review your climate impact risks using a spatial interface, from a general area view down to an individual asset. This enables an easy overview, quickly highlighting areas at risk from each or all hazards.

EasyXDI

EasyXDI delivers on-demand asset level physical risk analysis to help you more accurately assess the cost of climate change impacts to an existing or planned asset.

Off-the-shelf reports

XDI's standard reports present sophisticated analysis in a simple format suitable for presentation to management and key stakeholders.

Figure 24: Multiple available delivery options, (XDI, 2023).

Additionally, vendors accommodate financial institutions' preferred result presentation formats, such as visual dashboards and user-friendly interfaces, as seen in Figure 24. Vendors can provide different subscription plans with various delivery options covering different functionalities. Besides, tool providers offer real life examples of their use cases spanning from portfolio management, risk analysis, and climate reporting to industry research and supervisory publications for reference by end users. S&P Global & Oliver Wyman's Climate Credit Analytics, for example, has supported the International Monetary Fund's assessment of transition risks, and a scenario analysis and transition risk assessment with Bank of Canada (Oliver Wyman, 2023). Other solution providers such as ICE have also contributed to climate stress testing exercises conducted by regulators, such as the European Central Bank (ECB, 2021; 2023).

On the climate reporting front, many digital solutions can now auto-generate reports aligned with TCFD/ISSB, EU Taxonomy, or the Partnership for Carbon Accounting Financials (PCAF) based on portfolios. This is a feature actively supported by vendors like MSCI, ISS ESG, PwC GmbH WPG, and ICE, which also offer disclosure aids, TCFD/ISSB report generation, and best practice guides. Keeping tools updated and optimised is standard practice. Many vendors further enhance their value proposition by providing training and capacity-building support, either as part of their core offering or for an additional fee. Such features are in line with the services that financial institutions prioritise.

When it comes to engagement and action taking, Morningstar's Sustainalytics offers Global Standards Engagement. This is a separate to which service investors can subscribe whereby Sustainalytics engages with non-compliant companies on the investors' behalf (Morningstar, 2023). ISS ESG also offers proxy voting and engagement services. This allows clients to control their voting policy and final vote decisions, while remaining confident in outsourcing the processing and management portions of the proxy process to vote (ISS ESG, 2024c). In essence, while there is always room for enhancement (as flagged by financial institutions), these services lay a strong foundation for robust climate risk management and decision-making.

4.3 Integration of climate risk tools in financial institutions' governance and risk assessment systems

4.3.1 Significance of climate tools integration

In the evolving global landscape, the integration of climate risk assessment tools into the decision-making processes of financial institutions holds notable importance. Such integration is crucial for financial institutions aiming to effectively navigate their risk mitigation objectives and meet supervisory expectations. Systematic consideration of climate risks can enable financial institutions to proactively address potential vulnerabilities, bolstering their overall financial resilience. As global regulatory environments adapt to the increasing awareness of climate challenges, integrating these tools into decision-making becomes beneficial for financial institutions as they seek to align with emerging regulatory requirements. Beyond regulatory alignment, there is an inherent value in strategically harmonising operations with broader sustainability goals. Such harmonisation not only reflects a commitment to environmental well-being; it also underscores the symbiotic relationship between ecological health and economic stability. Integration can also provide financial institutions with a unique positioning in an increasingly competitive market, showcasing them as entities attuned to both current and long-term global challenges. Figure 25 illustrates how providers like Moody's deliver integrated solutions that span the entire cycle of risk management and decision-making for their clients. Planetrics/McKinsey's PlanetView also comes with flat file outputs and Application Programming Interface (API), leveraging their experience in integrating with existing bank systems (Planetrics, 2023). Similarly, Munich Re's Location Risk Intelligence can be easily integrated into a bank's core processes via an API (Munich Re, 2024). However, it ultimately falls upon financial institutions to take the initiative and determine the extent of their engagement with external climate tool vendors. It is worth noting that tools developed by financial institutions working in community-based, open-source projects could be inherently designed and developed for the purpose of integrating the needs of these organisations' use cases, such as credit analysis or loan origination.

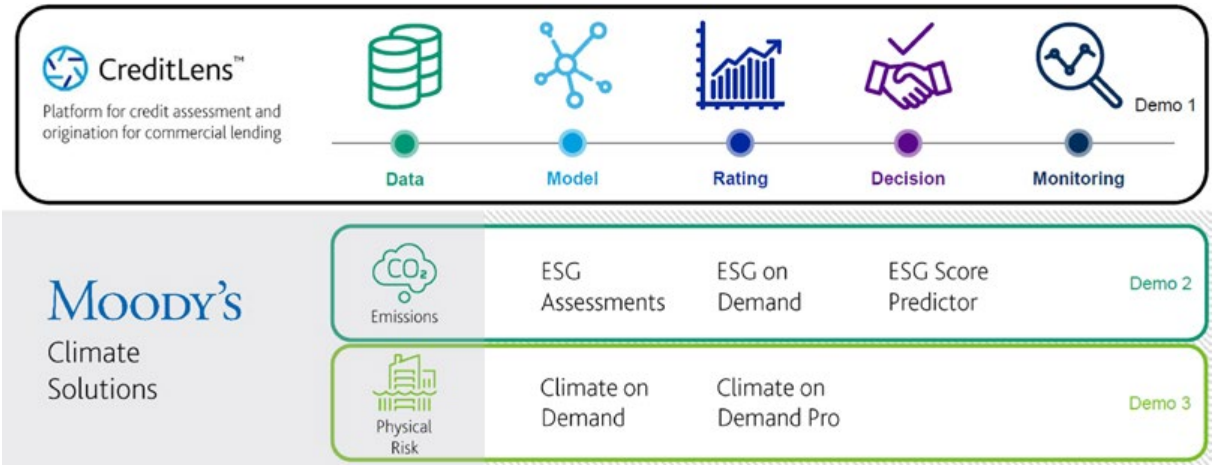


Figure 25: Moody's integrated climate solutions for commercial lending, (Moody's, 2023b).

As displayed in Figure 26, UNEP FI's survey also found that financial institutions would choose either to build up internal tools and capability or leverage open-source resources. This is due in part to data privacy and transparency concerns, and in part to the inconveniences arising from integration. Ensuring that these tools are seamlessly woven into their governance and risk assessment frameworks can foster holistic organisational coordination. From the perspective of the UN, it is imperative to acknowledge the importance of this integration in the broader context of global financial governance and the interplay with environmental challenges, with an emphasis on understanding and awareness rather than direct recommendations.

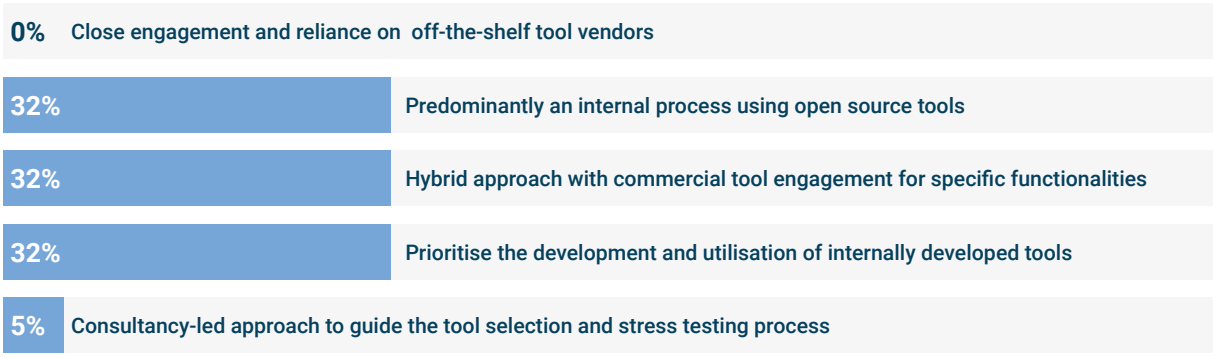


Figure 26: Financial institutions' preference in the usage of climate tools in stress testing process, (UNEP FI, 2023).

4.3.2 Roadmap/blueprint for successful tools integration

4.3.3 Best practices and case study in climate tool integration

This section builds upon the roadmap detailed in Section 4.3.2, showcasing a collection of notable best practices and case studies in decision-making and tool integration, as gathered from research and interviews with financial institutions. These best practices are designed to extend beyond foundational measures, fostering a holistic and effective risk management approach to optimise the use of climate tools.

Best practices:

Accessibility across departments

Make climate tools and their results readily accessible to all relevant departments, such as customer engagement, ESG & sustainability, risk management, legal, and compliance teams

Integration with existing solutions and metrics

Integrate climate tools with current accounting and risk management systems and metrics for ongoing, updated risk assessments

Holistic risk evaluation

Conduct a thorough evaluation of the institution's risk profile, considering the additional implications of climate risks to support effective decision-making

Capacity-building and internal tool development

Begin by assessing open-source data and platforms to pinpoint critical hotspots; then integrate external climate tools as foundational resources, while developing internal capacities and custom tools tailored to the institution's specific needs

Case study #1: Lloyds Banking Group

Lloyds Banking Group's approach to cross-departmental accessibility and utilisation of climate tools is well-aligned with its risk management framework, which operates on a three-tiered, line-of-defence model starting at the functional level. Central to Lloyds' approach is the integration of climate risk analysis into routine business activities. This integration ensures that discussions about climate-related risks and opportunities are a regular aspect of client engagement, especially within the Relationship Managers' interactions with clients. This contributes to the bank's own net-zero ambitions for financed and operational emissions at a group-level by 2050 (Lloyds, 2022). For example, when addressing credit risks, the bank considers climate risks as a core focus within its credit process to ensure appropriate management of ESG risks and opportunities. At portfolio-level, ESG credit integration is approached by focusing on continuous enhancement of internal tools and capabilities, as well as considerations of the policy landscape, alongside the use of external data sources. The bank expects to leverage the outcomes of scenario analysis and expected credit losses when developing lending criteria. Examples include the integration of climate risks within affordability decision-making and enhancements to risk criteria. At counterparty-level, the bank uses a bespoke, qualitative ESG risk assessment tool that focuses on both inbound and outbound risks as part of the bank's regular client engagement. Counterparty-level ESG risk assessments include client-specific questionnaires that assess exposure to, and management of, ESG climate-related risks. The outputs are overlaid with quantitative, sector-level emissions and transition risk data, as well as reputational risk data. This process combines to produce a score reflective of clients' climate impacts and their exposure to climate risks and opportunities.

This then enables Lloyds to gather data and understand the risk profiles of its clients and their portfolios and their sector spread. This helps the bank enhance its ability to help its clients identify and navigate climate-related risks in their day-to-day operations. The integration of climate and ESG risks complements Lloyds' existing credit assessment. Upon identifying areas of concerns, it then engages with clients or takes mitigating actions, such as ensuring that its lending activities remain within its risk appetite and align with its external commitments. The team at Lloyds has also piloted a specialist third-party sustainability tool with a small selection of suppliers. The tool includes insights into supplier environmental management practices, and helps the bank to further understand and inform its supplier engagement approach (Lloyds, 2022). This practice helps financial institutions to remove silos and create cross-functional engagement on climate risk management.

Case study #2: BBVA

BBVA Group has made sustainability a strategic cornerstone, aiming for carbon neutrality by 2050, which encompasses both its operations and the clients it finances. The bank has pledged to mobilize 300 billion Euros for sustainable business from 2018 to 2025, offering clients low-carbon transition support through advisory and financing solutions.

The institution integrates climate change considerations into its risk management framework by incorporating both transition and physical climate risks as factors influencing existing risk categories. The integration of climate-change related risks into the BBVA Group's risk management framework is based on their incorporation into the governance and processes already in place, taking into account regulatory and supervisory trends. As Figure 27 illustrates, climate change risk management in BBVA is based on the risk planning process, which is marked by the defined risk appetite and is specified within the management frameworks that determine its treatment of these risks in day-to-day operations (BBVA, 2024).

Figure 27: BBVA's integration of climate change into risk appetite framework, business strategy and risk management (BBVA, 2024).

Central to BBVA's strategy are robust decarbonisation goals and planning. The bank has set intermediate decarbonisation targets for 2030 in high-emission industries, including oil, gas, power generation, automotive, steel, cement, and coal, with plans to expand these goals to the aviation and shipping sectors. BBVA intends to publish alignment objectives to 2030 alignment targets for the sectors defined in the Net-Zero Banking Alliance's Target-Setting Guide, involving establishing specific objectives for the different sectors that are considered the largest emitters.

BBVA has developed internal tools integrating the management of reduction objectives into daily risk processes. The Sustainability Customer Toolkit, for example, consolidates ESG data from large corporations into a single repository, simplifying access for front-line teams. Additionally, specific tools have been developed to facilitate effective management and compliance with alignment objectives. For instance, the alignment management dashboard uses data provided by the internal calculation process based on the Paris Agreement Capital Transition Assessment methodology to monitor progress on portfolio alignment and reduction targets by sector (BBVA, 2024).

These tools are essential in managing portfolio alignment, aiding in the definition of risk appetite as outlined in the Sector Frameworks. They facilitate the integration of risk considerations, creating institutional synergies. This comprehensive approach ensures that the management is conducted responsibly and sustainably, in line with the Paris Agreement's objectives, reinforcing the institution's commitment to addressing climate change through its operational and financial strategies.

Case study #3: National Australia Bank

The National Australia Bank (NAB) exemplifies a proactive approach to environmental stewardship and risk management through the regular publication and review of its Group Environmental Management Policy. Updated triennially, this policy mandates the incorporation of environmental risk considerations within NAB's comprehensive Risk Management Framework and strategic business planning. To manage the direct and indirect environmental impacts, NAB decided that it must set targets and monitor performance related to operations and business activities in line with best practice and, at minimum, annually review commitments related to the environment and to its supply chain.

In its governance structure, NAB's Credit and Market Risk Committee has oversight of certain financial risks and ESG risks (including those linked to climate and human rights), as well as the Group's environmental compliance and performance. As Figure 28 illustrates, ultimate oversight of sustainability matters resides with NAB's Board. The Board's purview is broad, encompassing climate risks, social challenges such as affordable housing, and engagement initiatives with Aboriginal and Torres Strait Islander communities.

In a stride towards comprehensive environmental risk consideration, NAB is enhancing its approach to understanding and managing nature-related risks, focusing on critical areas such as forests, water, and biodiversity (NAB, 2023). The bank's commitment to transparency and stakeholder engagement is further evidenced by the publication of a Sustainability Data Pack alongside its 2023 annual report. This document offers detailed performance metrics across customer service, employee engagement, community involvement, and environmental stewardship. In this way, stakeholders are in a position to monitor NAB's progress across various ESG dimensions.

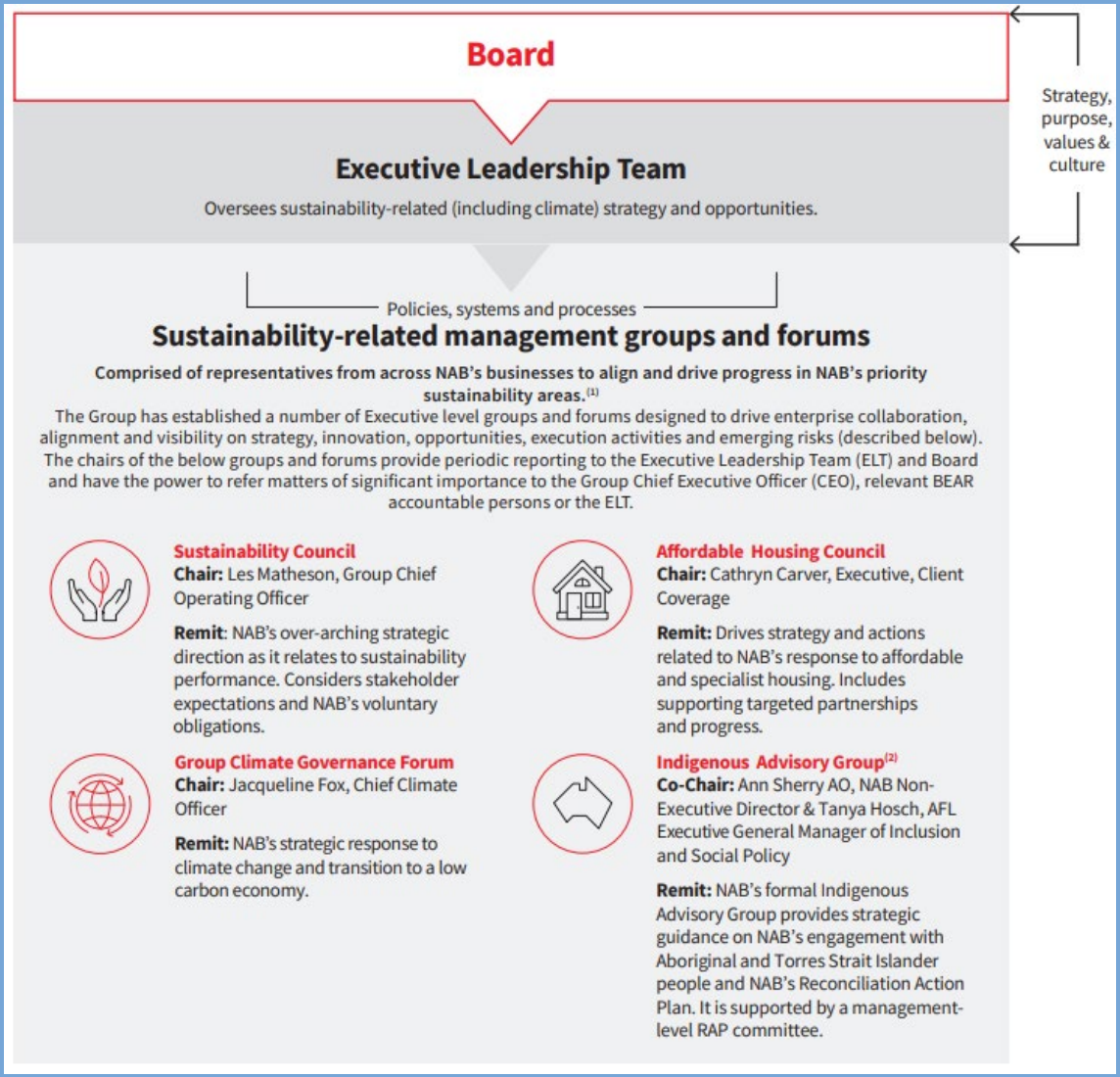
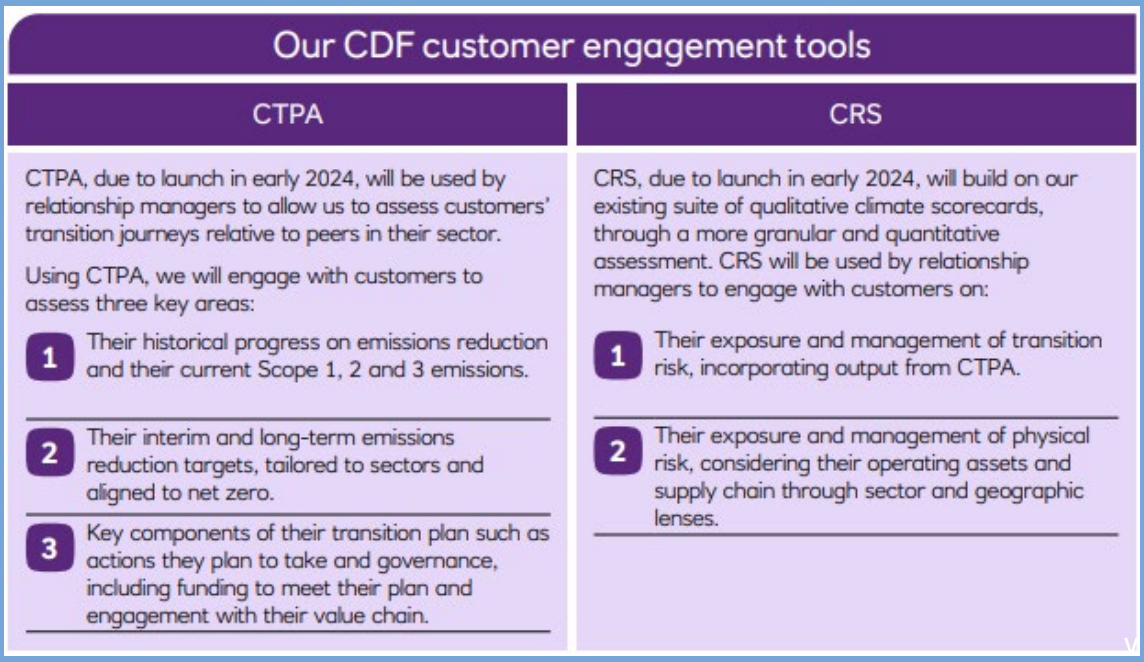


Figure 28: NAB's sustainability-related management groups and forums, (NAB, 2023).60

Case study #4: NatWest Group

NatWest Group has taken a strategic approach to climate change, aiming to support its customers through their transition to net zero. This initiative includes the development of both customer-facing and internal tools designed to facilitate decision-making processes related to climate change.

NatWest's Climate Decisioning Framework exemplifies this commitment, offering tools to both commercial and institutional clients to integrate climate considerations into their operational and strategic planning. These tools are designed to enhance NatWest's engagement with customers on climate issues, complementing existing climate dialogue touchpoints. A significant focus has been placed on developing the Customer Transition Plan Assessment and Climate Risk Scorecards. These tools aim to provide a structured and granular understanding of customers' transition journeys and associated climate risks, as Figure 29 illustrates below.



Additionally, NatWest is in the process of developing an internal carbon management framework aimed at assisting United Kingdom's businesses in managing their future fuel and operational costs and reducing their carbon footprint.

The introduction of these tools has led to a shift in mindset within NatWest. Initially, these tools aim to merely enhance the engagement with customers on climate and understand their transition journeys and climate-related risk in a more granular and structured way. As the financial institution learns over time, the tools are anticipated to allow the group to support customers' transition plans through providing funding, products, and propositions that they may require to develop and implement their transition plans.

Beyond customer-facing solutions, NatWest has also concentrated on enhancing its internal capabilities with the development of scenario analysis tools and advanced climate risk modeling techniques. These are integrated into the institution's risk management processes and are complemented by tools for estimating greenhouse gas emissions across assets under management and aligning portfolios with weighted average carbon intensity metrics. According to its latest climate-related disclosures, NatWest is committed to the ongoing development of metrics and tools for a nuanced assessment and management of climate-related risks and opportunities (NatWest, 2024).

Through its dual focus on empowering customers and enhancing internal processes, NatWest exemplifies how financial institutions can proactively assess and manage climate related risks and opportunities, shaping its business practices to support a sustainable future.

Conclusion

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The climate tools market is dynamic, reflecting the evolving landscape of our planet's climate. Since the release of UNEP FI's 2023 Climate Risk Landscape Report and its accompanying Technical Supplement report, there have been numerous advancements. This 2024 report seeks to capture all of these in a comprehensive snapshot. While not exhaustive, the report delineates the latest progress and outlines the ongoing challenges that financial institutions must navigate for further enhancement and evolution.

At their core, climate data and tools are instrumental in equipping end users to evaluate and address the climate-related risks and opportunities that they face. For financial institutions, the imperative is to extract maximum value from these resources, ensuring that they serve beyond compliance and reporting—informing operational and strategic decisions. Effective integration of these tools is crucial to the comprehensive appraisal, monitoring, and management of climate-related risks and opportunities. To this end, this report not only chronicles the latest developments in the field, but also provides strategic frameworks and best practices for the financial sector's benefit.

As the climate continues to change, so must our research into these phenomena also remain agile and forward-looking. Climate risk assessment tools, therefore, require continual refinement to reflect the dynamic of climate science, nature factors, and policy elements. Looking ahead, the future promises further innovation, with developments that will enable financial institutions to navigate their sustainability journeys more effectively and transition towards a resilient, low-carbon future.

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UNEP Finance Initiative brings together a large network of banks, insurers and investors that collectively catalyses action across the financial system to deliver more sustainable global economies. For more than 30 years the initiative has been connecting the UN with financial institutions from around the world to shape the sustainable finance agenda. It has established the world's foremost sustainability frameworks that help the finance industry address global environmental, social and governance (ESG) challenges. Convened by a Geneva, Switzerland-based secretariat, more than 500 banks and insurers with assets exceeding USD 100 trillion work together to facilitate the implementation of UNEP FI's Principles for Responsible Banking and Principles for Sustainable Insurance. Financial institutions work with UNEP FI on a voluntary basis and the initiative helps them to apply the industry frameworks and develop practical guidance and tools to position their businesses for the transition to a sustainable and inclusive economy.

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