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The 2023 Climate Risk Landscape

Technical supplement

June 2023

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Abbreviations and acronyms

ARA	Absolute Reduction Approach
BaFin	Bundesanstalt für Finanzdienstleistungsaufsicht
CCS	Carbon Capture and Storage
CLIMAFIN	Climate Finance Alpha
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CRR	Carbon Risk Rating
CTVaR	Climate Transition Value-at-Risk
CVaR	Climate Value-at-Risk
E3ME	Cambridge Econometrics' E3ME model based on sector-region modelled datapoints
EAD	Exposure at Default
EBITDA	Earnings Before Interest, Taxes, Depreciation, and Amortisation
ECB	European Central Bank
EL	Expected Loss
ESG	Environmental, Social, Governance
EU	European Union
EV	Electric Vehicle
FI	Financial Institution
FSB	Financial Stability Board
GARP	Global Association of Risk Professionals
GCAM	Global Change Assessment Model
GDP	Gross Domestic Product
GEVA	GHG Emissions per unit of Value Added
GHG	Greenhouse Gas
GICS	Global Industry Classification Standard
GLMs	Generalised Linear Models
ICE	Internal Combustion Engine
ICEVs	internal combustion engine vehicles
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
ISIN	International Securities Identification Numbering
ISS ESG	Institutional Shareholder Services group of companies ESG solutions
ITR	Implied Temperature Rise

LGD	Loss Given Default
Munich RE	Munich Reinsurance Company
NAICS	North American Industry Classification System
NGFS	Network for Greening the Financial System
NZE2050	IEA Net Zero by 2050 Scenario
OFS	Ortec Finance Scenario Sets
PAT	Portfolio Alignment Team
PCAF	Partnership for Carbon Accounting Financials
PCAV	Physical Climate Adjusted Value
PD	Probability of Default
PP&E	Property, Plant, and Equipment
PRA	Prudential Regulation Authority
PRI	Principles for Responsible Investment
PV	Present Value
PVaR	Physical Value-at-Risk
PwC GmbH WPG	PricewaterhouseCoopers GmbH Wirtschaftsprüfungsgesellschaft
RCP	Representative Concentration Pathways
REMIND	REMIND-MAgPIE model from NGFS scenario database
S&P	Standard & Poor's
SBTi	Science Based Targets Initiative
SDA	Sectoral Decarbonisation Approach
SDG	Sustainable Development Goals
SFDR	Sustainable Finance Disclosure Regulation
SSP	Shared Socioeconomic Pathways
TCAV	Climate-adjusted Value for Transition Risks
TCFD	Task Force on Climate-Related Financial Disclosures
TVaR	Transition Value-at-Risk
UNEP FI	United Nations Environment Programme Finance Initiative
UNFCCC	United Nations Framework Convention on Climate Change
VaR	Value-at-Risk
WACI	Weighted Average Carbon Intensity

List of definitions

The following list of definitions has been created by our team to provide a clear and consistent understanding of the terminologies used in this report. We hope these definitions will help harmonise the understanding of key concepts and terms used throughout the paper.

Absolute carbon footprint	Absolute carbon footprint refers to the total amount of greenhouse gas (GHG) emissions produced by an organisation, product, service, or an individual over a specific period of time. It is a measure of the exclusive total amount of emissions of carbon dioxide (CO_2) or CO_2 equivalent (CO_2e) that is directly and indirectly caused by an activity or is accumulated over the lifecycle stages of a product. The GHG Protocol gives GHG emissions scopes: Scope 1 covers emissions directly generated by reporting organisations; Scope 2 covers indirect emissions from purchased energy and utilities; and, Scope 3 covers all other indirect emissions from an organisation's value chain (IPCC, 2022).
Carbon intensity/ Emissions intensity	Carbon intensity, or sometimes referred to as emissions intensity, is the ratio of GHG emissions as a result of using one unit of energy in production (World Bank, 2023). This metric is often expressed relative to a specific business metric, such as production output or financial performance of the company in CO_2e (e.g. tonne CO_2e per unit of product produced or value added). This metric is used as an indicator of the carbon efficiency of an economy, sector, or company, and enables the comparison of carbon emissions for companies of different sizes. For different sectors, either absolute carbon footprint (in CO_2e) or intensity metrics are recommended (Science-Based Targets Initiative, 2020).
Carbon price	Carbon price is a cost applied to carbon pollution to encourage polluters to reduce the amount of GHGs they emit into the atmosphere. Carbon pricing can take various forms, such as explicit pricing in market-based policy instruments or financial planning (e.g. via introducing or modelling a carbon tax, cap-and-trade system), or implicitly via performance standards (London School of Economics, 2019).

Carbon risk rating	Carbon risk rating (CRR) assesses the climate-related performance of companies, taking into account not only industry-specific challenges and risk profiles, but also considers companies' positive impact. It provides investors with a central instrument for the future-oriented analysis of CO_2-related risks both at issuer and portfolio level (ISS ESG, 2018).
Cumulative returns	The cumulative return on an investment is the aggregate amount that the investment has gained or lost over time, independent of the amount of time involved. The cumulative return of an asset that does not have interest or dividends is easily calculated by figuring out the amount of profit or loss over the original price (Chen, 2007).
Climate Value-at-Risk/ Climate Transition Value-at-Risk	Metrics such as Climate Value-at-Risk (CVaR) and Climate Transition Value-at-Risk (CTVaR) have been developed by climate risk tool providers such as MSCI (2020) and WTW (2022) to capture estimated climate-related financial losses and profits. These metrics built upon the existing concept of Value-at-Risk (VaR) to include data on climate-related physical, and/ or transition risks with economic, sectoral, and company-level data to comprehensively quantify risks, enabling forward-looking assessments on risks and returns.
Expected loss	An expected, loss is the sum of the values of all losses that a company is statistically likely to incur. In general, expected losses are losses that are predicted to arise from loans or from a portfolio of assets with fluctuating or depreciating values. It is typically calculated as the expected value of the portfolio's loss above a certain level of confidence (i.e. quantification based on a certain tail risk) (Kokoska *et al.*, 2017).
Exposure at default	Exposure at default (EAD) is a financial term that refers to the amount of money that a lender or investor is exposed to at the time a borrower or debtor defaults on their financial obligations. It is a measure used by banks and other financial institutions to estimate their potential losses in the event of a default. EAD also considers the value of any collateral or security held by the lender that could be used to recover the debt. EAD is typically expressed as a percentage of the total amount of the loan or obligation and is used in conjunction with the probability of default (PD) and loss given default (LGD) to calculate the expected loss on a portfolio of loans or investments (Basel Committee on Banking Supervision, 2003).

Implied temperature rise	An implied temperature rise (ITR) attempts to estimate a global temperature rise associated with the GHG emissions of a single entity (e.g. a company) or a selection of entities (e.g. those in a given investment portfolio, fund, or investment strategy). Expressed as a numeric degree rating, ITR incorporates current GHG emissions or other data and assumptions to estimate expected future emissions associated with the selected entities. The ITR metric is expressed in a single temperature unit or range that is comparable to widely understood potential climate outcomes (e.g. 1.5°C, 2°C, 3.5°C) (TCFD, 2020).
Loss given default	Loss given default (LGD) is a financial term that refers to the amount of money that is lost when a borrower or debtor defaults on a loan or other financial obligation. It is a measure used by lenders and investors to estimate the potential losses should such a default occur. LGD takes into account the value of collateral or other assets that may be recovered after a default, as well as any costs associated with recovering the assets or liquidating them. LGD is typically expressed as a percentage of the total amount of the loan or obligation and is used in conjunction with the probability of default (PD) to calculate the expected loss on a portfolio of loans or investments (Basel Committee on Banking Supervision, 2004).
Portfolio weighting A	Portfolio weighting A gives every firm an equal weighting within a portfolio.
Portfolio weighting B	Portfolio weighting B gives each sector a unique weighting, which can be seen in the tab subsector in the header.
Portfolio value	Portfolio value refers to the total value of a collection of investments held by an individual or organisation. This can include a variety of different types of assets, such as stocks, bonds, real estate, and commodities. The portfolio value is calculated by summing up the current market value of all the assets held in the portfolio (Eqvista, 2022).
Relative emissions intensity	Relative emissions intensity refers to the comparison of a company's GHG emissions to either sector-specific pathways or a cross-sector pathway (Science-Based Targets Initiative, 2023). Results of the comparison can be used to: (i) benchmark a company's emissions intensity against a specific sector or cross-sector emissions intensity; and (ii) calculate near-term and long-term emissions reduction targets for net-zero transition plans.

Temperature alignment	Temperature alignment refers to the alignment of an organisation's or portfolio's emissions reduction goals with the level of decarbonisation required to limit global warming to a specific temperature target, such as the Paris Agreement's goal of limiting global warming to well below 2°C. This is basically the other side of the same coin as the ITR. Temperature alignment can include setting emissions reduction targets that are in line with the level of decarbonisation required to limit global warming to this target, as well as taking into account the potential physical risks and stranded assets caused by climate change (Baringa, 2021).
Probability of Default	The probability of default (PD) is a financial term that refers to the likelihood of a borrower or debtor defaulting on their financial obligations, such as failing to make timely payments or not repaying a loan at all. It is a measure used by lenders and investors to assess the risk associated with lending money to a particular individual or company. The probability of default is typically expressed as a percentage and is based on a range of factors, including the borrower's credit history, financial condition, and other relevant risk factors (Basel Committee on Banking Supervision, 2004).
Value-at-Risk	Value-at-Risk (VaR) is a metric used to estimate the potential loss on an investment portfolio over a given time and at a given level of confidence, useful for cross-comparison across different types of investments (GARP, 2022). VaR is typically expressed as a dollar or currency amount. It is calculated by analysing the historical performance of the portfolio and identifying the worst-case scenario that has a defined probability of occurring. For example, a VaR of USD 1 million at a 99% confidence level means that there is a 1% chance that the portfolio will lose more than USD 1 million over the given time period (Holton, 2012).
Weighted Average Carbon Intensity	Weighted Average Carbon Intensity (WACI) is a metric that calculates the average carbon intensity of a portfolio, index, or basket of assets. It is similar to the carbon intensity metric, but it takes into account the relative weight of each asset in the portfolio. The WACI is calculated by multiplying the carbon intensity of each asset by its weight in the portfolio, and then summing up these products. This gives an overall carbon intensity of the portfolio that reflects both the average carbon intensity of the assets and their relative importance in the portfolio (TCFD, 2020).

Executive summary

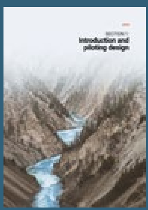
The technical supplement to the 2023 Climate Risk Landscape Report is a comprehensive analysis of climate risk assessment outcomes from multiple vendors. The report presents a comparison of vendor results based on a harmonised input of factors, offering financial institutions valuable insights into assessing the impact of a transition to a low-carbon economy on their counterparties' creditworthiness. The supplement provides insights into various transition and physical risk metrics analysed by vendors, such as Climate Value-at-Risk (CVaR), Climate Transition Value-at-Risk (CTVaR), cumulative return, implied temperature rise, green and brown share, carbon performance analytics, physical risk score, physical Value-at-Risk (PVaR), and expected loss.

The report also highlights the challenges of comparing results obtained from different climate tools, even when assessing the same metric, which emphasises the importance of comprehending the assumptions of each tool. Understanding the underlying assumptions and metric definitions used in climate risk assessments is vital for accurate interpretation of the outcomes. For that, it is crucial for firms to be informed consumers and understand the assumptions made by each tool.

The analysis conducted in this report is based on UNEP FI's dummy portfolio, which was constructed to harmonise the input factors and ensure a multi-asset analysis. The results are consistent with the dummy portfolio being exposed to significant economic value losses due to increasing transition risks and physical hazards arising from climate change, under the modelling assumptions and parameters and data used. Evidently, the portfolio is misaligned with the target of limiting global warming to 1.5°C by 2050. The report stresses the importance of ensuring the long-term resilience of the portfolio, for which financial institutions must consider both transition and physical risks, as well as the adaptive capacity of their assets and counterparties. Common metrics offered by tool providers include economic value outputs such as Value-at-Risk (VaR) and expected loss, as well as indirect measures such as temperature alignment scores and physical hazard scores. The report identifies data availability as a significant challenge for vendors in delivering more precise and comprehensive analytics, and various strategies are employed to address data gaps.

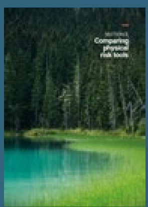
The report's key observations from financial institutions are the need to customise climate risk assessment metrics based on their input (such as the vulnerability score) to tailor the results to their specific risk profile and make more informed decisions. Additionally, there is an urge for a more in-depth discussion about whether to consider average risks or tail risks in institutions' risk assessments and reporting. Comparing results within a sector and across industries is also seen as a valuable feature, and financial institutions are keen to see expanded functionalities in this area. In addition, financial institutions not only assess physical risks but also evaluate future mitigation actions, such as reducing emissions, as well as adaptation measures, in order to gauge their potential impacts on their portfolio. Likewise, it is crucial to consider secondary risks like the impact of bushfires on air quality, health, jobs, and income sources. To facilitate climate change assessments, it is necessary to standardise the procedure and presentation of results.

This technical supplement provides financial institutions with valuable technical insights and tools to manage climate risks in their portfolios. The report is structured into the sections noted below:



Section 1:
Introduction and piloting design

Section 2:
Comparing transition risk tools



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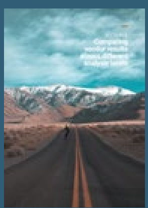

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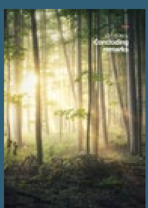


Section 5:
Concluding remarks

SECTION 1:

Introduction and piloting design

1.1 The climate risk assessment market

To help financial institutions (FIs) navigate the expanding climate risk tool universe, the United Nations Environment Programme Finance Initiative (UNEP FI) has conducted a series of thematic research through piloting exercises and developed in-depth publications introducing and comparing physical and transition risk assessment tools for reference by FIs. The goal of various projects is to encourage firms to integrate climate risk analyses into their operations and ensure they are informed consumers of climate tools and data (UNEP FI, 2022). In 2021, UNEP FI published The Climate Risk Landscape report. This gave an overview of the main climate risk tool providers in the market today. It also compared the methodologies these providers deploy, as well as assessing the level of their analysis and providing information about the sectors on which they focus. The Climate Risk Tool Supplement published in 2022 then presented a series of case studies jointly delivered by banks and vendors. This report catalogued the actual experiences from financial users while piloting different tools and informing tool providers on specific areas for their future enhancement.

Stemming from the outlines provided by these two reports, UNEP FI published the 2023 Climate Risk Landscape in March 2023. In this report, UNEP FI presented the latest updates in the climate risk assessment tool market. The report also includes further discussion about advances in different tools and their methodologies, coupled with information about general trends and challenges observed in the market. It concludes with use cases as well as a roadmap for banks to pick and use these tools to fulfil their demands. As the outcomes of UNEP FI's tool demonstration Working Groups, these three publications together serve as a great overview for FIs to start the journey of choosing and utilising commercially available or open-source tools in this market.

Given the rapid evolvement of the climate risk assessment space, there is a regular need to update the reports and further inform their audiences through in-depth research, guidance, and communities of practice. UNEP FI continues to contribute to the progress of the reports by exploring new ways of audience engagement and providing more useful information that FIs are interested in learning about, such as the drill down of tool comparisons. For that, UNEP FI believes that a live database of tools would allow greater access to information on this important and dynamic theme. To that end, UNEP FI is launching a Climate Risk Tool Database in June 2023, with plans to update it on a quarterly basis.

1.2 The Tool Demonstration Working Group of 2022

The 2022 TCFD and Climate Risk Program has been widely supported by international FIs from across the global, including 17 global climate risk tool providers. The Working Group brought together banks and vendors, enabling exchanges and feedback in the research and demonstration of climate risk tools. On the one hand, this Working Group aims to help FIs get to know tool providers worldwide and understand the existing tools for measuring physical and transition risks. Throughout the process, banks learn the latest landscape of climate risk tools for different risks, review the use cases, and understand each tool's strengths and weaknesses to determine which best suits their needs. On the other hand, the tool demonstration exercise aims to enable vendors to interact directly with FIs and showcase their products to potential clients. Tool providers also receive feedback regarding critical gaps or limitations related to their products. This helps them explore how to better address participants' concerns and expectations in future tool developments and releases.

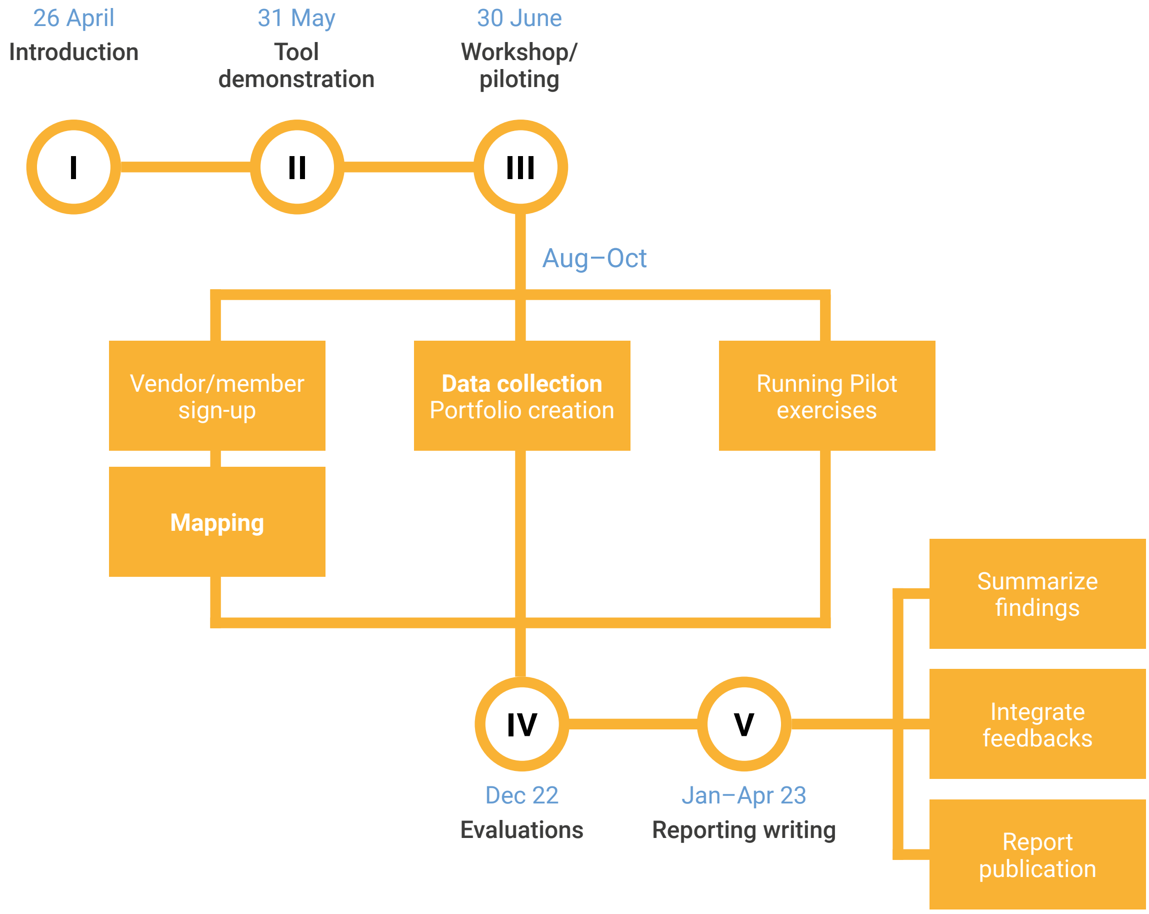


Figure 1: Timeline and milestones of the 2022 Tool Demonstration WG (UNEP FI, 2022)

When creating groups for the piloting exercises, banks were allowed to choose three vendors they wished to learn more about based on their interests and objectives. The piloting stage allowed members to compare the features of various tools and work closely with vendors to enable in-depth discussions about different methodologies for climate risk assessments. At the end of this phase, most tool providers conducted in-depth analysis and delivered their results through workshop sessions. The final composition of the working groups is presented in Table 1 below.

Table 1: Providers and tools demoed in the working group (UNEP FI, 2022)

#	Firm	Tool
1	Blackrock	Aladdin Climate
2	CLIMAFIN	Transition Risk Toolkit
3	Entelligent	SmartClimate Technology
4	Intercontinental Exchange (ICE) (formerly, Urgentem)	Element6 (ICE Climate Transition Analytics Tool)
5	ISS ESG	Climate Analytics suite
6	Moody's/RMS	Climate Solutions
7	Munich RE	Location Risk Intelligence
8	MSCI	Climate Value-at-Risk
9	Oliver Wyman/S&P Global	Climate Credit Analytics
10	Ortec Finance	ClimateMAPS, ClimateALIGN, and ClimatePREDICT
11	Planetrics/ McKinsey	PlanetView
12	PwC GmbH WPG	Climate Excellence
13	S&P Global Sustainable1	Climanomics and S1 Sustainability Analytics Services
14	WTW	Climate Diagnostic and Climate Transition Value-at-Risk
15	XDI	Cross Dependency Initiative

The project entered Phase 4 in December 2022, when UNEP FI started to wrap up the programme by seeking feedback and evaluations from banks and vendors. From January to April 2023, Phase 5 concluded the project by summarising findings and best practices into two reports. The first report, 2023 Climate Risk Landscape Report, provides the latest updates and trends on the climate risk tool market. This second report highlights the procedure of the working group with a primary focus on the piloting exercises and tool comparison.

1.3 Creation and objectives of the dummy portfolio

UNEP FI created a fictional asset portfolio with the FIs that were participating in the Climate Risk and Tool Working Group. Based on their particular interests, participating banks first voted to distinguish the top sectors, regions and asset classes to include in the piloting portfolio. Then they provided UNEP FI with specific companies picked from the defined scopes. The top five requested sectors comprised agriculture, real estate, energy, oil and gas, and transportation. These sector consequently became the focus for the Working Group.

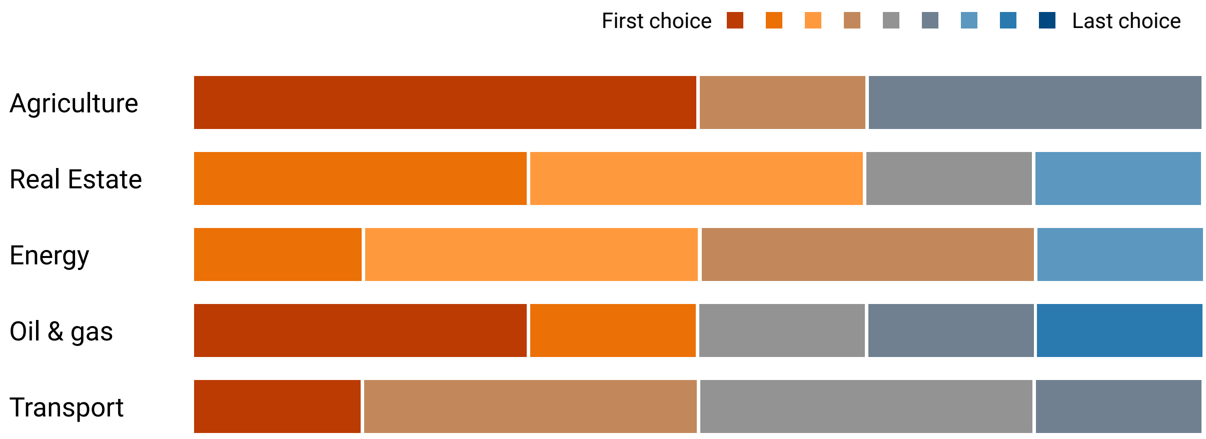


Figure 2: Voting results concerning what sectors to include in the dummy portfolio

The final dummy portfolio holds 358 securities geographically spread across 44 countries. The spread leans towards North America as participating banks tend to have significant asset holdings in Canada (74/358) and the United States (145/358). In terms of asset types, the dummy goes beyond corporate loans and equity, covering mortgage loans, real estate, municipal bonds, and sovereign bonds. It is worth noting that 15 unlisted companies are included in corporate loans. The intention here is to test vendors' ability to cope with imperfect data input. Banks also incorporated five dummy residential properties in Canada and only provided their postcodes to observe how tool providers assess physical risks based on location purely. The data set consisted of input only, and the Working Group did not set any restrictions regarding metrics or templates that vendors could use to run the analysis.

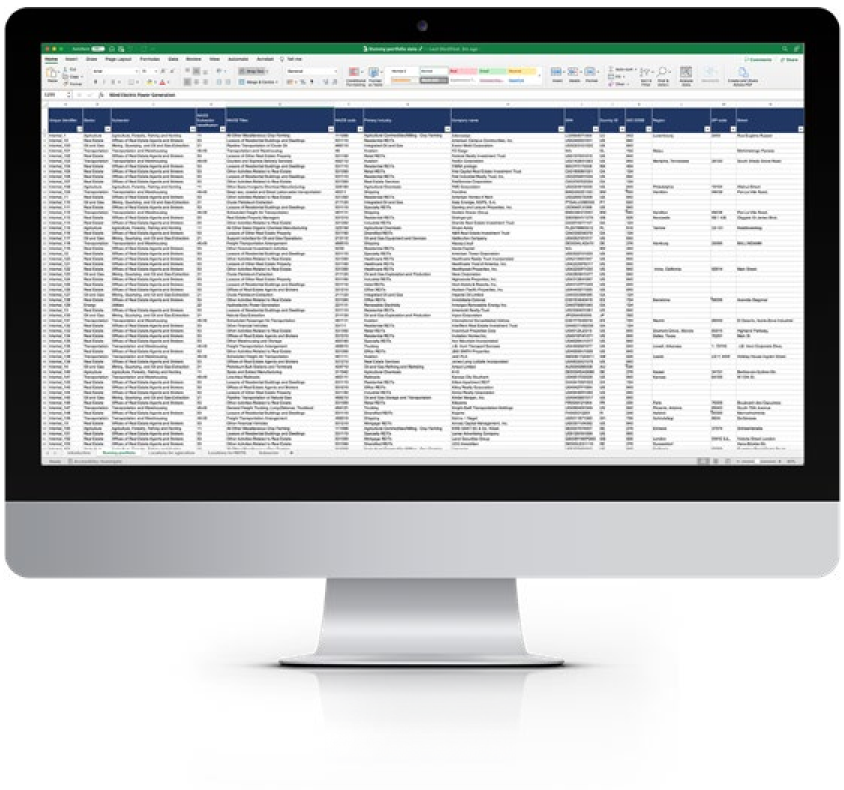


Figure 3: Data attributes in the dummy portfolio (UNEP FI, 2022)

Notably, the dummy portfolio defines two sets of portfolio weightings for this project's exploratory research purpose. Weighting A gives every security within the portfolio an equal weighting for comparison, which also avoids a sector focused risk within the data. Weighting B assigns each sector a unique weighting: agriculture 20%, energy 10%, oil and gas 20%, real estate 20%, transportation 20%, and bonds 10%. Weighting B thus tilts toward emission-intense industries and is expected to endure more severe losses under transition scenarios than Weighting A.

It is the underlying asset locations instead of head offices that determine the risk, especially for issuers from the agriculture and real estate sectors. To address this concern, some vendors also requested data input to assess the physical risks of the agriculture industry and real estate investment trusts (REITs), and mandatory fields include information on location, property type, building size, and construction year. The dummy portfolio provides a list of provinces, states, and countries where agriculture companies have their farming operations and factories. It also identifies the sources where property holding details for real estate companies can be found so as to harmonise the input data and assumptions used by vendors. There were various challenges in obtaining granular data as requested from UNEP FI and the banks, including capacity restrictions and limited availability of the data. As a result, tool providers had to rely on their internal data capacity or use proxy approaches to conduct the exercise and cover the analytics.

The vendors had the chance to give their input regarding mandatory data fields for their tools. Most commonly, vendors request mandatory data fields such as identifier, company name, sector, market cap, and weighting for each entry. The excel file comprises an internal identifier and International Securities Identification Numbering (ISIN) code (if applicable) to trace each security ISIN was the attribute that the vendors were most keen on including. Both the North American Industry Classification System (NAICS) and the Global Industry Classification Standard (GICS) codes are mapped out for sector classification purposes; the former is widely adopted in North America, while the latter is a global classification standard developed by S&P and MSCI. To measure the value of holding and exposure, vendors took the market value as of 2022 for listed companies, estimated 2020 revenue for private companies, and 2020 gross domestic product (GDP) for municipal and sovereign bonds. All values are expressed in US dollars (USD) to lift the impact of exchange rate fluctuations.

Theoretically, the data currently available should enable vendors to conduct a comprehensive climate risk analysis, assuming all data gaps are adequately addressed. This would facilitate a robust examination of both physical and transition risks, as well as scenario analysis, risk quantification and benchmarking. It would also aid compliance with reporting and disclosure requirements. In contrast, gaps in data and capacity often result in potential inaccuracies and necessitate the use of various assumptions to fill in the missing information. Certain intricate insights and strategic considerations may exceed the capabilities of these tools, calling for the expertise of climate risk consultants to provide nuanced understanding and advice. The limitations and desires are further discussed in Chapter 1.4 and Chapter 5.

1.4 Scope and limitations of the tool methodology assessment

Various limitations and challenges that exist may impact the effectiveness of the dummy portfolio exercise. These limitations include: limited coverage of assets; regional concentration or biased selection of assets; lack of comparability due to different metrics and scenarios used; limited capacity and depth of analysis; different time horizons and assumptions used; lack of standardisation; difficulties in providing granular data; and challenges related to data quality and accuracy. These limitations may result in less meaningful or incomplete analysis of certain assets, making it difficult to compare vendors' results.

1. **Results are less comparable due to differing coverage levels across the dummy portfolio from vendors:** Since the dummy portfolio is constructed using data from various FIs, the coverage of assets may be limited. Vendors may not have enough data on some assets or may not cover some regions, leading to a lack of insight into the analysis.
2. **Biases in concentration and selection when creating the portfolio:** When constructing the dummy portfolio, there may be a regional concentration or biased selection of assets, leading to skewed results. For example, if the majority of assets are located in North America, the results may show that North America is the riskiest region for climate risks. This may not be an accurate representation of the risks associated with other regions. A concentration in specific sectors or locations may result in a particular emphasis on certain physical hazards or vulnerabilities.
3. **Variations in metrics and methodologies used across different vendors:** Different vendors may use varying metrics or scenarios for their analysis. Furthermore, vendors may change methodologies for different metrics, adding to the lack of consistency in their results.
4. **Limited capacity and depth due to the pro bono basis of the exercise:** The dummy portfolio exercise is conducted on a pro bono basis, meaning that vendors are not getting paid for their work. This may limit the capacity and depth of analysis that vendors are willing to undertake. Vendors may not offer the full access to their solution and databases, resulting in less comprehensive analysis.
5. **Different time horizons and assumptions:** Different vendors may use different time horizons and base assumptions when analysing the assets in the dummy portfolio. For example, if one vendor uses a longer time horizon than another, the results may be difficult to compare.
6. **The Working Group did not set any restrictions regarding metrics or templates vendors could use to run the analysis:** This lack of standardisation may impact the comparability of output formats.
7. **Data availability was restricting certain sectors:** UNEP FI and banks may have had difficulties in providing the granular data requested by vendors. Tool providers may have had to cover the analytics with their internal data capacity or take proxy approaches to run the exercise. This may have resulted in a less accurate or incomplete analysis of certain assets, limiting the effectiveness of the exercise.

8. **Data quality, accuracy, and mapping challenges:** The fidelity and precision of data in the dummy portfolio exercise could present hurdles for tool providers. Mapping data to NAICS codes can be complex as it requires accurate alignment with industry classifications. Currency exchange rate fluctuations, particularly when converting assets or revenues to USD, can also distort the values of foreign holdings in the portfolio. These factors can lead to inaccurate business representation and valuation discrepancies.

The report does not display climate risk assessment results for sovereign and municipal bonds. This exclusion is not indicative of vendors' expertise or capabilities, but rather a decision to focus on selected aspects of analysis within limited space. Given that the vendors participated in this exercise on a pro bono basis, the provided analytics—such as cumulative returns, absolute emissions, carbon intensity, and physical risk scores—are commendably valuable and comprehensive.

SECTION 2:

Comparing transition risk tools

2.1 General approaches for transition risk assessment

This chapter discusses the general approaches and common input needed in the transition risk assessment process in the context of utilising climate risk assessment tools. It also introduces a few of the most employed metrics by tool vendors that participated in UNEP FI's 2022 Tool Demonstration project. While it may not be possible to understand every technical detail in each approach, this report strives to communicate some critical assumptions in simplified language to ensure that FIs make informed decisions when selecting risk assessment solutions. By way of conclusion, this chapter presents the results of the transition risk assessment for UNEP FI's dummy portfolio. This helps clarify the type of outcomes that users can expect from the assessment, while also permitting an examination of the reasons for receiving different outputs for an identical input portfolio.

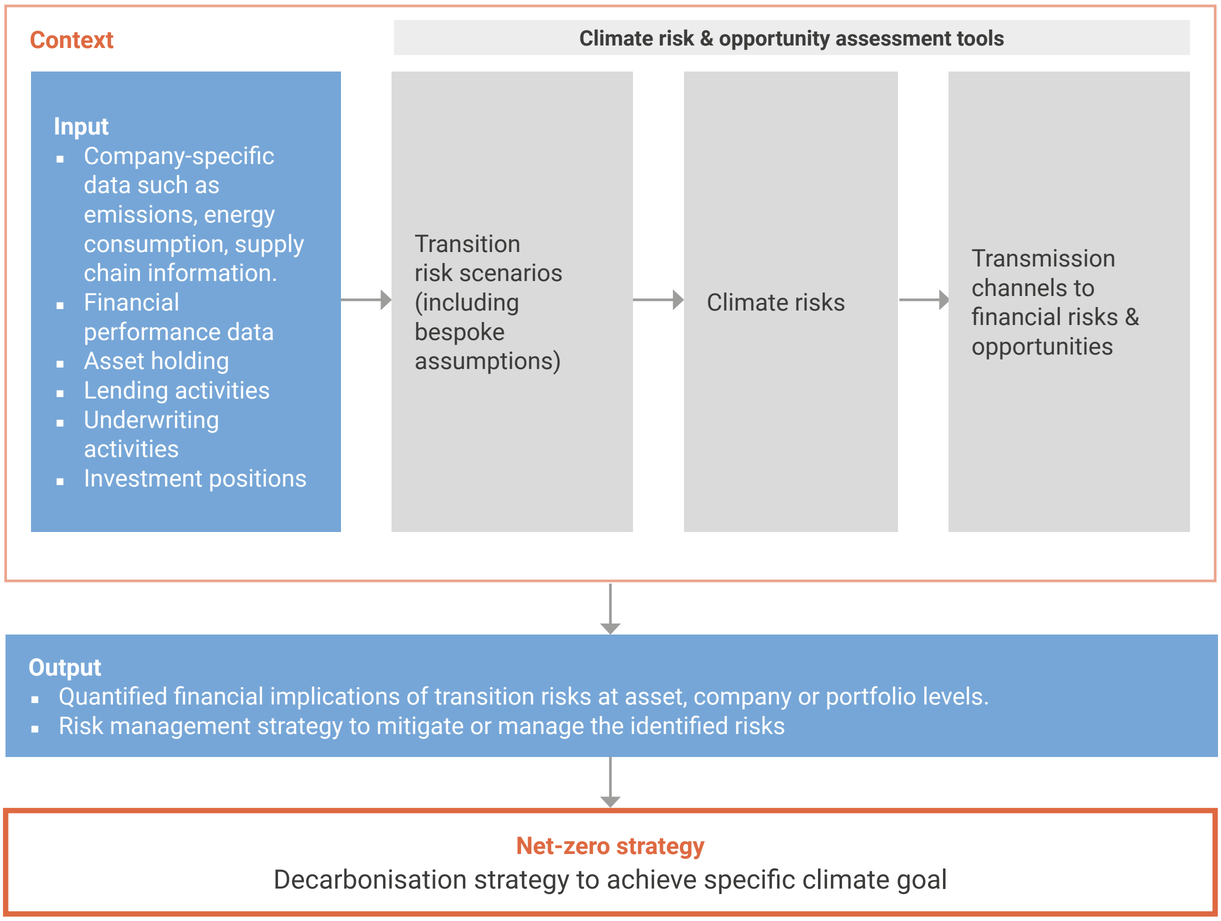


Figure 4: Transition climate risk assessment framework for FIs (UNEP FI, 2023)

Transition risk assessment evaluates the potential financial impacts that an entity or a portfolio may experience due to the global shift towards a low-carbon economy. An illustrative workflow for such an assessment, including possible inputs, processes, and outcomes, can be found in Figure 4. In contrast, a net-zero strategy represents a concrete plan to achieve a predetermined carbon emissions reduction target, effectively neutralising the overall carbon impact of a particular portfolio or company. While not an immediate outcome of a transition risk assessment, the formulation of a net-zero strategy is ideally shaped by the insights gained from the risk assessment. This ensures that the strategy aligns with larger climate objectives.

There are different approaches that can be used to conduct a transition risk assessment. In the context of climate risk assessment tools, some commonly applied attributes include:

- **New statistical techniques-driven analytics**, which use large data sets and machine learning algorithms to analyse the financial performance and operational data of a company.
- **Scenario analysis**, which involves modelling different future scenarios of climate change and assessing the potential impacts of those scenarios on global, national, and regional economies as well as on a company's operations, assets, and financial performance.
- **Stress-testing**, which simulates different 'stress-test' scenarios to evaluate a company's resilience to potential changes in market conditions and in regulations. This goes one step further than conventional scenario-based approaches as it simulates extreme or severe scenarios that may test the resilience of a company's operations and financial performance.
- **Benchmarking approach**, which compares a company's performance and risk exposure to industry peers and best practices.
- **Expert judgment**, which involves leveraging the expertise of subject matter experts to identify and assess transition risks and opportunities.
- **Qualitative approaches**, which consider factors such as management quality and a leadership team's commitment to climate actions and the robustness of climate-related targets and strategies. In addition, it enables a more comprehensive understanding of a company's exposure to transition risks.
- **Heatmapping**, which is a visualisation approach that allows tool users to identify potentially high-risk sectors and regions by representing exposure levels with varying colours.

Transition risk assessments often involve a combination of these attributes. As such, they often complement each other by providing a more holistic view of the risks and how to manage them. The specific approach used will depend on factors such as the size and complexity of the organisation in question, the availability of data, and the required level of detail in the analysis.

2.2 Metrics used to quantify transition risk

Transition risk metrics are quantitative measures that enable FIs to assess the potential financial impacts of the transition to a low-carbon economy on a company's operations, assets, and overall financial performance. These metrics also help firms to identify potential climate-related risks and opportunities.

A series of metrics can be applied to assess transition risks. Among FIs, common activities that affect transition risks include lending to high-carbon sectors, investment in high-carbon assets, exposure to carbon-intensive clients or clients with revenues highly dependent on high-emitting sectors/activities, and the financing of energy efficiency and renewable energy projects or carbon capture and storage (CCS) projects. By combining different transition risk metrics, FIs can gain a comprehensive view of the transition risks they face, and also of the energy transition opportunities they might capture.

The chart below presents some examples of metrics commonly used to quantify transition risks, summarised from PRI (2022) and TCFD (2017):

Table 2: Examples of metrics commonly used to quantify transition risks, summarised from PRI and TCFD

Metric	Common unit	Description
Carbon footprint	Tonnes of CO_2e (tCO_2e)	Carbon footprint refers to the total amount of GHG emissions produced by an organisation, product, service, or an individual over a specific period of time. It is a measure of the exclusive total amount of CO_2 that is directly and indirectly caused by an activity or is accumulated over the lifecycle stages of a product. The GHG Protocol gives GHG emissions scopes: Scope 1 covers emissions directly generated by reporting organisations; Scope 2 covers indirect emissions from purchased energy and utilities; and Scope 3 covers all other indirect emissions from an organisation's value chain.
Carbon intensity/Emissions intensity	Grammes or tonnes of CO_2e per unit of energy consumed (gCO_2e/kWh/ tCO_2e/kWh)	Carbon intensity, which is sometimes also referred to as 'emissions intensity', is the ratio of GHG emissions as a result of using one unit of energy in production (World Bank, 2023). This metric is often expressed relative to a specific business metric, such as production output or financial performance of the company in CO_2e (e.g. tCO_2e per unit of product produced or value added). This metric is used as an indicator of the carbon efficiency of an economy, sector, or company, and enables the comparison of carbon emissions for companies of different sizes. For different sectors, either absolute carbon footprint (in CO_2e) or intensity metrics are recommended (SBTi, 2020).
Carbon price	Dollars per metric tonne of CO_2e (USD/ tCO_2e)	A carbon price is a cost applied to carbon pollution to encourage polluters to reduce the amount of GHGs they emit into the atmosphere. Carbon pricing can take various forms, such as explicit pricing in market-based policy instruments or financial planning (e.g. via introducing or modelling a carbon tax, cap-and-trade system), or implicitly via performance standards.
Temperature Alignment Score	Degrees Celsius (°C)	Assesses the alignment of a portfolio's carbon emissions trajectory with different temperature scenarios. This metric can help investors determine whether their portfolio is aligned with the goals of the Paris Agreement to limit global warming to well below 2°C above pre-industrial levels.
Renewable energy mix	Percentage (%)	The proportion of renewable energy sources in a company's energy mix. It is used to identify the areas of the company's operations that are most exposed to carbon-related risks and to compare a company's performance to industry peers.

Energy efficiency	Ratio in percentage (%) or kilowatt-hours per square meter (kWh/m²)	The energy efficiency of a company's operations and assets, such as energy use per unit of output. It is used to identify the areas of a company's operations that are most exposed to carbon-related risks and to compare that company's performance to industry peers.
Stranded asset risk	Monetary value in US dollars (USD)	The risk that a company's assets will lose value due to changes in regulations, technology, or consumer preferences. It is used to estimate the potential financial impacts of changes in the energy market and regulations on the company's operations and assets.

2.3 General assumptions underlying transition risk tools

Different transition risk tools utilise different assumptions and methodologies. In addition, the data that underlie each tool also distinguishes the tools from each other. Originally compiled by UNEP FI and subsequently reviewed by various vendors who participated in the piloting exercise, the list below outlines these assumptions, and serves as a starting point for climate risk tool users to comprehend the unique parameters associated with a metric before comparing results across different tools or making decisions based on tool outcomes.

Table 3: General assumptions underlying transition risk tools

Factor	Influences on transition risk tools	Examples from dummy portfolio exercise
Reference data set	The reference data set is the data used in the process of building and refining a transition risk assessment tool. It shapes the tool's underlying assumptions, which in turn influence how the tool assesses transition risk. It is important to consider the reference data because the quality and relevance of the data can vary over time.	A tool reference period: 1990–2020

Underlying data	**Data sources:** Data availability and quality may vary depending on whether a vendor is using self-collected or external data to perform its analysis, and whether the validation has changed the data. **Counterparty coverage:** Not all tools will be able to cover every counterparty in a given portfolio, and some may rely on general assumptions or proxies for missing counterparties. Even if two tools have the same percentage of coverage, it is important to note that the counterparties covered by that percentage may differ. This is because not all tools can cover every counterparty in a given portfolio. Additionally, some tools may rely on general assumptions or proxies for counterparties that are not included. **Approach for estimating proxies or covering data gaps** (including where no direct data are available) **Rationale for exclusion of counterparties**, such as a lack of ISIN codes.	**Data source**: Self-collected **Counterparty coverage**: An analysis included 200/358 securities, excluding unlisted equity, sovereign, and municipal bonds. **Approach for data gaps**: When some issuers' emission targets are missing, a tool uses a data hierarchy and estimates the future emissions with either historical emissions or sector-level averages. **Rationale for exclusion of counterparties:** Some of the positions fall outside a tool´s standard coverage universe.

There are also several factors that are subjectively determined by either the tool creators or users. These impact the results of forward-looking transition risk assessments:

Table 4: Factors impacting forward-looking transition risk assessment

Factor	Explanation of effects on forward-looking assessment results	Examples
Time horizon	**Definition:** The period over which the tool estimates results. **Explanation:** Some tools may estimate risk over the next 10 years, while others may estimate it over a more extended period, such as next 50 years	A tool is forward-looking, estimating risks over 2020–2100, with five-year timesteps.
Baseline year	**Definition:** The period against which the emission pathway is compared. **Explanation:** Using a baseline year with relatively high emissions means that it serves as a reference point for evaluating emission reductions and identifying progress. On the other hand, using a baseline year with low emissions means that it sets a more ambitious starting point for emission reductions, highlighting the need for greater efforts to achieve significant emission reductions.	The baseline year is status quo (2022).
Climate scenarios	**Definition:** A plausible representation of future climate that has been constructed to investigate potential impacts of climate change (IPCC, 2018; 2022). **Explanation:** Even among scenarios that examine the same future temperature increase (e.g. 1.5°C of warming by 2100), socioeconomic and policy pathways to reach that given temperature can vary widely. Different pathways have different implications for firms' transition risks (IPCC, 2022).	A model uses GCAM for NGFS 1.5°C orderly transition scenario.

Inclusion of interaction effects	**Definition:** The assumptions made about the interactions between sectoral risks, between physical and transition risks, and second order effects such as economic consequences of the primary risk. **Explanation**: The inclusion of interaction effects in the assessment considers how different risks interact with each other, including sectoral risks, physical and transition risks, and second-order effects. These interactions have significant implications for the assessment results, providing a comprehensive understanding of the interconnected nature of climate risks.	A model assumes the increasing adoption of clean energies will reduce emissions and mitigate a certain level of physical risks.
Statistical methodology or calculation approach	**Definition:** The statistical methodologies used to translate information of climate scenarios and climate models to risk outputs. **Explanation:** The statistical methodology or calculation approach employed in the assessment plays a crucial role in translating climate scenario information and climate models into risk outputs. The choice of methodology can significantly impact the assessment results, influencing the accuracy, precision, and reliability of the risk assessments. It determines how the available data are analysed and interpreted, ultimately shaping the insights and findings regarding climate risks.	A model uses GHG Emissions per unit of Value Added (GEVA)/ Sectoral Decarbonisation Approach (SDA) approach for implied temperature rise (ITR) calculation.

Regarding time frames, there are general assumptions related to reference and baseline periods. These are crucial periods to distinguish from the year that the model starts from. For metrics with economic value outputs such as Climate Value-at-Risk (CVaR) or Climate Transition Value-at-Risk (CTVaR), probability of default, and expected losses, the baseline year (which commonly relates to the starting year) is significant for interpretations. On the other hand, implied temperature rise (ITR) metrics usually use the preindustrial temperature as a baseline, although this may vary by provider. The starting year can also vary depending on the vendor.

This section highlights the importance of understanding the assumptions and methodologies behind transition risk metrics provided by vendors of assessment tools, which helps FIs to effectively select and use transition risk metrics. Specific focus is given to a few common transition risk metrics offered by tool providers during UNEP FI's 2022 piloting exercise. Different vendors' metrics are also used to assess the transition risk of a dummy portfolio, facilitating the comparison of results. While the selected metrics are not exhaustive, they are considered as frequently used outcomes of the transition risk assessment exercises and as the source of valuable insights for FIs.

2.3.1 Carbon performance analytics

Carbon performance analysis assesses a company's carbon emissions and its carbon reduction progress. With carbon emissions as the primary cause of climate change, companies emitting heavily face mounting regulatory and reputational risks. Carbon performance uses metrics like carbon footprint, carbon intensity, and emissions reduction targets. The carbon footprint quantifies the GHG emissions from a company's operations, products, and services. Carbon intensity gauges the emissions per unit of output or activity. Although it doesn't directly measure transition risks, carbon performance serves as a vital exposure indicator and proxy.

This section discusses **carbon emissions** and the **Weighted Average Carbon Intensity (WACI)** given their universality across climate risk tools. These two metrics primarily offer a snapshot of current carbon performance, but do not directly correlate these emissions to transition risk and associated financial implications.

The carbon footprint is typically quantified using CO_2e emissions and consists of three primary 'scopes':

1. **Scope 1 emissions**: i.e. direct emissions from owned or controlled sources.
2. **Scope 2 emissions**: i.e. indirect emissions from the generation of purchased energy.
3. **Scope 3 emissions**: i.e. all indirect emissions (not included in Scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions (GHG Protocol, 2023)

Quantifying Scope 3 emissions can be challenging due to their occurrence outside an organisation's direct control and owing to the potential unavailability of data. However, in some cases (particularly those in industries with extensive supply chains), Scope 3 emissions can account for more than 80% of a company's total emissions and are often the largest contributor to their overall carbon footprint.

Recognising Scope 3 emissions' relevance in climate risk assessment, tool providers like ICE, ISS ESG, and Moody's are integrating metrics in relation to Scope 3 emissions. ICE, for instance, identifies and calculates both disclosed and undisclosed Scope 3 emissions, prioritising the most impactful of the 15 GHG protocol sub-categories. It adjusts for outliers and infers values where data are unavailable. Similarly, ISS ESG evaluates disclosed Scope 3 emissions, scrutinising their quality against the GHG protocol's sub-categories. It discounts reported emissions not corresponding with identified impactful sub-categories, providing a detailed breakdown of quality-checked emissions. Moody's measures the company-level carbon footprint across all emission scopes, offering category-specific breakdowns and a percentage analysis of green revenue share. Its grading system (A, B, C, D), which is updated bi-annually, serves as a standardised assessment, aligning with the national GHG inventories of the United Nations Framework Convention on Climate Change (UNFCCC).

A recent study compared 14 different transition climate risk assessment methods applied to the same portfolio of companies, concluding that despite consistently identifying the firms emitting the most and least GHGs, considerable variation exists between different risk assessment results for most companies (Bingler et al., 2020). Considering the assumptions made by different vendors for carbon emission metrics is therefore essential. In addition to the general assumptions mentioned in Section 2.3, emission-specific considerations include the following factors:

Table 5: Emission-specific considerations for transition risk assessment

Factor	Explanation	Examples
Emissions boundaries/ life cycle boundaries	Determining whether an assessment includes only Scope 1 and 2 emissions or also encompasses Scope 3 emissions is crucial. Understanding the precise scope of Scope 3 emissions considered is essential, as vendors may focus on specific aspects, such as upstream or downstream emissions.	A tool covers Scope 1 + 2 emissions.
Assumed portfolio size	Different vendors may base their calculations on varying investment amounts, which can lead to inconsistencies in results. As the assumed portfolio size increases, the absolute emissions tied to the results also tend to rise, thus affecting the overall evaluation.	An assumed portfolio size is USD 1 billion.

While carbon emissions provide an absolute measure of an organisation's carbon footprint, the WACI offers a relative measure that compares the carbon intensity of an investment portfolio against a benchmark or a previous period. Some WACI-specific assumptions include:

Table 6: WACI-specific assumptions for transition risk assessment

Factor	Explanation	Examples
Emission calculation approaches	An activity-based approach computes emission data based on companies' activity data and multiplies these by an emission factor representing the average emissions associated with that activity. Alternatively, a life cycle assessment (LCA) approach considers the entire life cycle of a company's products or services, from raw material extraction to end-of-life disposal or recycling. A supply chain-based approach estimates emissions from various stages, such as raw material extraction, transportation, manufacturing, and product distribution.	A tool calculates emissions with an activity-based approach.
Emissions boundaries	Determining whether an assessment includes only Scope 1 and 2 emissions or whether it also encompasses Scope 3 emissions is crucial. Understanding the precise span of the Scope 3 emissions considered is essential as vendors may focus on specific aspects, such as upstream or downstream emissions.	A tool covers Scope 1 and 2 emissions.

Although most vendors provide carbon intensity results to capture the carbon performance of portfolios at the current time spot, a few tools also offer forward-looking intensity estimation following certain scenarios or emission pathways to help with target setting and budget compliance. For example, ICE provides forward-looking estimated carbon intensity to 2060 under a series of scenarios by the Intergovernmental Panel on Climate Change (IPCC), the International Energy Agency (IEA), and the Network for Greening the Financial System (NGFS). It then compares the sector intensity against emissions allowance to calculate an annual reduction target. ISS ESG uses issuer-level emission intensity trends, GHG reduction targets and projected future GHG emissions within scenario limits to calculate the portfolio emissions pathway till 2050. It then compares this against the portfolio's allocated carbon budgets to judge if there is an overshoot. PwC GmbH WPG has also developed an approach designed to translate future scenarios to sectoral impacts, which will be combined with bottom-up analytics to compute company-level impacts.

Figure 5 displays the assessment output of ICE's tool. By selecting input metrics for emissions and portfolio market value, users could yield outputs in the form of portfolio emissions intensity and remaining emission budget. As part of this selection, it is important to specify assumptions such as the chosen reference scenario, the scope of emissions included for analysis, and the target year of portfolio alignment with emission reduction targets with reference to the chosen warming scenario.

In contrast, PwC GmbH WPG (Figure 6) showcases another approach which considers the present conditions of a company and the sector(s) in which it operates, plus the chosen pathway of transition. This yields forward-looking estimated impacts of climate-related risks and opportunities on a company's products, financial valuations, and business strategy.

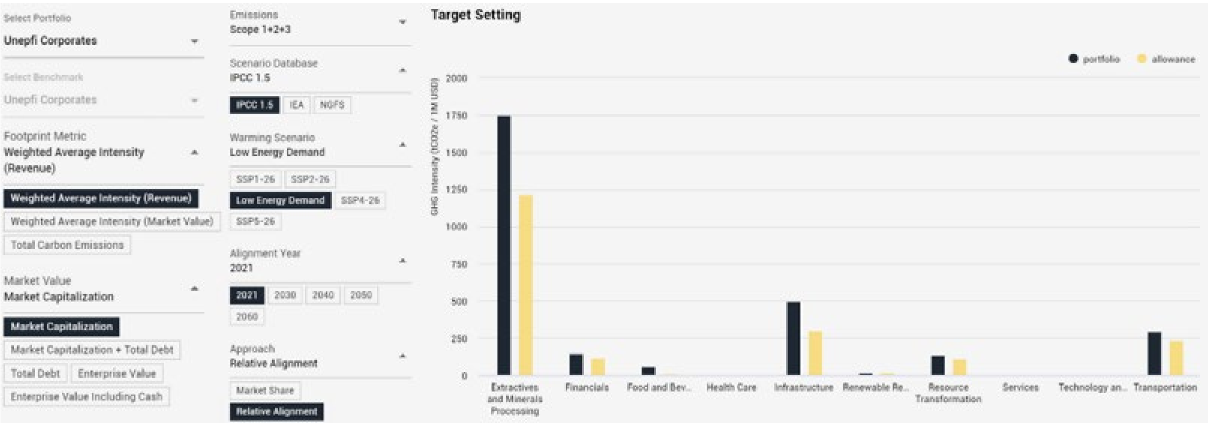


Figure 5: Forward looking carbon intensity alignment based on dummy portfolio (ICE, 2022)

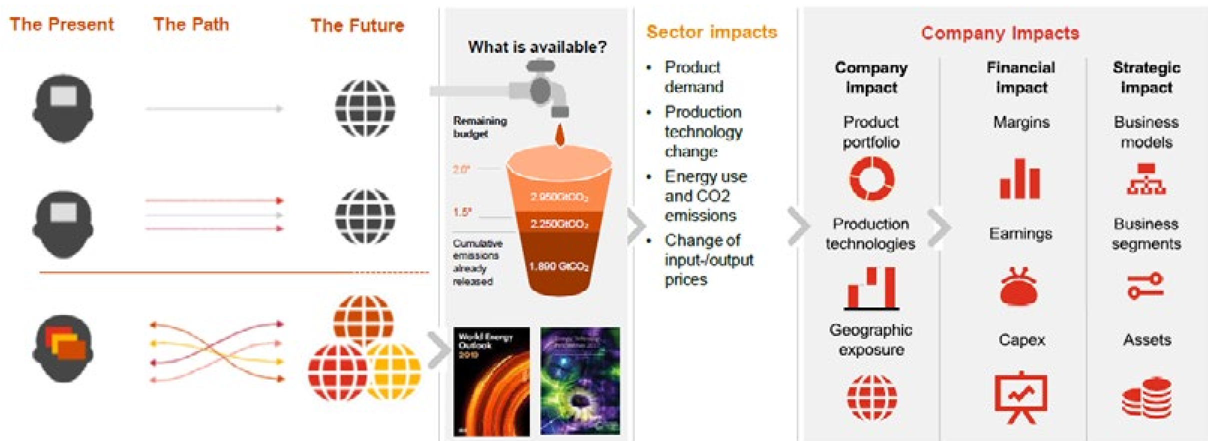


Figure 6: Relationship between climate scenarios, carbon budget, and sector (PwC GmbH WPG, 2022)

2.3.2 Implied Temperature Rise

Implied Temperature Rise (ITR) is a measure that estimates the global average temperature increase resulting from a specific level of GHG emissions. ITR projections are based on models that consider radiative forcing caused by emissions and other factors such as Earth's climate system dynamics. While ITR is not a prediction of future temperature changes, it serves as a valuable tool for understanding the potential impact of varying GHG emissions levels on the Earth's climate. ITR aids in setting targets for emissions reduction, informing decision-making processes, and highlighting the potential consequences of inaction regarding climate change mitigation. Key assumptions for ITR across climate risk assessment tools include:

Table 7: Key assumptions for ITR across climate risk assessment tools

Factor	Explanation
ITR Definition	The level of warming associated with a portfolio based on that portfolio's emissions trajectory in a given year, usually 2050 or 2100
Reference period of temperature	The period against which the temperature increase is compared, if it is pre-industrial, last 30 years, or some other baseline.
Carbon budget	The carbon budget sets the maximum amount of emissions allowed to limit global warming. Implied temperature rise metrics estimate the expected temperature increase based on GHG levels. The carbon budget plays a crucial role in influencing the implied temperature rise by guiding efforts to control emissions within the set limits, thereby helping to mitigate the impacts of climate change.
Emissions boundaries/ life cycle boundaries	Determining whether an assessment includes only Scope 1 and 2 emissions or also encompasses Scope 3 emissions is crucial. Understanding the precise span of Scope 3 emissions considered is essential as vendors may focus on specific aspects, such as upstream or downstream emissions.
Forward-looking input	Models used by vendors to generate forward-looking emissions and required data fields for the input

Collecting forward-looking emission data is the first step for tool providers to conduct warming analytics. A forward-looking degree warming metric requires an approach to determining companies' future emissions. To date, there is a range of approaches across providers and little methodological consensus. There are many possible options, including holding emissions constant at current levels, extrapolating historical emissions, using self-reported targets, estimating performance based on proxy data or a hybrid of these approaches. Approaches vary along three dimensions: the weight on targets versus historical emissions, the use of proxy data, and whether they employ a single or a hybrid approach (PAT, 2020).

It is crucial to understand that ITR serves as an indirect metric to assess risks, meaning that a higher ITR could indicate increased risks. ITR does not directly depend on the specific narratives of climate scenarios. Instead, the metric focuses on assessing a company's current carbon performance and future plans, while remaining agnostic to the potential impacts of various scenarios or policy developments. However, if clients switch from IPCC 1.5 to NGFS scenarios, the ITR results will change given that the calculation is influenced by the selected scenario's emission pathways and underlying climate models. This is because some scenarios rely heavily on negative emissions technologies or CCS to achieve their temperature goals.

There are two approaches to translating emissions to a temperature score—by assessing them against one (or several) temperature pathways, and by estimating a warming function that relates emissions to a range of temperature outcomes (PAT, 2020). The former is more intuitive and simpler to apply and is widely used by tool vendors to translate data proxies or emission reduction targets into ITR. Common attributes include:

- **SDA (Sectoral Decarbonisation Approach)**: This approach assigns decarbonisation pathways to specific sectors based on their contributions to global emissions and their reduction potential. By comparing the emissions pathway of a company, sector, or portfolio with the assigned sector-specific decarbonisation pathway, it determines the compatibility with a specific temperature target (e.g. 1.5°C or 2°C). If the emissions pathway aligns with the target, the ITR is considered consistent with that specific temperature target.
- **GEVA (Greenhouse Gas Emissions per Value Added)**: GEVA calculates the emissions intensity relative to the value generated by a company, sector, or portfolio. By comparing the GEVA of an asset with a benchmark or sectoral target, one can assess its alignment with climate goals and estimate the ITR. If the asset's GEVA is on track to meet or exceed the benchmark or target, it implies an ITR consistent with the associated temperature target.
- **ARA (Absolute Reduction Approach)**: ARA focuses on the absolute emissions reduction required for a specific company, sector, or portfolio to align with a given climate scenario or temperature target. By comparing the asset's actual emissions reduction trajectory with the required absolute reduction, one can determine its compatibility with the climate target. If the asset is on track to achieve the required emissions reduction, it implies an ITR consistent with the associated temperature target.

To gain a more comprehensive understanding of each company's contribution to the portfolio's overall alignment with climate objectives, many tool providers evaluate alignment at the company level and then aggregate those assessments to the portfolio level. They typically do this either by calculating a weighted average of company-level temperature scores, or by aggregating the over-shoot (or under-shoot) of company-level absolute emissions relative to their allocated carbon budgets and then converting the result into a temperature score. This method allows for a nuanced analysis of the portfolio's climate alignment and the individual contributions of its constituent companies.

2.3.3 Green and brown share

Green shares and brown shares represent distinct types of stocks associated with companies operating in different sectors of the economy. Green shares are stocks linked to companies operating in renewable energy, clean technology, and environmental sectors. These companies typically prioritise reducing their carbon footprint and promoting sustainable practices, making them generally more environmentally friendly than other types of businesses. Brown shares, conversely, are stocks connected to companies operating in fossil fuel, mining, and other resource-intensive sectors. These companies tend to have a higher carbon footprint and may be perceived as more environmentally detrimental than others.

It is important to note that these terms are not official financial classifications but are used in various operational contexts. Some investment firms use this terminology to differentiate their portfolios, while some sustainability indices employ it to categorise companies. In addition to the general assumptions, key building blocks of this metric include:

Table 8: Key building blocks of green shares and brown shares

Factor	Explanation	Examples
Definition of green/brown share	Criteria for defining green/brown shares may vary across tools. Comparability across vendors should therefore be considered. Some use a quantitative approach based on companies' carbon intensity or emission reduction targets, while others may use a qualitative approach based on industry classification or ESG ratings.	A tool defines green revenues as the estimated proportion of the issuer's revenue considered to be derived from products or services with significant or limited contribution to SDG 13 Climate Action.
Weighting methodology	The weighting method used to evaluate the carbon intensity of each company can also impact results. Vendors might employ different weighting schemes.	The weighting for green share employed by a tool is market capitalisation divided by revenue.

As more and more companies commit to net-zero ambitions, there are rising concerns aboutfossil fuel reserves and stranded assets. As a result, many vendors provide measurements of green and brown shares as a means of quantifying the proportion to which companies are involved in low-carbon industries or in fossil fuel related activities and the nature of their environmental impacts.

2.3.4 Portfolio transition value-at-risk

In addition to the proxies discussed in Section 2.3.1–2.3.3, the climate risk tool universe also offers a range of quantitative metrics to directly evaluate transition risks, each with a unique focus. The table below showcases some available financial metrics that assess the impact of climate transition risks on an FI's key balance sheet component—namely, assets, liabilities, and equity value. These metrics, which can evaluate basic risk types such as market, operational, liquidity, and credit risks (GARP, 2022), provide a comprehensive understanding of how climate transition impacts an FI's financial standing. In addition, economic model outputs offer insights into macroeconomic implications of climate transition risks.

Table 9: Types of metrics for portfolio-level transition risk assessment

Metric Types		Description	Examples
Balance sheet line items	Market risk metrics	**Definition:** Financial metrics that directly assess the extent of potential financial loss that can arise from market shifts triggered by climate transition scenarios. **Explanation:** These metrics aid FIs in aligning investment strategies with climate goals, managing climate risks and opportunities, and helping FIs to reduce unforeseen losses and to identify emerging market opportunities due to climate transition.	Climate Value-at-risk (MSCI, 2020) Climate Transition Value-at-Risk (CTVaR) (WTW, 2022) Cumulative return
	Operational risk metrics	**Definition:** Metrics that evaluate the impact of climate transition risks on the operations of a firm, assessing its vulnerability to climate-related disruptions. **Explanation**: These metrics help FIs understand and manage the impact of transition risks to their operations and take steps to mitigate them.	
	Liquidity risk metrics	**Definition:** Metrics assessing the potential influence of climate transition risks on the liquidity of assets in a portfolio, considering how market reactions to climate risks could affect asset sellability. **Explanation:** These metrics help FIs assess the potential impact of climate change on the liquidity of their assets, especially as climate transition could potentially lead to certain assets becoming 'stranded' or difficult to sell at a reasonable price.	Liquidation Horizon Liquidation value
	Credit risk metrics	**Definition:** Metrics measuring the credit risk associated with climate transition risks, especially regarding the creditworthiness of borrowers and default probabilities. **Explanation:** These metrics helps FIs to understand the vulnerability of their loan portfolios to climate risk and, consequently, to make informed lending decisions to mitigate potential losses.	Default Probability
Economic model outputs (NGFS, 2020)		**Definition:** Metrics evaluating macroeconomic impacts of climate transition risks (such as alterations to GDP, inflation, or interest rates), which in turn influence financial markets and institutions. **Explanation:** These metrics assist FIs in understanding and preparing for broader changes in the economic environment, such as alterations in market conditions, interest rates, and inflation.	Yield Curves

Given the scope of this report, Sections 2.3.4 and 2.3.5 will focus on metrics pertaining to balance sheet elements, with a particular emphasis on TVaR and other economic value metrics such as Cumulative Return. This focus arises from their noteworthy results in the recent pilot study, thus demonstrating their importance in this context.

VaR is a statistical technique employed in finance to quantify the level of financial risk within a firm or investment portfolio over a specific time frame. It represents the maximum expected loss, given a predetermined level of confidence (Risk.net, 2023). This measure has found widespread use among FIs for calculating the magnitude and likelihood of potential losses within their portfolios.

Given the increasingly recognised financial implications of climate change, climate risk tool vendors have innovated on the traditional VaR metric to underscore the potential economic impacts of this global phenomenon. In the pilot exercise, these tool providers utilised TVaR to gauge the potential volatility in portfolio-level performance, attributable to the shift towards a low-carbon economy. Some assumptions relevant to TVaR include:

Table 10: Assumptions relevant to portfolio-level transition risk assessment

Factor	Explanation	Examples
TVaR	Transition Value-at-Risk measures the potential financial impact on a portfolio resulting from the worldwide shift towards a low-carbon economy. Various vendors provide TVaR-like metrics; however, the underlying definitions can vary. Therefore, understanding the specific implications and methodologies of these metrics is a crucial first step in effectively utilising TVaR results.	MSCI developed a CVaR tool to show sector-level risks found within a portfolio. It works by comparing the weighted average aggregated CVaR, arithmetic average aggregate CVaR, and spread between the highest and lowest CVaR in a sector.
Confidence level	Traditional value-at-risk metrics estimate maximum loss at different confidence levels, such as 90%, 95%, and 99%. The level of risk that is acceptable to an FI determines what confidence interval it uses. A 99-percentile confidence level may result in a significantly larger loss compared to a 90-percentile confidence level.	A model uses a confidence level of 99%.
Choice of probability distribution	Vendors may use probabilistic modelling with varying assumptions on probability distributions on transition pathways' materialisation, such as normal or skewed distributions like lognormal distribution, for the assessment of transition risks or risk drivers. The choice of tail of the distribution influences the likelihood of extreme events in the distribution. A fat-tailed distribution can result in a higher CTVaR or CVaR estimate.	A model assumes a fat-tail distribution of cost.

Vendors may use expected loss or maximum loss to calculate TVaR, depending on specific needs of their users. Expected loss offers an average estimate of potential losses and can be intuitive for users who want a single summary measure of transition risk. Maximum loss, on the other hand, focuses on the worst-case scenario and is more relevant for clients who are particularly concerned about tail risks and downside risks. In terms of economical valuation, vendors typically use discounted cash flow (DCF) approach to transfer transition risks to financial indicators.

Examples include the CVaR of MSCI and the CTVaR of WTW. Both metrics provide an estimation of the potential change in portfolio value during the transition towards a low-carbon economy. Furthermore, MSCI's CVaR includes the potential for financial gains or losses arising from physical climate risks (see Section 3.4.2 for further details).

Both CVaR and CTVaR encapsulate the effects of strategic actions such as the implementation of carbon pricing, fossil fuel phase-out, and the integration of renewable energy technologies. In addition, these tools factor in transition risks by assessing elements like demand fluctuations and cost variations. These are influenced by policy modifications, technological innovations and other transition risk factors.

It is crucial to note that unlike the traditional VaR approach, the definition and calculation of these two metrics are not primarily based on probability distributions. Instead, they focus on the potential percentage cost that could expose businesses to risk. The ensuing sections of this report will delve deeper into the insights and implications derived from CVaR and CTVaR as provided by specific vendors.

2.3.5 Other economic value metrics

As explained in Section 2.3.4, there are other metrics measuring economic value changes for a given portfolio under future plausible states. This section will delve into notable examples, predominantly focusing on the cumulative return methodology, which is highly favoured among climate tool providers for quantifying potential losses to a specified dummy portfolio stemming from transition risk. The application of this metric typically encompasses several stages:

- **Identifying the assets in the portfolio** that are most exposed to transition risks, such as fossil fuel-related assets, and those that may benefit from the transition, such as renewable energy assets.
- Assessing the potential impact of **different transition scenarios** on the value of the assets in the portfolio. This could be done using DCF analysis, or option pricing models to capture the potential for large changes in value.
- Estimating the **probability of transition pathways** materialising and the resulting expected loss for the portfolio.
- Developing a **risk management strategy** to mitigate or offset the expected loss.

Various approaches to cumulative return analysis exist. Which specific methodology is used depends on the type of assets in a portfolio, the level of data and information available, and the goals of the analysis. Additionally, this metric can be used in combination with credit modelling, which aims to assess the creditworthiness of a borrower and the likelihood of default.

Climate-adjusted value is also employed by some vendors on the market. In contrast to cumulative return, which reflects the overall performance of an asset over a specific period, a given asset's cash flows are adjusted based on the projected transition events (considering their potential impact) and then discounted back to the present value (PV). For corporate issuers, issues under consideration are company fundamentals, business activities linked to transition and to non-transition factors, sector-specific dynamics, and projections under selected scenarios. Expected value impact is another conceptually different metric, which gives an expected value under a climate scenario compared to a hypothetical baseline.

In addition to the generic assumptions discussed at the beginning of this section, key building blocks of these metrics include:

Table 11: Key building blocks of metrics used for portfolio-level transition risk assessment

Factor	Explanation	Examples
Definition of metrics	This consideration can affect the comparability of results between vendors.	A tool defines cumulative return as the percentage change of EBITDA compared to 2021 and are weighted according to the indicated investment exposure.
Underlying methodology of financial modelling	The model that links risks to financial results and the approach taken to model the financial impacts of climate risks will determine the accuracy and usefulness of the cumulative return analysis.	A tool derives EBITDA and sales impacts from changes in the volume and the margin. It does so by breaking down an individual company's economic activity into sectors. A vendor can then map a specific climate-related financial impact for this individual activity, in its relevant geography.

2.4 Transition risk quantifications at a portfolio level

This section will delve deeper into transition risk outputs by examining the results of a hypothetical portfolio, focusing on the five most used transition metrics introduced in Section 3.2. However, it is essential to note that the intention is not to evaluate which tool performs better, whose results are more accurate, or which metrics are more useful to clients. Instead, the focus is on using results from the piloting exercise examples to explore the differences in assumptions and models. The ultimate goal is to offer reference value to readers and ensure FIs are well-informed when using the various tools now in the market. The analysis presented should be viewed to deepen understanding of the tools' underlying methodologies, rather than as a judgment of their relative merits or effectiveness.

Due to space constraints in this report, this section will focus on showcasing the most intriguing and relevant assumptions for discussion.

2.4.1 Carbon performance analytics

Carbon performance metrics emerged as the most popular module during the pilot exercise. When calculating absolute emissions, vendors may use different investment amounts, resulting in inconsistent outcomes. To address this, results have been harmonised, assuming a portfolio size of USD 1 billion. To ensure comparability across figures, vendors were asked to provide extrapolated results for the entire portfolio, taking coverage levels into account. Vendors tend to be transparent about the counterparty coverage.

Further, the extrapolated results are provided upon request solely for the harmonisation purpose in this exercise.

The processed carbon footprint data can be found below:

Table 12: Processed carbon footprint data from five vendors

Vendor	Carbon footprint tCO_2e	Emissions boundaries	Reference data	Data sources (self-collected/ external)	Counterparty Coverage
ICE	275,287 1,597,922[5]	Scope 1+2 Scope 1,2 and 3 (both upstream and downstream emissions)	2020 Data	Self-collected	317/358 dummy portfolio entries
ISS ESG	161,062 1,240,382	Scope 1+2 Scope 1,2 and 3 (both upstream and downstream emissions)	Emissions data are from 2020[6]	Self-Collected and external sources	302/358 dummy portfolio entries
MSCI	197,804 1,181,256	Scope 1+2 Scope 1,2 and 3 (both upstream and downstream emissions)	Depends on each entity's individual history of reporting	Self-collected and external sources	301/358 dummy portfolio entries
S&P Global Sustainble1	265,762 1,097,588	Scope 1+2 Scope 1,2 and 3 (both upstream and downstream emissions)	2021 (With footnote: 2018–20 data were used for four companies only)	Self-collected, external data and modeled data	299/358 dummy portfolio entries

All carbon footprints above took 38 sovereign bonds and municipal bonds out of the scope, given that guidelines of the Partnership for Carbon Accounting Financials (PCAF) suggest that FIs shall treat these asset classes differently (PCAF, 2022). It's noteworthy, however, that during the piloting exercise, several tool providers were capable of delivering separate carbon footprint results for sovereign and municipal bonds. There are also 18 entries without ISIN codes in the dummy portfolio including unlisted corporate loans. Vendors excluded most of these due to challenges in mapping them to their databases.

One critical assumption is the choice of emission boundaries, which determines the scope of emissions included in the analysis. The decision to include or exclude certain scopes can lead to vastly different outcomes, as it may either overstate or understate a company or portfolio's actual carbon footprint. Another notable assumption is the exclusion of certain counterparties or industries deemed as high-carbon emitters. Some tools might exclude these industries to present a more favourable carbon footprint, which could create a skewed representation of the actual emissions.

5 Market Value was calculated by Market Capitalisation + Total Debt in the results
6 Modelled Scope 1 + 2 emissions input are also using companies 2020 data to model 2020 emissions

Vendors employ various strategies to address emission data gaps. For instance, Moody's estimates a company's integrated Scope 1 and 2 emissions using methods such as regression, sector-specific physical emissions intensities, sector average intensities comparison, and peer comparison. When companies fall outside its database, Moody's relies on proxies based on industry, size, and location.

MSCI employs a production model for power utilities and a company-specific intensity model for firms with partial reports to estimate Scope 1 and 2 emissions. For non-reporting companies, it uses industry or segment-specific intensity levels. For Scope 3, MSCI employs a blend of top-down (emissions per unit of revenue or other economic measures) and bottom-up (company-specific production data) approaches. To estimate emissions for private companies not in its database, MSCI uses a combination of sector and revenue data.

ISS ESG addresses Scope 1 and 2 emissions gaps with sub-sector specific models that use operational and financial data. For Scope 3 emissions, both downstream and upstream emissions are estimated using top-down and bottom-up approaches based on a company's operations and emissions profile.

Intuitively, the results measuring a portfolio's WACI are affected by factors such as data sources, timing of data collection, calculation methodologies, and the scope of emissions. This is because WACI follows a standard and straightforward calculation process.

Table 13: WACI results from four vendors

Vendor	WACI Scope 1+2 tCO_2e/bUSD	WACI Scope 3 tCO_2e/bUSD	Reference data	Data sources (self-collected/ external)	Counterparty Coverage
ICE	659,910	2,523,400 including both upstream and downstream emissions	2020	Self-collected	317/358 dummy portfolio entries
ISS ESG	592,470	N/A	2020	Self-collected and external	302/358 dummy portfolio entries
MSCI	435,000	1,763,300 including both upstream and downstream emissions	2021	Self-collected and external	252/358 dummy portfolio entries
S&P Global Sustain-ble1	942,361[7]	3,469,846	2021[8]	Self-collected	299/358 dummy portfolio entries

7 This result includes part of Scope 3—Non-Electricity First Tier Supply Chain (Scope 3) CO_2e emissions generated by companies providing goods and services in the first tier of the supply chain.

8 2018–2020 data were used for companies only.

Due to the challenges in accessing robust data, tool providers are increasingly transparent about their data sources in standard reports, which helps FIs address information asymmetry. For instance, ICE includes a graph in its auto-generated portfolio analytics report that displays data robustness. In the UNEP FI dummy portfolio, over 50% of data concerning Scope 1 and 2 emissions is publicly available, and over 30% is third-party assured. ICE actively collaborates with companies to promote transparency and data sharing among supply chain partners, ultimately enhancing the accuracy of emissions estimates. Leveraging [PCAF's data quality score framework](), MSCI assesses the quality of financed emissions data across Scope 1, 2, and 3. The scoring system ranks data quality on a scale of 1 (highest) to 5 (lowest). An examination of 301 securities in the carbon footprint module revealed scores of 2.82, 2.9, and 3.26 for Scope 1, 2, and 3 respectively. This highlights opportunities for data quality enhancement across the three emission categories. This progressive decline in data quality from Scope 1 to 3 is anticipated given the complexities and data constraints in estimating emissions based on granular asset information.

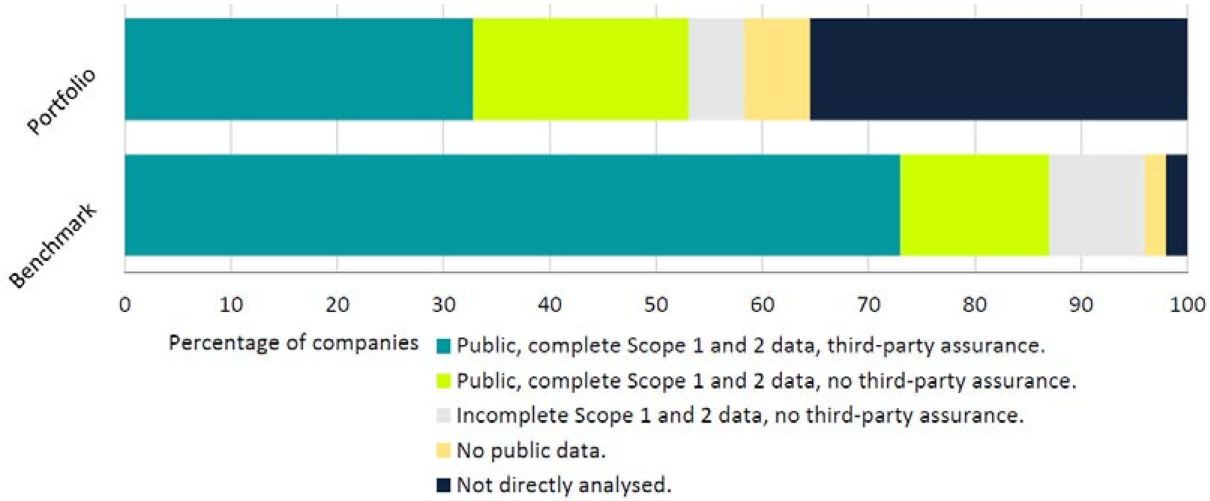


Figure 7: Robustness of Scope 1 & 2 emissions employed (ICE, 2022)

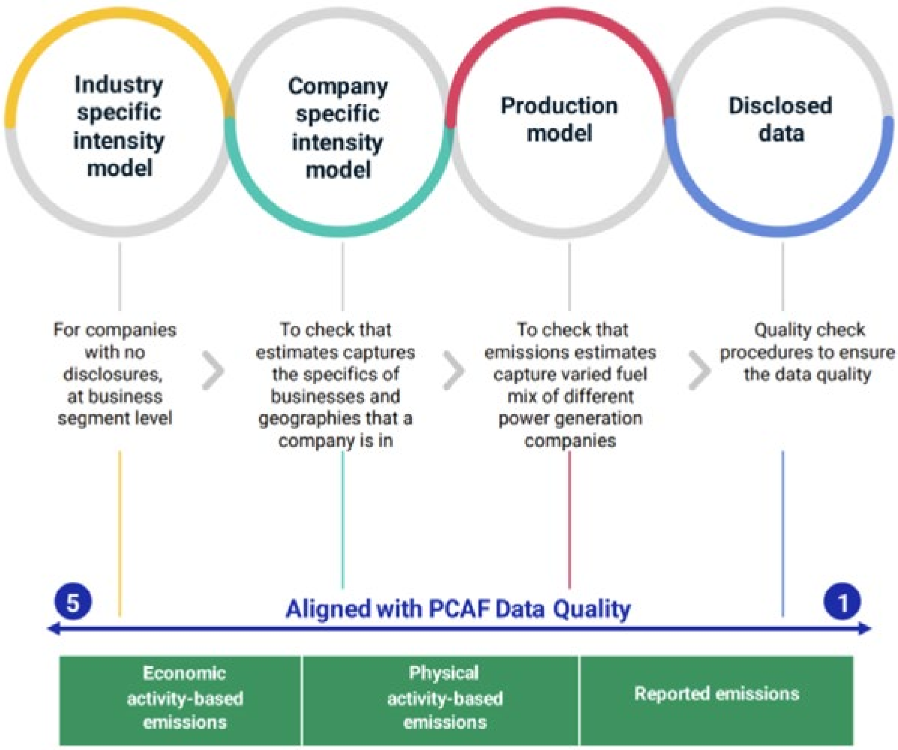


Figure 8: MSCI's framework for PCAF quality scores (MSCI, 2022)

In the meantime, S&P Global Sustainable1 employs a 'disclosure flag' for all collected data to indicate the source of each data point. These flags fall into three 'disclosure categories': Full Disclosure, Partial Disclosure, or Modelled Disclosure. Full Disclosure refers to unedited company-reported data that meets the required reporting scope and accuracy. Partial Disclosure involves adjusting company-reported data to match the research process's required scope (e.g. extrapolating emissions from 85% of operational sites to 100%) or deriving values from data from previous years using changes in business activities and consolidated revenues. In the absence of usable disclosures, modelled data are generated with GICS Sub-industry emissions factors. Its report offers a detailed breakdown of the percentage of each data type used, ensuring clients can make informed decisions based on the robustness of the data provided. ISS ESG offers a disclosure breakdown for portfolio holdings in respect of quantity and weight. This enables quick comparisons of modelled versus reported Scope 1 and 2 emissions. It also indicates whether data were modelled or reported, as well as the source of reported emissions. The Scope 1 and 2 trust metric gives a numerical measure of the reliability of an issuer's reported emissions.

Users of these tools can anticipate receiving sector breakdowns and information on the top contributors to portfolio emissions in standard reports provided by vendors. Emission attributions are often compared with benchmarks to determine if the portfolio is overperforming or underperforming. Further details on this topic will be explored in Chapter 4.

2.4.2 Implied temperature rise

The table displays ITR results from seven vendors with the time frames they deployed. The vendors are presented in chronological order. It should be noted that Ortec Finance included sovereigns and treated municipals as equivalent to sovereigns for the sake of simplicity. For portfolio weighting A, all results are beyond the warming ambition of 1.5°C by 2050. This is intuitive considering the composition of the dummy portfolio in sector selections.

Table 14: ITR results from six vendors

Vendor	Temperature Alignment	Time Horizon	Emissions boundaries	Reference data	Methodology applied	Counterparty Coverage
S&P Global Sustainable1	>3°C	2030	Scope 1 & 2	2012–2030	A combined SDA and GEVA approach	262/358 dummy portfolio entries
Ortec Finance	2.2°C	2050	Scope 1 & 2	100 years of economic data and up to five years of company emission data	SDA approach	353/358 dummy portfolio entries
Moody's	2.6°C	2050	Scope 1, 2 & 3	Depends on each entity's individual history of reporting	A mixture of SDA and ARA approaches	78/358 dummy portfolio entries
ISS ESG	2.8°C	2050	Scopes varying per sector depending on scenario requirement	Emissions and Financials FY2020 Historic emissions data from past six years 2015–2022	SDA approach	302/358 dummy portfolio entries

Planet-rics[9]	3.6°C (Pathways method) 2.9°C (Budget method)	2050 (modelling horizon) 2100 (temperature horizon)	Scope 1 & 2 for Pathways method, with downstream Scope 3 effects captured using company revenue modelling Scope 1, 2 & 3 for budget method	Depends on each entity's individual history of reporting	SDA approach	244/358 listed dummy portfolio entries where ISINs were available
MSCI	4.7°C	2070	Scope 1, 2 & 3	Based on 2021 data points	SDA approach	252/358 dummy portfolio entries
ICE	3.14°C	2100	Scope 1, 2 & 3	2015–2020	SDA approach	317/358 dummy portfolio entries

Vendors employ a hybrid approach that combines historical emissions and future targets for their analytics. Where company specific data are unavailable, vendors usually either take these securities out of scope to ensure the overall accuracy or use approximations instead. For example, Ortec Finance's data input and proxy hierarchy shows that 60% of the 99% of assets analysed had company-specific data available, including emission trends and targets. Likewise, S&P Global Sustainable1 uses a decision hierarchythat incorporates forward-looking data. These include: disclosed emissions reduction targets; asset-level data; company-specific historical trends for homogeneous business activities; sub-industry-specific average historical trends for heterogeneous business activities; and no change in emissions intensity beyond the latest year.

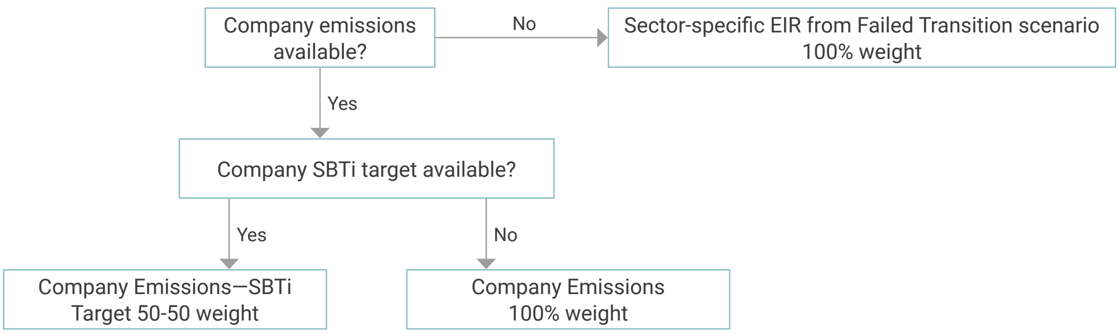


Figure 9: Decision hierarchy to calculate a company specific ITR (Ortec Finance, 2022)

ICE employs externally validated and regularly updated self-reported targets for its calculations. If securities lack available targets, ICE infers data based on sector or indus-

9 The information in this table has been created by UPEP FI drawing on selected data provided by Planetrics, a McKinsey & Company solution (which does not include investment advice). This table represents UNEP FI's own selection of applicable scenarios selection and/or and its own portfolio data. UNEP FI is solely responsible for, and this report represents, such scenario selection, all assumptions underlying such selection, and all resulting findings, and conclusions and decisions. McKinsey & Company is not an investment adviser and has not provided any investment advice.

try averages. Furthermore, ICE utilises multiple targets per company when possible in order to capture companies' their announced transition plans throughout their respective decarbonisation journeys. ISS ESG evaluates historical emissions trends for companies without targets and assigns a reduction rate based on the alignment with a specific scenario. Planetrics uses a proprietary database of company targets and enables calculation of temperature alignment scores with and without achievement of companies' targets (results reported above exclude the impact of company targets). Moody's relies on companies' stated targets and interpolates emissions reductions for future years accordingly. It aims to provide temperature scores for a nearer-term horizon (to 2030) as it is more reliable than distant targets. Individual company trajectories are calculated for investors to understand each company's unique target and decarbonisation ambition. MSCI calculates projected emissions by considering 58.1% of companies with GHG emission reduction targets and 15% with targets across all scopes. These targets are taken at face value and incorporated into the ITR. For companies with specific decarbonisation targets, MSCI relies on those targets directly. If a company does not have decarbonisation targets, MSCI assumes a 1% annual increase in emissions.

Most tool providers offer ITR estimations for 2050 or 2100 as these are significant milestones in global climate change efforts. The 2050 time frame, used by vendors like Ortec Finance, helps clients evaluate progress towards net-zero emissions targets, as it is a common intermediate goal. In contrast, the temperature rises by 2100 offer a long-term view of the potential impact of emissions on the climate system, highlighting the need for additional actions to mitigate climate change. Interestingly, S&P Global Sustainable1 provides ITR results for the short-to-medium term, until 2030, in line with typical company disclosures. It does not extend beyond 2030 due to the decreasing quality of emissions forecasts and the likelihood of errors in scenario alignment models.

The scope of emissions considered in ITR calculations significantly influences results. Notably, for example, including broader Scope 3 emissions typically leads to higher temperature rises. Vendors like ICE aim to incorporate Scope 3 emissions for a more comprehensive assessment. Providers such as Ortec Finance, on the other hand, focus only on Scope 1 and 2 emissions, citing data gaps in Scope 3 as an obstacle to meaningful outcomes. Planetrics provides two complementary ITR methodologies to address Scope 3 emissions in different ways. The 'Budget' approach considers companies' cumulative Scope 1, 2 and 3 emissions over the period to 2050 and calculates an ITR using a warming function. The 'Pathways' approach compares companies' projected future Scope 1 and 2 emissions with sector-specific pathways. The climate impact of the company's products is captured using scenario-based economic modelling for each company. This enables each company's 'downstream' Scope 3 impacts to be captured without relying directly on Scope 3 emissions data.

MSCI reported a 2070 ITR of 4.7°C for portfolio Weighting A, which may appear to be an outlier compared to other vendors. It indicated that almost 25% of the companies in the portfolio belong to the GICS Sub-Industry Oil, Gas & Consumable Fuels. Its 4.7°C ITR is mainly driven by the large weight of energy companies with higher ITRs due to high Scope 3 emissions associated with fossil fuel products. In its calculation, individual firms' ITR is floored and capped at 1.3°C and 10°C.

MSCI has planned major updates to its ITR methodology in 2023. These changes include adopting the REMIND Net Zero 2050 scenario developed by the NGFS (2020), shifting the modelling time horizon from 2070 to 2050, and incorporating target credibility assessment and budget rollover features (MSCI, 2023). The integration of sector-specific Scope 3 pathways will result in a lower average and median ITR for the energy sector. Clients can expect lower-level results once these enhancements are considered.

Current modelling approach	Updated model: improvements and enhancements
2.0°C scenario benchmark with a 2070 net zero horizon	1.5°C scenario benchmark 2050 net zero horizon
In-house MSCI decarbonization pathways based on IPCC high-level assumptions Pathway differentiation in S1 (sector/country) and S2 (sector)	Use of open-source, differentiated pathways from the Network for Greening the Financial System (NGFS) across all scopes: S1 and S2 pathways (region/sector) and S3 (sector)
Carbon budgets indexed to company revenue growth Past company emissions not deducted from carbon budgets	Budget rollover: market-share adjustment of company budget + realized emissions deducted from company budget
Company targets taken at face value	Company targets subjected to credibility assessment

Figure 10: Key enhancements proposed for ITR model (MSCI, 2023)

Ortec Finance highlights that the alignment of weighting A with net-zero targets will decrease over time. In the early years, there is a larger carbon budget available, allowing more companies to have ITRs in line with the available carbon budgets based on their modelling. However, as carbon budgets tighten in accordance with the net-zero pathway, the portfolio's emissions may not decrease quickly enough. In essence, even if a holding is currently aligned with net-zero goals, it must continue to improve its performance to maintain that alignment in the long run. Ortec Finance attributes their 2.2-degree ITR in 2050 to the inclusion of listed Real Estate issuers in their analysis and, for the purpose of this pilot, the exclusion of Scope 3 emissions— which can otherwise be provided.

2.4.3 Green and brown share

The table showcases the green and brown share composition in portfolio weighting A, as reported by four vendors below:

Table 15: Green and brown share composition in portfolio weighting A from five vendors

Vendor	Green share composition	Brown share composition	Criteria of green/brown share (e.g. SFDR, European taxonomy)	Weighting factor (e.g. revenue)	Data	Counterparty coverage
ISS ESG	2%	20%	Percentage Green Revenues provides the estimated proportion of the issuer's revenue considered to be derived from products or services with significant or limited contribution to climate change mitigation. Brown corresponds to significant or limited obstruction to climate change mitigation.	Revenue	Self-collected	302/358 dummy portfolio entries
Moody's	0-10%	0-10%	Green share: Activities linked to renewable energy, green lending, and green building. Brown share: activities related to fossil fuels, upstream, midstream, generation, fossil fuel reserves, coal, and many others.	Revenue	Self-collected	279/358 dummy portfolio entries
MSCI	9.50%	15.20%	Green revenue: the weighted average of revenue exposure to alternative energy, energy efficiency, green building, pollution prevention, sustainable water, and sustainable agriculture. Fossil fuel-based revenue: the weighted average of revenue exposure to thermal coal extraction, unconventional and conventional oil and gas extraction, oil and gas refining, as well as revenue from the thermal coal power generation.	Revenue	Self-collected and external	252/358 dummy portfolio entries
CLIMAFIN	8%	71.80%	CSRD, EU Taxonomy	Revenue	Self-collected	247/358 dummy portfolio entries
S&P Global Sustainble1	5.6%	13.8%	Fossil Fuel Revenue exposure captures revenues from Fossil Fuel Extraction and Energy production	Revenue	Self-collected and external	275/358 dummy portfolio entries

The criteria for determining green shares vary significantly among tool providers. For instance, ISS ESG evaluates a company's alignment with SDG 13 Climate Action using its SDG Solutions Assessment (SDGA) tool, which measures the sustainability impacts of companies' product and service portfolios. It applies a proprietary classification system that quantifies the share of net sales generated with relevant products and services based on their sustainability impact. In contrast, vendors like MSCI and Moody's assess green or brown shares based on underlying companies' activities, considering factors such as revenue exposure to renewable energy, green building, green lending, and sustainable agriculture.

Moody's relies solely on company data, excluding any entries not covered in its database. MSCI and ISS ESG use both reported and estimated data. To estimate figures for companies that do not disclose revenue derived from power generation by fuel type, MSCI uses a two-step process; estimation of total power-generation revenue, and estimation of power-generation revenue by fuel type.

The following figure from Moody's illustrates the green share component in portfolio weighting A. As indicated, one company named Starwood Property Trust, Inc. in the dummy portfolio has minor involvement in green lending, and 15 companies have a major involvement in green building.

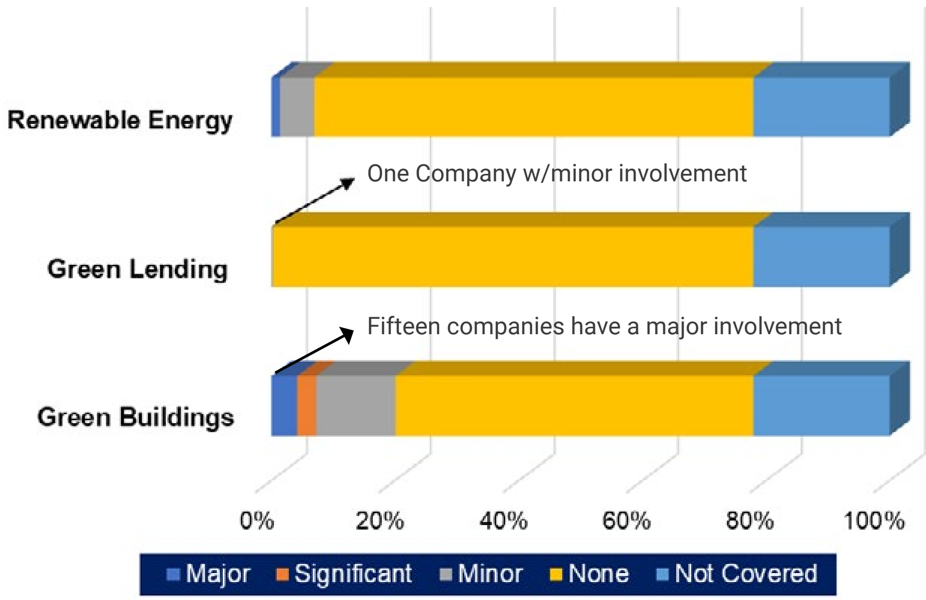


Figure 11: Green share composition for Weighting A (Moody's, 2022)

2.4.4 Portfolio transition value-at-risk

The portfolio-level TVaR results by three vendors are displayed below:

Table 16: Portfolio-level TVaR results by three vendors

Vendor	Definition of TVAR metrics	Metric result	Climate model and 'stress' scenario	Materiali-sation time frame/year	Baseline	Data sources	Counterparty coverage
ISS ESG	ISS ESG's VaR is a net number between the positive and negative potential share price performance in the portfolio. A negative TVaR means positive share price movement.	-12%[10]	IEA NZE 2050	2050	2020	Self-collected and external	302/358 dummy portfolio entries
MSCI	MSCI's CVaR considers economic, sectoral, and company-level data for an estimated change in financial valuation of assets and portfolios that could be resulted from policy costs and technology opportunities (MSCI,2020).	Transition Risks and Opportunities -20.2% Policy Climate VaR -25%[11] Technology Opportunities +4.83%	NGFS Orderly—Net Zero 2050	2100[12]	2021	Self-collected and external	252/358 dummy portfolio entries
WTW	WTW's CTVaR quantifies the financial impacts of transition risks in a portfolio. Multiple factors ranging from climate, environmental, to emissions are taken into consideration, to identify a portfolio's exposure to transition risks and opportunities (WTW,2022).	-2.95%[13]	Well-below-2-˚C-by-2100 scenario with a probability of 67% (equivalent to IPCC's SSP2-RCP2.6 scenario)	2100	Current market expectations (typically equivalent to IPCC's SSP3-RCP4.5 scenario)	Self-collected	301/358 dummy portfolio entries

10 The Value-at-Risk presented is a net number between the positive and negative potential share price performance in the portfolio. A negative TVaR means positive share price movement. The Transition (and Physical) VaR is an equity-based analysis, and its output should not be interpreted as the potential change in price of a bond. Nevertheless, the VaR remains a useful metric for fixed income as it is a holistic indicator of the issuer's exposure to physical or transition risks, even if not directly material to the bond price itself. VaR measures the expected losses over a range of climate scenarios.

11 Policy Risk Climate VaR considers potential risks due to climate policies, and is computed as the net PV of future additional costs (as a percentage of a company's enterprise value) due to carbon pricing. Future costs for a given climate scenario are computed as the product of projected carbon emission reductions needed to meet a certain temperature scenario and carbon price for that scenario. Net PV of future additional costs is then normalised by the company's market value (i.e. sum of its market capitalisation and market value of debt) to compute the Policy Risk Climate VaR.

12 2021–2100 with one-year timesteps

13 WTW's CTVaR gives the portfolio-level transition risk assessment results in terms of expected loss rather than estimated maximum loss, which might be used by other data providers.

MSCI developed the metric CVaR to evaluate a portfolio's TVaR under various NGFS narratives by examining policy costs and technology opportunities. Notably, the metric is also applicable to estimated changes in the financial valuation of a portfolio as a result of physical risks (MSCI, 2020). The policy risk model breaks down country-level GHG emission targets into company-specific emission reduction requirements and calculates policy costs by multiplying location-specific GHG reduction requirements with scenario-specific carbon prices. The technology opportunity component identifies potential innovators and growth opportunities in low-carbon technologies using company-specific patent data (MSCI, 2021). MSCI also reports a TVaR of -80.16% under the NGFS Disorderly—Divergent Net-zero scenario, reflecting the high policy cost in this narrative.

NGFS Scenarios	1.5° Orderly Scenario	1.5° Disorderly Scenario	2° Orderly Scenario	2° Disorderly Scenario	3° NDC Scenario
Transition Risk Total	**- 20.18%**	**-80.16%**	**-6.32%**	**-48.31%**	**-3.00%**
Policy Cost (Scope 1,2,3)	- 25%	- 91.35%	- 7.18%	- 55.84%	- 3.18%
Technology Opportunity	+4.83%	+11.20%	+0.86%	+7.53%	+0.17%

Figure 12: TVaR breakdown under NGFS scenarios (MSCI, 2022)

MSCI has defined and calculated TVaR based on the percentage cost that could bring the enterprises into the risk instead of probability distributions. This methodology translates the climate-related risk and opportunities into financial impact; i.e. the impact of the PV of future climate cost on current enterprise valuations. Both mathematical functions for policy cost and technology opportunities are combinations of quadratic and linear functions, creating a profile of cost profiles.

The ISS ESG TVaR reflects the difference in a company's current share price and its share price once the financial implications of a transition scenario have been taken into account. The VaR includes both potential risks and opportunities from the transition.

WTW's CTVaR metric is essentially different from the standard value-at-risk concept used by financial professionals, which measures a portfolio's maximum loss at a certain confidence level. Instead, WTW's CTVaR methodology calculates the difference in the value of a company between a transition scenario and a business-as-usual scenario (current market expectations). It accomplishes this calculation by estimating how the company's individual characteristics, and the characteristics of its sector, change under different climate scenarios; and then using discounted cash flow valuation to derive the difference in value of the company between scenarios. As a result, WTW's CTVaR measures expected losses—or increases in value—for a particular transition scenario. For this methodology, neither the confidence level nor the probability distribution assumptions are relevant.

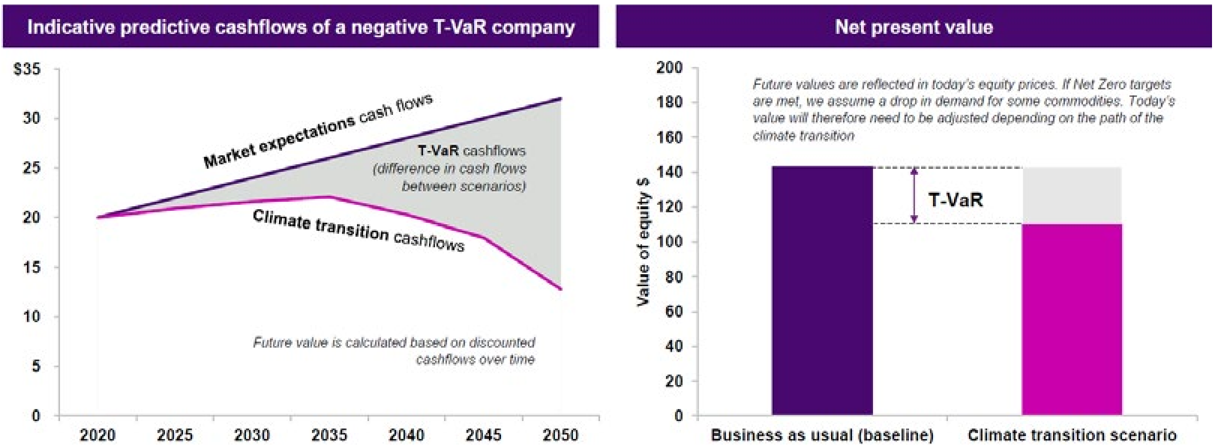


Figure 13: TVaR calculation with predictive cashflows (WTW, 2022)

WTW estimated that 48% of Weighting A attributes have a zero CTVaR, which is expected due to the portfolio's loan-heavy composition. It indicated that debt instruments typically have a 0% TVaR unless they exhibit a combination of factors, such as long tenor, low coupon, high duration, poor credit rating, and low business CTVaR.

2.4.5 Other economic value results

The tables below display economic value outcomes from transition risks, as analysed by PwC GmbH WPG and Aladdin Climate. Although both vendors focus on NGFS scenarios with a 2050 time horizon, their economic metrics are fundamentally distinct.

PwC GmbH WPG uses the cumulative return method, calculating the percentage change of EBITDA compared to 2021 and then weighting this figure based on investment exposure. The latter calculation considers changes in volume and margin influenced by individual company activities and geography. With a 'mainstream' adaptive capacity assuming companies align with market trends and meet their climate targets, PwC GmbH WPG reports positive cumulative returns. In particular, it spotlights transition opportunities in North American renewable energy and transportation. Portfolio value is bolstered by significant investments in rail transportation, growing shares in electric utilities due to electrification demand, and the benefits accrued to manufacturers from transition products. However, a large mining sector share tempers performance.

Table 17: Cumulative return results from PwC GmbH WPG

Vendor	Cumulative return	Time frame	Baseline year	Reference data	Climate model and scenario
PwC GmbH WPG	8.31% (Mainstream adaptive capacity) -33.57% (Inaction adaptive capacity)	2050	2021	2021	IEA 1.5°C (GEC model)
PwC GmbH WPG	15.46% (Mainstream adaptive capacity) -22.41% (Inaction adaptive capacity)	2050	2021	2021	NGFS Orderly—Net Zero 2050 (GCAM model)
PwC GmbH WPG	5.19% (Mainstream adaptive capacity) -33.54% (Inaction adaptive capacity)	2050	2021	2021	NGFS Disorderly—Delayed Transition (GCAM model)

The vendor has emphasised that positive results with the mainstream assumption should not be mistaken for an absence of risks. If the cumulative change is compared with the projected growth until 2050, the discrepancy between this expected growth rate and the cumulative results accentuates the adverse impact of climate change in comparison to a world unaffected by climate change.

Conversely, Aladdin Climate scenario analytics are expressed as Climate-Adjusted Values for Transition Risks (TCAV). These are based on discounted cash flow analysis in each scenario relative to a 'counterfactual' scenario that is assumed to be priced into current valuations. The 'counterfactual' (NGFS Current Policies) assumes that no additional policies are enacted for transition risk. The outputs are therefore conservative by design (i.e. they produce more severe outcomes), which is consistent with market practice for stress testing.

Table 18: TCAV results from Aladdin Climate

Vendor	TCAV	Time frame	Baseline year	Reference data	Climate model and scenario
Aladdin Climate	-12.8%	2050 (discounted back to present value)	2021	Depending on data availability	NGFS Orderly—Net Zero 2050 (A combination of Integrated Assessment Model REMIND-MAgPIE and the macroeconomic model NiGEM is used in the Aladdin Climate models.)
Aladdin Climate	-11.3%	2050 (discounted back to present value)	2021	Depending on data availability	NGFS Disorderly—Delayed Transition (A combination of Integrated Assessment Model REMIND-MAgPIE and the macroeconomic model NiGEM is used in the Aladdin Climate models.)

To address data gaps where company-level data are unavailable, PwC GmbH WPG suggested proxying company data with sector and country-level information. Aladdin Climate can infer or calculate certain key financial metrics from the remaining financial data provided by the company. Clients are encouraged to engage with vendors and contribute information. Neither PwC GmbH WPG nor Aladdin Climate process companies with insufficient data to infer required metrics in limited instances.

Some tools presented integrated risk assessment results that merged both transition and physical risk assessments. Given the close relationship between transition risk and integrated risk outcomes, the integrated results are also incorporated in this section, as presented below.

Table 19: Integrated risk assessment results from two vendors

Vendor	Integrated economic value results	Time frame	Baseline year	Data source	Climate model and scenario	Counterparty coverage
Ortec Finance	-7.10%	2060	N/A	External	Orderly Net Zero	353/358 dummy portfolio entries excluding mortgage lending
Ortec Finance	-9.70%	2060	N/A	External	Disorderly Net Zero	353/358 dummy portfolio entries excluding mortgage lending
Ortec Finance	-19.70%	2060	N/A	External	Failed Transition	353/358 dummy portfolio entries excluding mortgage lending
Planetrics[14]	-2.4%	2050 (transition risk), 2080 (physical risk)	2021	External	Current Policies Scenario (NGFS)	244/358 listed dummy portfolio entries where ISINs were available
Planetrics	-14.6%	2050 (transition risk), 2080 (physical risk)	2021	External	Net Zero 2050 (NGFS)	244/358 listed dummy portfolio where ISINs were available
Planetrics	-13.3%	2050 (transition risk), 2080 (physical risk)	2021	External	Forecast Policy Scenario (UN PRI Inevitable Policy Response)	244/358 listed dummy portfolio entries where ISINs were available

14 Information in this table has been created by UPEP FI drawing on selected data provided by Planetrics, a McKinsey & Company solution (which does not include investment advice). This table represents UNEP FI's own selection of applicable scenarios selection and/or and its own portfolio data. UNEP FI is solely responsible for, and this report represents, such scenario selection, all assumptions underlying such selection, and all resulting findings, and conclusions and decisions. McKinsey & Company is not an investment adviser and has not provided any investment advice.

Notably, Ortec Finance deviated from standard NGFS scenarios in its development of bespoke scenarios created in collaboration with Cambridge Econometrics' E2ME model (McGovern., *et al.*, 2018) based on sector-region modelled datapoints. These scenarios utilise a non-equilibrium model, accounting for real-world inefficiencies, such as involuntary unemployment, and they do not assume optimising behaviour or full resource use. Ortec Finance suggests that non-equilibrium models should be increasingly considered for fields requiring projections of non-equilibrium phenomena, like the low-carbon transition, where trend continuation does not lead to a long-term optimum (Bowdrey and Hidi, 2022).

Equilibrium models (GEM-E3, GTAP, PRIMES etc)	Non-equilibrium (eg post-Keynesian E3ME)
Neoclassical microeconomic assumptions	Not assume optimising behaviour
Rational agents **optimise** their behaviour	Derive behavioural parameters from historical relationships using econometric equations
Efficient markets hypothesis broadly consistent with the CGE model assumptions	Bounded rationality; uncertainty; **path dependence; learning effects**
Money supply determined by central banks (exogenous) • **Neutrality of money** • **Crowding out of investments**	Endogenous money • Money is created by banks through new loans • **No crowding out of investments** • New investments are financed by new bank loans (if banks have confidence that those investments are profitable)

Figure 14: Key differences between equilibrium and non-equilibrium models

Ortec Finance establishes a baseline for comparing cumulative returns using Ortec Finance Scenario Sets (OFS). This baseline differs from the Failed Transition scenario, as it does not account for the significant physical risks that will impact all financial markets of business-as-usual. Ortec Finance's approach emphasises capturing systemic climate risk through a top-down methodology, rather than aggregating climate risk at the holding-specific level.

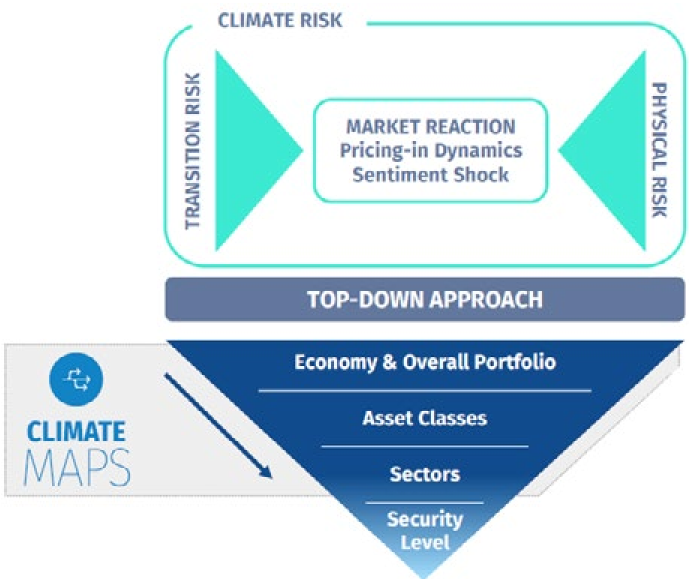


Figure 15: Top-down approach illustration (Ortec Finance, 2022)

For this exercise, the dummy portfolio data were combined with two scenario sets in the Planetrics PlanetView model: the NGFS scenarios and the UN PRI scenario set, which represents a high conviction, policy-based forecast with 'bottom up' view of which technology and policy developments are most likely to emerge.

The overall value result generated using the Planetrics model represents the combined impact of several distinct transition risks as well as a range of chronic and acute physical impacts. This is expressed as a change in value relative to a baseline scenario that assumes no additional physical impacts or climate policies beyond the baseline year. As well as the direct impact of the physical and transition risks, the model also captures actions that reduce companies' exposure to transition risks (abatement) and physical risks (adaptation). It also takes account of market dynamics for the companies being modelled. Specifically, companies that are highly affected by additional costs from physical or transition risks may need to exit some of the markets in which they compete, and will be limited in the extent to which they can pass additional costs through to consumers—resulting in a larger impact on value. Conversely, companies that are less negatively impacted may gain market share and pass a higher proportion of their increased costs on to consumers.

SECTION 3:

Comparing physical risk tools

3.1 General approaches for physical risk assessment

The 2023 Climate Risk Landscape Report has provided a comprehensive overview of various physical hazards, the types of data available, and the step-by-step process for physical climate risk assessments. As such, this section will only briefly summarise the common methods. Generally, the steps outlined below can be employed to achieve a more comprehensive assessment:

Identifying the physical hazards that are relevant to a company's operations and assets, such as floods, hurricanes, droughts, and heat waves

Assessing the likelihood and potential **severity of these hazards** by analysing historical data and making forward-looking risk projections based on climate models and other relevant information

Evaluating the exposure and vulnerability of a company's assets and infrastructure to these hazards, taking into account factors such as location, design, and maintenance

Identifying the **potential financial impacts** of these hazards on a company's operations, assets, and overall financial performance.

Developing a risk management plan that includes strategies for mitigating the risks and reducing the potential impacts of the hazards on a company.

3.2 Metrics used to quantify physical risk

Physical risk metrics are quantitative measures that are used to assess the potential impacts of physical hazards such as extreme weather events, sea level rise, and changes in precipitation patterns on a company's operations, assets, and overall financial performance. Some examples of physical risk metrics summarised from various climate tools include:

Table 20: Examples of physical risk metrics

Metrics	Description
Return period	This is the average time between occurrences of a given hazard, such as a 100-year flood, which has a 1-per-cent probability of occurring in any given year. It is used to estimate the likelihood of a hazard occurring in a given location.
Damage ratio	This is the ratio of the total damage caused by a hazard to the value of the assets at risk. It is used to estimate the potential financial impacts of a hazard on a company's operations and assets.
Vulnerability index	This is a measure of the susceptibility of a company's assets and infrastructure to a given hazard, considering factors such as location, design, and maintenance. It is used to identify the assets and infrastructure that are most at risk from a given hazard.
Adaptive capacity index	This is a measure of a company's ability to adapt to the impacts of climate change, taking into account factors such as financial resources, technical expertise, and governance structures. This also includes broader measures such as local flood and storm surge defences.
Loss Event Frequency (LEF)	This is the number of times the specific event happens in a certain period of time. It can be used to calculate the probability of an event happening.
Loss Event Magnitude (LEM)	This is the loss/damage caused by an event. It can be used to understand the severity of the event and its impact on the company.
Annualised Loss Expectancy (ALE)	This is the expected loss for a specific hazard, per year, based on its occurrence frequency and expected damage per event. It can be used to understand the financial impact of a hazard.
Exposure at Risk (EAR)	This is a measure of the assets and liabilities that are exposed to the event. It can be used to understand the total potential loss of the event.
Business Downtime	These include impacts to business operations, such as days downtime, repair costs, productivity loss, and higher production costs
Local Economic Impact	These metrics incorporate hazard impacts to local economic conditions, such as GDP losses, increased unemployment, and decreased property values.

3.3 General assumptions underlying physical risk metrics

There are several factors that drive differences in the results between tools, including:

Table 21: Factors driving differences in results for physical risk assessment

Factor	How it influences physical risk tools	Examples from dummy portfolio exercise
Reference data set	The data set over which the model was built. The consideration of the reference year is essential in climate risk assessment, as the quality and relevance of the data can vary over time.	Model reference period: 1990–2020
Range of hazards	The number and types of hazards included in the study. For example, coastal floods being included in some examples but not in others.	A model covers three hazards: floods, heat, and wildfire
Adaptation assumptions	The extent to which assets are expected to adapt to changing climate conditions and to mitigate physical risks. Some models assume no adaptation whereas others have dynamic adaptation.	A model considers flood defences at a country level and assumes them to remain at the same level in the future.
Geographic resolution	The level of detail in the data, ranging from country-level to building/asset level. Additional locational information may be included, such as hydrological data or building material.	A tool has a resolution of asset-level with archetype and building construction year considered.
Underlying data	▪ **Data sources**: if a vendor is using self-collected/ external data to perform analysis, and if the validation has changed the data. ▪ **Counterparty coverage**: not all tools will be able to cover every counterparty in a given portfolio, and some may rely on general assumptions or proxies for missing counterparties. Even if two tools have the same percentage coverage, the counterparties covered by that percentage may differ. ▪ **Approach for estimating proxies or covering data gaps** (including where no direct data are available) ▪ **Rationale for exclusion of counterparties**, such as no ISIN codes.	**Data source**: Self-collected **Counterparty coverage**: The results studied 200/358 securities, excluding unlisted equity, and sovereign and municipal bonds. **Approach for data gaps**: A model uses backfilling and disaggregates companies' total fixed asset value and total enterprise value by location based on certain physical attributes and economic variables. **Rationale for exclusion of counterparties:** Some of the positions fall outside of a tool´s standard coverage universe.

For forward-looking physical risk metrics, key building blocks also include:

Table 22: Key building blocks of forward-looking physical risk metrics

Factor	Explanation of effects on forward-looking assessment results	Examples
Time horizon	**Definition:** The period over which the tool estimates results. **Explanation:** Some tools may estimate risk over the next 10 years, while others may estimate it over a more extended period, such as next 50 years.	A tool is forward-looking estimating risks over 2020–2100, with five-year timesteps.
Baseline year	**Definition:** The period against which the future physical risk is compared. **Explanation:** The choice of the baseline year has implications for comparing future physical risks. The baseline year serves as a reference point to assess changes and trends in physical risk over time. By establishing a baseline, it becomes possible to measure the extent of deviations or shifts in risk levels in the future. Different base-line years may lead to variations in the perceived magnitude and direction of future changes in physical risk.	The baseline period that a tool employs is 2000-2020.
Climate scenarios and models	**Definition:** Scenario elements such as Representative Concentration Pathways (RCPs) and shared socioeconomic pathways (SSPs) as well as the underlying physical hazard model (often part of the coupled model intercomparison project [CMIP] or IPCC set). **Explanation:** Different climate scenarios and models may yield varying projections of future climate conditions, leading to differences in estimated physical risks. It is important to consider a range of scenarios and models to capture the uncertainties associated with climate change and provide a more comprehensive understanding of potential future risks.	A tool uses REMIND-MAgPIE climate model for the NGFS Hot House World scenario for physical risk assessment.
Vulnerability curves	**Definition:** Vulnerability curves represent the relationship between a hazard intensity (such as flood depth or wind speed) and the resulting damage or loss to assets or systems. These curves provide insights into the vulnerability of different elements exposed to hazards, helping to quantify the potential impacts. **Explanation:** Changes in the shape, parameters, or underlying data of vulnerability curves can influence the projected outcomes of physical risks. For example, updating a vulnerability curve to reflect improved resilience measures may lead to lower estimated damages, while incorporating more accurate asset vulnerability data may result in higher projected damages.	A climate risk assessment tool incorporates vulner-ability curves for coastal regions to understand the relationship between sea-level rise and the potential damage to infrastructure and ecosystems. The curves quantify how different levels of sea-level rise can lead to varying degrees of erosion, inundation, and loss of habitats.

Damage functions	**Definition:** Damage functions translate the hazard intensity into monetary or physical damage estimates. They provide a systematic way to assess the potential losses or damages that can occur due to specific hazard events. **Explanation:** The shape and parameters of damage functions determine how hazard intensity is converted into monetary or physical damage estimates. By incorporating these functions, risk assessments gain accuracy in estimating the economic and physical implications of future hazard.	In a flood risk assessment tool, damage functions are utilised to estimate the monetary losses caused by different flood intensities. The functions consider factors such as the depth and duration of flooding, building characteristics, and the vulnerability of assets. By applying the damage function to the flood intensity, the tool can estimate the financial impacts on infrastructure, buildings, and other exposed elements.
Geospatial data	**Definition:** Data that provides information on the spatial distribution of assets, hazard exposures, and vulnerabilities. **Explanation:** By providing detailed and accurate information about the location, characteristics, and vulnerabilities of assets, as well as the spatial distribution of hazards, geospatial data enables a more precise assessment of physical risk. The quality and availability of geospatial data directly impact the accuracy and granularity of forward-looking assessments.	The data include information on vegetation types, topography, weather patterns, and historical fire occurrences. By analysing the spatial distribution of these factors, a tool can identify high-risk zones and assess the potential extent and severity of future wildfires in specific geographic areas.
Inclusion of interaction effects	**Definition:** The assumptions made about the interactions between sectoral risks, between physical and transition risks, and second order effects such as economic consequences of the primary risk. **Explanation:** By considering the interactions between sectoral risks (such as the interconnectedness between different industries or sectors) and the interactions between physical and transition risks (such as the influence of climate change on market dynamics), a more comprehensive understanding of risk dynamics emerges. These interaction effects also encompass second-order effects, including the economic consequences that arise as a result of primary risks.	A model assumes the increasing adoption of clean energies will reduce emissions and mitigate some physical risks.
Underlying risk model and methodology	**Definition:** The statistical methodologies to translate information of climate scenarios and climate models to risk outputs. **Explanation:** Different models and methodologies may utilise various statistical techniques, assumptions, and algorithms to capture and quantify the relationship between climate variables and physical risks. Factors such as the model's sensitivity to different climate scenarios, its ability to capture extreme events, the consideration of uncertainties, and the incorporation of relevant factors like adaptation and mitigation strategies all impact the final results.	A tool uses multiple regression for the calculation of expected loss.

The following sub-sections will delve into the reasoning and specific assumptions associated with three selected metrics that vendors from the working group predominantly utilise for portfolio-level assessments: physical risk score, PVaR, and expected loss.

3.3.1 Physical risk score

Climate physical risk scores offer a method for evaluating the potential impact of climate change on specific locations or regions. These scores consider physical factors such as temperature, precipitation, sea level rise, and extreme weather events in order to determine the likelihood of physical damage or disruption to infrastructure and property. They can inform risk management and adaptation strategies as well as help identify areas particularly vulnerable to climate change effects.

Physical risks are assessed using hazard indicators, with each asset receiving a risk score. Most tool providers include an indicator score along with a raw value. Tools typically aggregate data on individual hazards, as in the case of Munich RE's 17 hazards or XDI's 10 perils, for example. Tool providers may first apply hazard impacts at the company level, considering hazard intensity and probability, and then assessing vulnerability. The risks are subsequently applied across multiple time horizons by estimating the PV of cash flows, which are then converted into a risk score. Essentially, this represents the climate hazard's impact over an asset's lifetime. However, not all vendors base their approaches on discounted cash flows or hazard aggregation, despite their common use in physical risk scores calculations.

The definition and interpretation of physical risk score are critical elements in tool comparison. Even if vendors provide results at similar levels, tool users cannot assume that they are directly comparable. This is because the use cases and underlying scale can be totally different.

Hain *et al.*'s paper compared six physical risk scores from Trucost (M1), Carbon 4 Finance (M2), Southpole (M3), Truvalue Labs (L1), Firm-level Climate Change Exposure (L2), and BERT-based climate risk measure (L3). The table below presents the distribution of climate risk scores generated by commercial tools, highlighting the low agreement among scores for 408 US corporations. There is significant divergence between scores, even among those using similar methodologies. Thus, it is crucial for tool users to understand the key assumptions in Section 3.2 and ensure clear communication of physical risk score definitions. Transparency regarding tool methodologies, use cases, and limitations is vital when utilising physical score results.

Table 23: Physical score ranking from six tools for 11 sectors (Hain et al., 2022)

Sector ranking: Horizon 2050, RCP8.5.								
Sector	**M1**	**M2**	**M3**	**L1**	**L2**	**L3**	**Avg**	**SD**
Health care	9	6	7	10	9	11	8.7	1.9
Consumer staples	7	5	5	4	8	3	5.3	1.9
Consumer discretionary	3	8	9	6	6	6	6.3	2.1
Information technology	10	7	6	5	10	9	7.8	2.1
Energy	4	2	1	7	5	4	3.8	2.1
Materials	5	3	2	8	3	2	3.8	2.3
Industrials	6	4	8	2	2	7	4.8	2.6
Communication services	8	10	10	3	11	10	8.7	2.9
Financials	11	9	3	1	7	8	6.5	3.8
Real estate	2	11	11	9	4	5	7.0	3.8
Utilities	1	1	4	11	1	1	3.2	4.0

3.3.2 Physical value-at-risk

Similar to transition value-at-risk, physical value-at-risk (PVaR) measures of the risk of loss for investments and asset holdings. Most vendors use PVaR to estimate how much a portfolio or investment may lose (within a given level of confidence) over a certain time period. Other vendors focus on quantifying the additional value-at-risk specifically attributable to climate change. They assume that the baseline physical risk is already fully priced in, and their PVaR calculations concentrate on assessing the incremental risk posed by climate-related factors.

In addition to the general assumptions explained above, other PVaR-specific considerations include:

Table 24: Factors affecting PVaR

Factor	Explanation	Examples
Definition of PVaR	The way PVaR is defined may vary across tools, which can affect the comparability of results between vendors. It is important to understand whether a tool measures the maximum loss under a worst-case scenario or the expected losses over a range of climate scenarios. For example, MSCI's CVaR considers economic, sectoral, and company-level data for an estimated change in financial valuation of assets and portfolios that could be resulted from physical risks and opportunities.	A tool defines PVaR as the maximum loss that would result from the financial impact of physical risks from all hazards for a certain portfolio.

Confi-dence level	Different confidence levels, such as 90%, 95%, or 99%, can impact the magnitude of estimated losses and the level of risk that is acceptable to the FI. For instance, a 99-percentile confidence level may result in a significantly larger loss compared to a 90-percentile confidence.	A model uses a confidence level of 99%.
Choice of probability distribution	Vendors may use probabilistic modelling with varying assumptions on probability distributions of physical risks' materialisation, such as normal or skewed distributions like lognormal distribution, for the assessment of transition risks or risk drivers. The choice of tail of the distribution influences the likelihood of extreme events in the distribution. A fat-tailed distribution can result in a higher CVaR estimate.	A model assumes a fat-tail distribution of cost.

Vendors offering PVaR results utilise mathematical modelling approaches to connect climate models and scenarios so as to calculate climate impacts on costs and revenues and integrate forecasted results into standard investment indicators like PVaR results. A general assessment workflow might look like this:

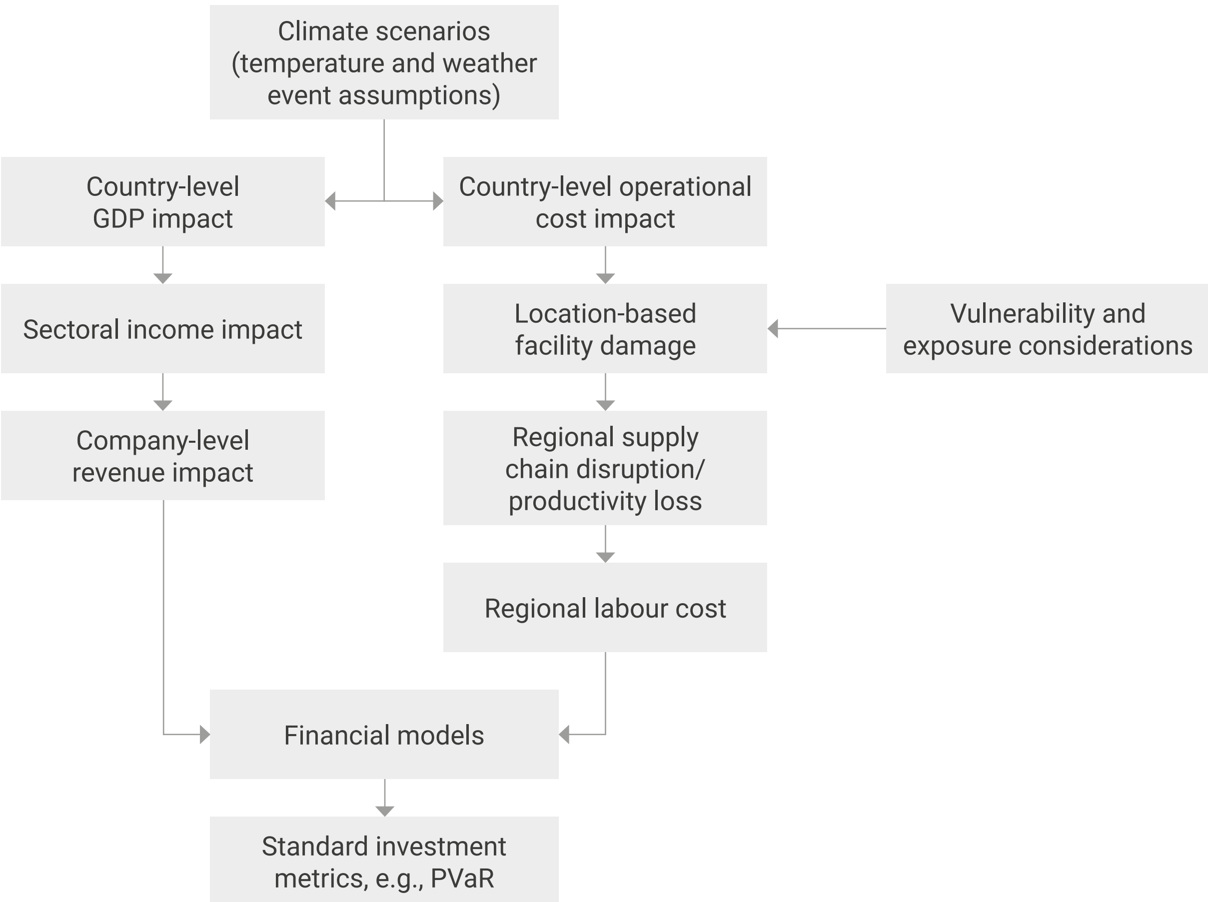


Figure 16: A general physical risk assessment workflow (UNEP FI, 2023)

For instance, MSCI measures vulnerability, hazard, and exposure elements for its PVaR. Here, exposure is defined as the presence of people, livelihoods, resources, and other assets in places and settings that could be adversely affected. Vulnerability is the propensity or predisposition of an asset to be affected, including sensitivity or susceptibility to financial harm (or opportunity) and capacity to cope and adapt (MSCI, 2021). This hybrid model combines top-down elements assigning portions of risk or opportunity to several asset classes and bottom-up elements with asset location risk assessment.

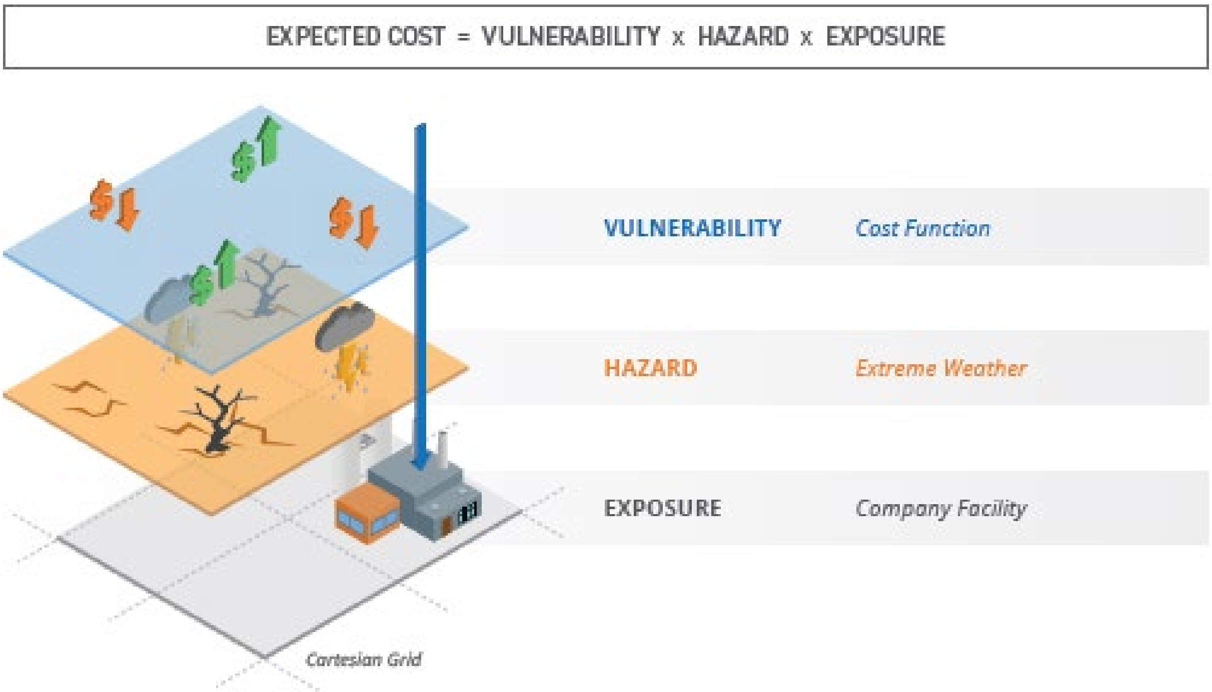


Figure 17: High-level overview of physical risk calculation (MSCI, 2021)

Another example is Blackrock's Aladdin Climate model, which measures the output risk and operations risk from climate scenarios. For output risk, it captures the hazard impact on country-level GDP and distributes company revenue losses as a function of country exposure. For operational risk, the model accounts for peril damage, impact to labour, and energy costs considering locations of physical assets and facilities. CLIMAFIN also estimates yearly future damages on physical capital as a share of global GDP and creates a linear model to allocate direct damages among private, public, and insurance sectors. It focuses on linkages to the financial sector through ownership links, credit risk transfer instruments, and mutual asset exposure.

3.3.3 Expected loss and climate adjusted value

Physical risk expected loss is a metric used to quantify the potential impact of physical risks, such as natural disasters, on specific locations or regions. Expected loss is the average anticipated loss faced by an asset under a given scenario. It is often presented as a percentage of asset value. The results are then employed to inform decisions about risk management, adaptation strategies, and the identification of areas particularly vulnerable to physical risk effects.

Some expected loss-specific assumptions to consider include:

Table 25: Assumptions related to expected loss

Factor	Explanation	Examples
Definition of Expected Loss	The way expected loss is defined may vary across tools and it may impact whether expected loss results are comparable across vendors.	A tool defines expected loss as the projected financial costs (in USD) relative to the baseline summed across all the modelled hazards.
Loss functions	This assumption determines how climate-related hazards are translated into financial impacts, whether through a replacement cost approach, income approach, or more complex methods.	A tool uses a function of revenue impact due to changes in macroeconomic conditions in the indicated region, and additional costs due to direct impact on facilities by hurricanes, labour, and energy costs.
Confidence level	Different confidence levels, such as 90%, 95%, or 99%, can impact the estimated losses based on the loss distribution. A 99-percentile confidence level may result in a significantly larger loss compared to a 90-percentile confidence.	A model uses a confidence level of 99%.
Choice of probability distribution	Vendors may use probabilistic modelling with varying assumptions on probability distributions of physical risks' materialisation, such as normal or skewed distributions like lognormal distribution, for the assessment of physical risks or risk drivers. The choice of tail of the distribution influences the likelihood of extreme events in the distribution. A fat-tailed distribution can result in a higher CVaR estimate.	A model assumes a fat-tail distribution of cost.

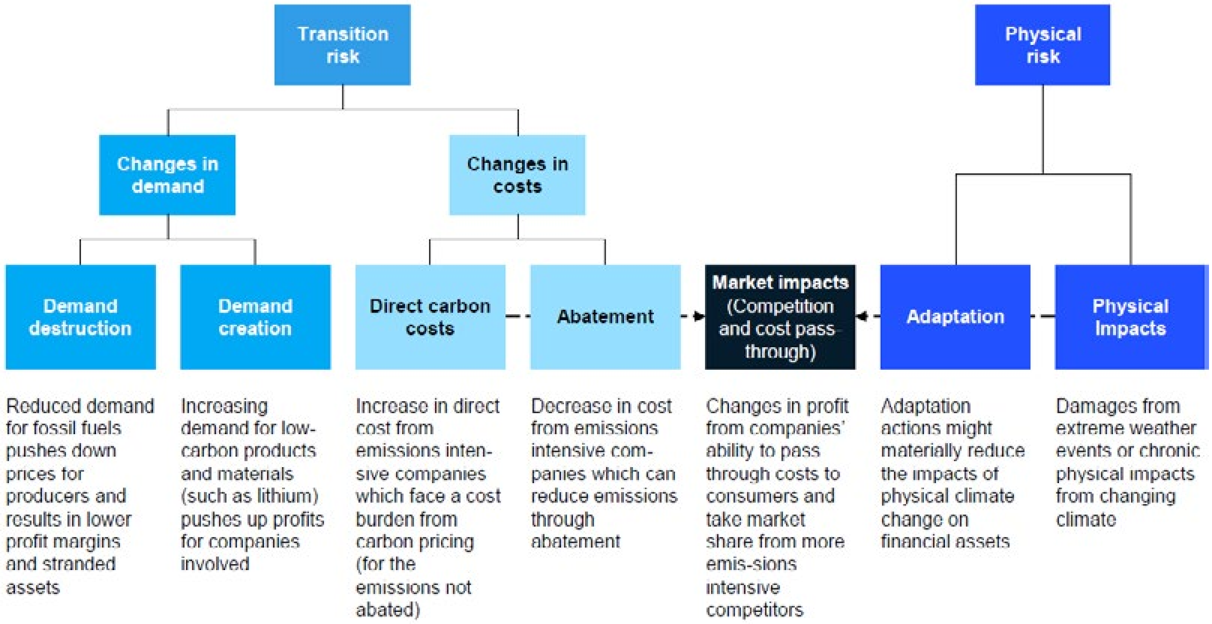


Figure 18: Physical risk impact channels[15] (Planetrics, 2022)

As with other economic value outputs, expected loss calculation typically starts from assuming a scenario and assessing physical risks under impact channels within that scenario. Next, it is ordinary to model the valuation through a loss function of climate change impact on revenue and additional expenditures due to the direct damages on facilities by natural hazards or impacts through other elements such as labour/ energy costs. PWC GmbH WPG, for example, derives financial impacts via multiple steps from changes in hazard frequency and sales share to impacts on an issuer's earnings before interest and taxes margin.

Several statistical techniques can be used for expected loss calculation. The primary purpose is to model the relationship between the dependent variable (i.e. expected loss) and independent variables (i.e. hazards or risk factors) and to make predictions and estimations. For example, multiple regression and generalised linear models (GLMs) help explore the relationship between expected loss and multiple independent risk predictors (hazard intensity, exposure, and vulnerability). It also allows metric users to determine the weight or importance of each risk factor in contributing to the expected loss.

In addition to expected loss, tool users also see metrics such as physical climate adjusted value in the market. The given asset's cash flows are adjusted based on these projected climate events and are discounted back to the PV. The results for both metrics will be discussed in Section 3.4.3.

15 The physical risk modelling capabilities employed in this simplified exercise represent a limited set of Planetrics overall capabilities. It is important to note that the capabilities utilised were carefully selected to suit the scope of this exercise.

3.4 Physical risk quantifications at portfolio level

Like the transition risk outputs in Section 2.4, the last part of Chapter 3 displays the aggregate-level results from the most used physical risk metrics and aims to discuss the assumption difference across tool providers. The analysis presented should be viewed to deepen understanding of the tools' underlying methodologies, rather than as a judgment of their relative correctness or effectiveness. This section will also focus on presenting the most intriguing and relevant assumptions for discussion.

3.4.1 Physical risk score

Although one of the most common parameters for physical risk assessment, a physical risk score can have different scales and very distinct implications, as already described in Section 3.3.1. Results at a high level are presented as follows:

Table 26: High-level results of physical risk score from three vendors

Vendor	Physical risk score (100)	Scope of hazards	Geographical resolutions	Time frame	Reference data	Baseline	Climate Scenario	Data sources	Counterparty coverage
S&P Global Sustainable1	76.9	8 hazards[16]	Variable resolution by hazard type	2050	Variable reference by hazard type 1950-2010	Not relevant	Medium-High Scenario SSP3 -RCP7.0	External	272/358 dummy portfolio entries
Moody's	53.4	6 hazards[17]	Variable resolution down to 10x10 meters	2030-2040	Variable reference by hazard type 1975-2005	2021	RCP 8.5	External	260/358 dummy portfolio entries
ISS ESG	63	6 hazards[18]	Spatial resolution of 100 km by 100 km	2050	Climate model data from the historical period (baseline 1975 or 1950-2000) to the year 2050.	2020	RCP4.5	External	302/358 dummy portfolio entries

16 Wildfire, extreme cold, extreme heat, water stress, coastal flood, riverine flood, tropical cyclone, and drought.
17 Floods, heat stress, hurricanes & typhoons, sea level rise, water stress, and wildfires.
18 River floods, coastal floods, heat stress, wildfires, tropical cyclones, and drought.

S&P Global Sustainable1 has developed a composite exposure score as a point-in-time assessment of exposure to climate hazards, independent of a specific location's asset characteristics and relative to global conditions. It calculates physical risk exposure based on a database of over 3.1 million asset locations. Where no asset-level data are available, it considers the location of the company's headquarter (20-per-cent weight) and a revenue-weighted average of the country-level physical risk exposure where the company generates revenues (80-per-cent weight). The score uses a 1-100 scale, with 100 indicating the highest risk and 1 the lowest. Exposure scores from S&P Global Sustainable1 are not calculated with reference to a baseline; they are normalised against global upper and lower hazard thresholds. For instance, a score of 76.9 compared to a score of 38.45 implies that the former is closer to the global upper threshold (maximum) than the latter. Composite exposure scores are provided as a logarithmic function of exposure to all eight hazards.

Moody's follows a similar approach with a 1-100 scale but considers six climate hazards. Its tool measures supply chain risks, operations risks (hazards), and market risk, providing information on the trend and magnitude of change in chronic and acute climate-related events. A score of 53.4/100 suggests companies in the portfolio weighting A have moderate physical risk exposure compared to others in Moody's universe.

ISS ESG, on the other hand, includes two physical risk scores in its calculation process. It calculates an absolute risk score measuring a company's exposure to physical risks by 2050 based on the total financial risk relative to company revenues and also a sector-relative physical score with the company-level weighted averages. The sector-relative physical risk score measures a company's financial risk exposure to physical risks compared to its peers within the GICS sector. Thus, the sector relative result of 63/100 would mean companies in the dummy portfolio represent a lower level of risk than their sector medians.

Vendors also apply different adaptation assumptions in their assessment. S&P Global Sustainable1 includes flood defences in coastal flood projections, for instance, but does not account for adaptation measures for other hazards. Meanwhile, Moody's acknowledges regional defences such as sea walls, but does not explicitly account for adaptation measures. Both Moody's and ISS ESG evaluate the risk management strategies employed by companies within the portfolio holdings to understand their preparedness for climate-related challenges. For example, ISS ESG incorporates a global flood protection database with flood risk maps, assuming constant flood protection standards. Moody's physical risk management scores, on the other hand, are predicted using company size, industry, and location to estimate a company's ability to manage its physical risk hazard exposures.

Tool providers are able to provide disaggregated company-level physical risk scores and help clients identify higher-risk companies. This enables engagement on mitigation plans and informs investment decisions such as acquisitions or dispositions. It also supports disclosure efforts.

3.4.2 Portfolio physical value-at-risk

PVaR measures the potential financial losses due to the physical impacts of climate change on assets and infrastructure. During the piloting exercise, three tool providers studied the PVaR parameter for portfolio weighting A and gave the results below.

Table 27: PVaR results for portfolio weighting A from three vendors

Vendor	PVaR	Scope of hazards	Physical geographical resolutions	Time frame	Reference data	Baseline year	Climate scenario	Confidence level	Distribution expectations	Data sources
CLIMAFIN	2.47%–2030 2.69%–2080 2.49%–2030 2.78%–2080	4 hazards[19]	From 500m to 0.5° depending on hazards	2030 2080	IPCC and NGFS scenario, ISIMIP bias-adjusted climate-input data sets.	2020	RCP 4.5 RCP 8.5	95th percentile	Hazard specific	Climate impact data sets are sourced from specialised modelling groups in the scientific community
ISS ESG	0.6%	6 hazards[20]	Spatial resolution of 100 km by 100 km	2050	Climate model data from the historical period (baseline 1975 or 1950-2000) to the year 2050.	2020	RCP 4.5	Not relevant	Not relevant	External
MSCI	9.98% 21.36%	10 hazards[21]	Varying spatial resolutions by hazard types[22]	2100	Variable reference by hazard types	2021	MSCI Average Scenario (RCP 4.5) MSCI Agressive Scenario (RCP 8.5)	The average scenario represents 50th percentile The aggressive scenario represents 95th percentile of the cost distribution[23]	Normal distribution of cost	Self-collected and external

19 Costal floods, river floods, wildfires, and cyclones
20 River floods, coastal floods, heat stress, wildfires, tropical cyclones, and drought.
21 Costal floods, fluvial floods, extreme heat, extreme cold, extreme snowfall, extreme wind, river low flow, wildfires, tropical cyclones, and rainfall.
22 For example, typical cell sizes are 90m x 70m for acute hazards such as floods and 56km x 42km for chronic hazards.
23 MSCI uses the python scipy.stats.norm.ppf method to obtain the values for the 95th percentile, based on the mean (average physical risk) and the standard deviation.

Regarding metric definition, ISS ESG clarifies that its scenario-based Physical Risk Value-at-Risk should not be equated with financial VaR. Instead, it represents the change in company valuation due to physical risks until 2050. A 0.6% Value-at-Risk in an RCP 4.5 likely warming scenario implies that incorporating physical risk costs into a valuation model leads to a 0.6% loss in the portfolio's value. ISS ESG highlighted that filling asset location data gaps is crucial for physical risks assessment.

MSCI also recognised the data gap in terms of the value of an enterprise's fixed assets and the revenue produced by these assets. Enterprise facility data are collected either via manual collection, web-scraping, or import of third-party databases. However, in order to estimate the fixed asset value and revenue for every facility in the portfolio, an algorithm is used to disaggregate companies' total fixed asset value and total enterprise value by location based on certain physical attributes and economic variables. Backfilling is done to close data gaps. For example, gaps in asset attributes are filled using sector mean values or averages per building type and country.

Regarding adaptive assumptions, ISS ESG mentioned that certain sovereign climate change protection measures are directly incorporated into its climate models. MSCI, on the other hand, considers regional adaptation to chronic risks by applying vulnerability reductions, believing that the vulnerability is lower in areas with frequent chronic weather extremes as local businesses have experience dealing with them. MSCI applies a regional vulnerability reduction that depends on the number of annual threshold exceedances. This can be up to 50% in regions where thresholds are commonly surpassed.

3.4.3 Expected loss and climate adjusted value

The table below presents economic value outcomes provided by three vendors for weighting A. Although all results quantify the portfolio's financial value loss from future physical hazards, there are two essentially different metrics: expected loss and physical climate adjusted value (PCAV).

Table 28: Economic value outcomes for physical risk assessments for weighting A by two vendors

Vendor	Metric results	Climate scenario	Scope of hazards	Reference data	Time frame	Baseline year	Confidence level	Distribution expectations	Data sources	Coun-terparty coverage
Aladdin Climate (PCAV)	-3.4% -4.2%	RCP 4.5 RCP 8.5	5 hazards[24]	Depending on data availability	2100	2021	Not included	Mean and 83rd percentile distri-bution points	External	297/358 dummy portfolio entries
The Climate Service (EL)	-2.4%	Medium High Scenario SSP3–RCP7.0	8 hazards[25]	Depending on data availability	2050	Not included	Not included	Not included	Self-col-lected	272/358 dummy port-folio entries

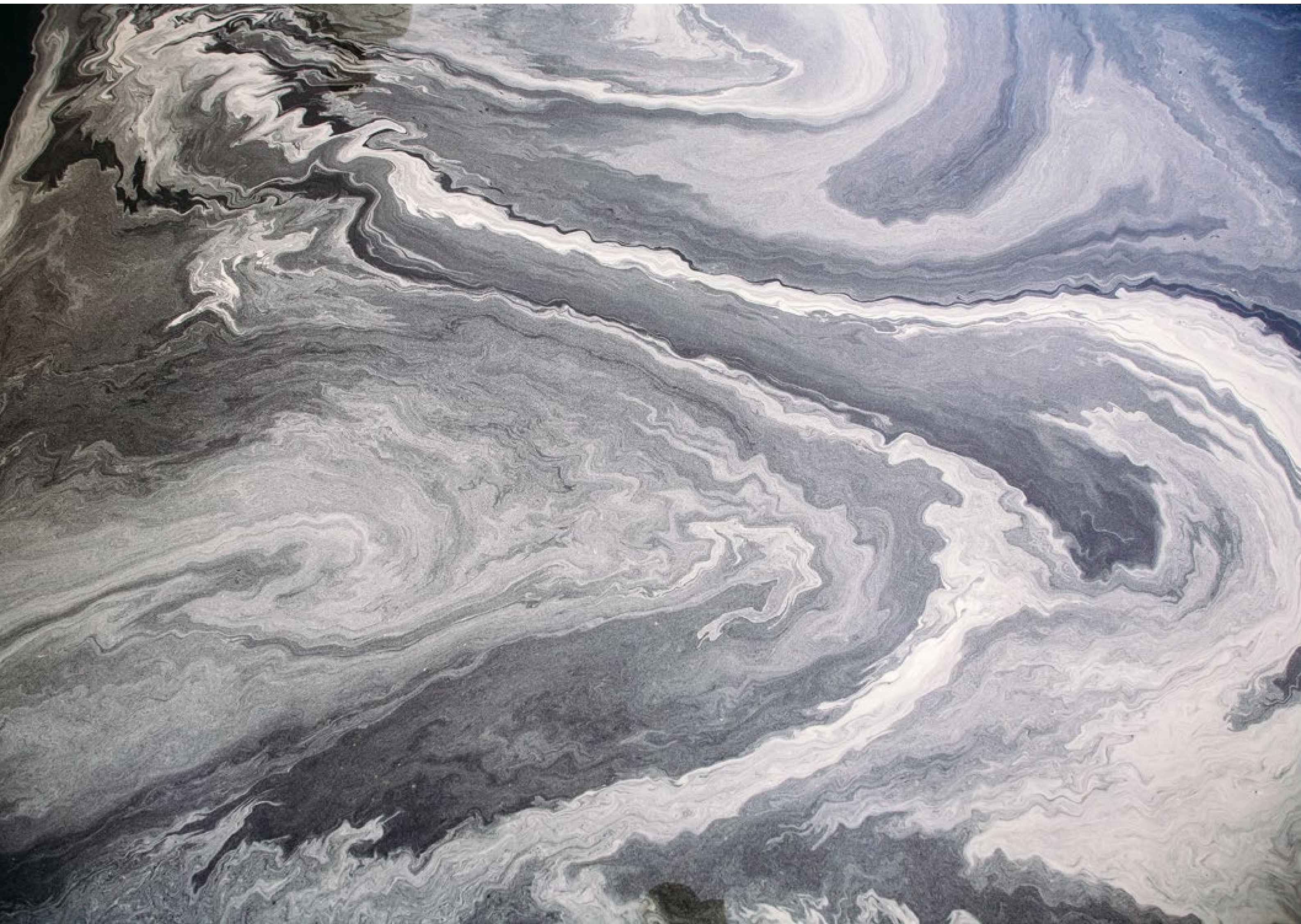
24 Rising temperatures, tropical cyclones, sea level rise, wildfires, and fluvial & pluvial flooding.

25 Wildfire, extreme cold, extreme heat, water stress, coastal flood, riverine flood, tropical cyclone, and drought.

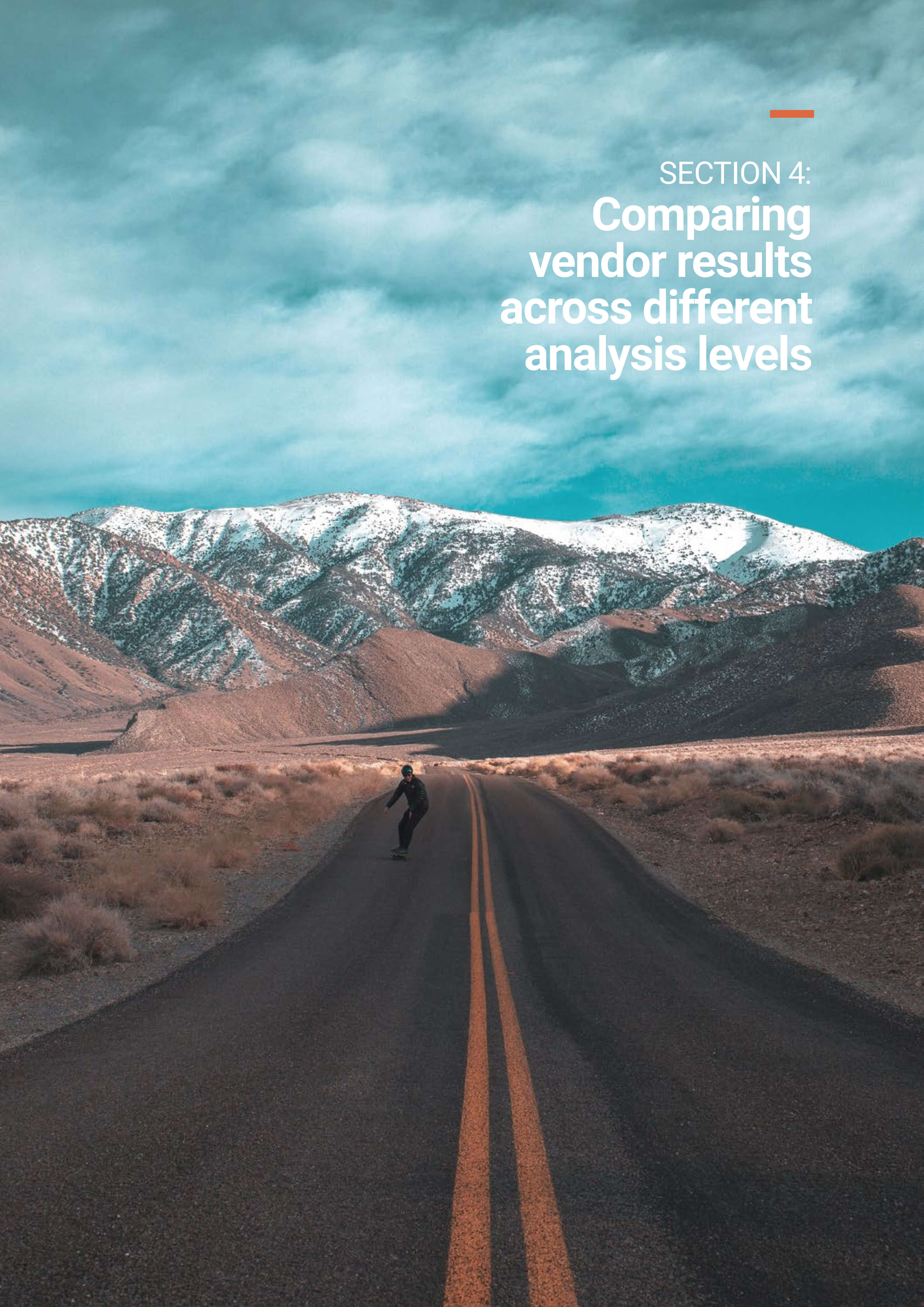
Aladdin Climate's PCAV estimates the impact on asset values by adjusting the cash flows of underlying assets according to the geolocation-level impacts of projected climate events relative to the counterfactual of no additional warming. The expected loss metric from S&P Global Sustainable1, meanwhile, represents the projected financial costs relative to the baseline summed across all the modelled hazards. As the accurate value of assets is unknown, S&P Global Sustainable1 uses a relative approach in percentages rather than in USD terms to measure expected losses.

Vendors often employ high emission scenarios such as the RCP 8.5 scenario. These worst-case scenarios underscore the potential financial implications of failing to address climate change effectively, and help clients grasp the magnitude of potential losses and adopt appropriate risk mitigation strategies. However, even lower scenarios may not take into account extremes that could occur locally.

Aladdin Climate and S&P Global Sustainable1 both indicated their physical geographical resolutions differ per hazard. For example, the most granular resolution from Aladdin Climate is 30m x 30m for inland flooding, while other hazards (e.g. temperature data) have a resolution of 27km x 27km. All vendors quantify the impact on the projected annual value stream and change in equity value using discounted cash flow analysis. In the integrated value impact results presented in Section 2.4.5, Planetrics also considers adaptation actions (e.g. flood defences at a region level) that may materially reduce the impacts on financial assets.



SECTION 4: Comparing vendor results across different analysis levels



4.1 Sector drill down: hotspot analysis

The upcoming subsection sector drill down explores the various sectors that contribute to carbon emissions and investigates why they impact the dummy portfolio in the way they do. The analysis begins by examining the overall contributions of each sector to carbon emissions; to standardise the sector analysis, the focus is on the Net-zero Emissions by 2050 scenario (NZE2050) by IEA. However, as some vendors utilise scenarios other than those from IEA, examples from other scenarios are also presented. In addition, the focus is on results that are unexpected or counterintuitive. While energy companies are expected to have a large negative impact on portfolios, for instance, transition risk analysis reveals that this might not always be the case.

By diving deep into certain key sectors, readers can gain a better understanding of how sectors impact portfolios and identify potential risks and opportunities related to their carbon emissions. The focus of this 'drill down' will be sectors with the highest weights in the dummy portfolio, including Agriculture, Oil & Gas, Energy and Transportation.[26] To ensure a wide variety of vendors and methodologies are represented, this section covers both transition risks and physical risks.

Agriculture

For assets in the agricultural sector, estimates of transition risk vary by vendor. However, across the board, the results from the assets in this sector show high absolute emissions. According to Moody's, agriculture is among the top four highest-emitting sectors and is responsible for 9% of the whole portfolio's emissions. Oliver Wyman/S&P Global's analysis shows a high impact on creditworthiness of sampled counterparties in that sector. This is explained by the sector's high Scope 1 emissions intensities (especially from livestock). Likewise, sample portfolio results of Aladdin Climate's scenario analysis show a transition risk-adjusted value of around 10%. The figures below show portfolio level impacts from Oliver Wyman/S&P Global. The results from the pilot exercise indicate significant transition climate risks in the agricultural sector and potential negative financial returns if companies do not adapt to stricter climate conditions.

26 The Real Estate Sector was excluded from the scope of the project due to limitations in the ability to provide vendors with granular data.

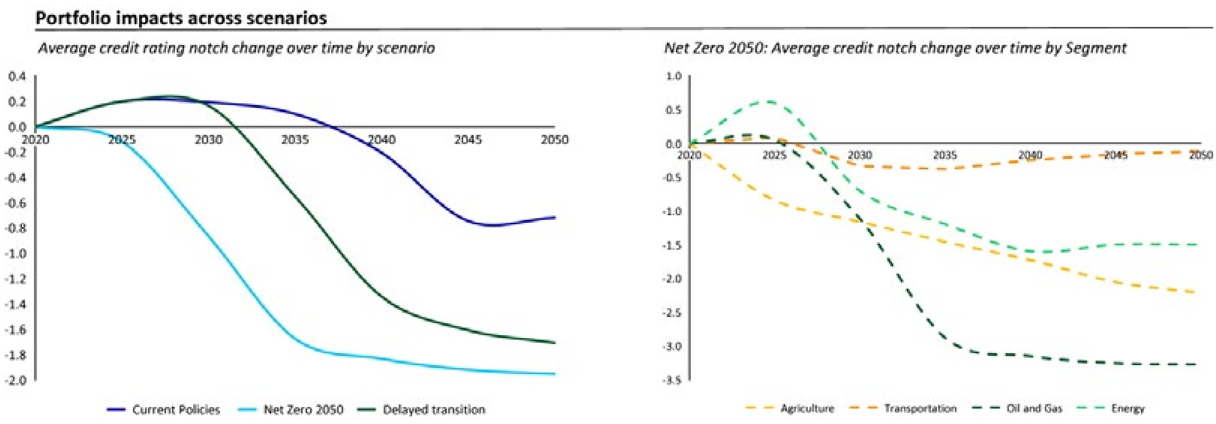


Figure 19: Portfolio-level credit score across scenarios and sectors (Oliver Wyman/S&P Global, 2022)[27]

Meanwhile, high-risk scores are received from several vendors for companies in this sector. Further, results extracted from PwC GmbH WPG show positive cumulative returns. In its analysis, those companies with the highest positive results are operating in animal production and aquaculture in Latin America. In contrast, lower results are shown for crop production for various regions. A reason for this could be that companies in the animal production and aquaculture industry are facing more favourable conditions than other industries in the sector.

Energy and oil & gas

According to the overall analytics of absolute emission contribution from Moody's, the oil and gas sector stands for 60%, while the energy sector stands for 8%. The fossil fuel sector is expected to see considerable shocks in the long term, with a loss of up to 92.04% under the 1.5°C by 2050 scenario, according to CLIMAFIN. ISS ESG's analysis highlights high potential future emissions of 4,732 tCO_2, which points to a high risk of stranded assets linked to fossil fuel reserves held in the portfolio. The results of the pilot exercise from all vendors also highlighted the challenges faced by the energy sector in lowering its burden on the environment. ISS ESG's results also show negative cumulative returns for companies heavily related to fossil fuels.

Figure 20: Absolute emissions by sectors (Moody's, 2022)

27 S&P Global Ratings does not contribute to, or participate in, the creation of credit scores generated by S&P Global Market Intelligence. Lowercase nomenclature is used to differentiate S&P Global Market Intelligence PD credit model scores from the credit ratings issued by S&P Global Ratings

Aladdin Climate scenario analysis for the sample of oil and gas exposures included in the pilot exercise also indicate high risks. The analysis credits changes in downstream oil and gas production caused by fluctuations in the commodity market for these elevated risks. WTW's analysis shows that, the oil and gas sector contributes the most to the potential decline in the portfolio's value under both weightings. On average, the sector has the largest CTVaR of all sectors, at -10.27%, WTW finds. The majority of positions facing the highest potential impact on the portfolio's value belong to the oil and gas sector, with a CTVaR of up to -44%. However, the impact of the transition might vary widely for each company and position within the sector. Planetrics' modelling accounts for company-level differences in the oil and gas sector, leading to different drivers and magnitudes of risk. The results could vary, for instance, due to emission intensity or the cost structure of the production assets of the company in questions (which leaves some companies more vulnerable to 'asset stranding' than others). Firms that invest in companies that produce oil and gas need to consider how assets are stranded and how margins are affected by changes in demand.

Figure 21: Doughnut chart of sector contribution to portfolio VaR (ISS ESG, 2022)

Ortec Finance's analysis of Portfolio A and Portfolio B revealed that both portfolios are unlikely to meet the net-zero target by 2050. The firm cites the allocation of these portfolios in the oil and gas sectors of the United States and Canada as a significant reason for this failure as these are highly exposed to transition risks. These findings highlight the critical importance of carefully considering the allocation of assets within a portfolio to mitigate climate risks and achieve climate goals.

When reviewing the energy sector in general, Oliver Wyman/S&P Global highlights that it is less impacted under the IEA NZE2050. WTW's analysis shows a wide distribution of CTVaR with some companies (e.g. renewable energy companies) having a positive CTVaR—meaning they are expected to benefit from the transition.

Transportation sector

Climate risk in the transport sector represents an area of concern. Whilst the share of absolute emissions from the sector is as high as 22% (Moody's), the dummy portfolio analysis showed some bright spots, even under the NZE2050 scenario. PwC GmbH WPG projects growth in the rail transportation sector, notably in North America. This forecast arises from an anticipated surge in demand driven by the region's inadequate infrastructure, among other factors. These factors are rooted in scenario inputs that model a shift in the transportation landscape (including behavioural changes) that are expected to drive this growth. Automakers such as BMW and Tesla that have a higher mix of hybrid cars or electric vehicles (EVs) are likely to perform better in the transportation sector, especially when coupled with improvements in related infrastructure. Oliver Wyman/S&P Global concludes that the transportation sector is less impacted because the dummy portfolio has many companies with plans to transition to EVs. In the figure below, a deep dive into the projections of an automotive company's income statement and balance sheet is made by Oliver Wyman/S&P Global. Illustrating the shift from internal combustion engine vehicles (ICEVs) to EVs.

Income statement ($M)	2020	2050	% change
Automotive	66,538	79,165	19%
Electric vehicles (EV)	4,150	74,751	1,701%
Internal combustion engine (ICE)	62,388	4,415	-93%
Other	26,607	26,607	0%
Total revenue	**93,145**	**105,772**	**14%**
Automotive COGS	58,330	64,188	10%
EV COGS	4,028	60,376	1,399%
ICE COGS	54,303	3,812	-93%
Other COGS	23,325	23,325	0%
Total COGS	**81,655**	**87,513**	**7%**
Gross profit	**11,490**	**18,260**	**59%**
EBITDA	**8,719**	**14,698**	**69%**
D&A	4,168	4,849	16%
EBIT	**4,552**	**9,848**	**116%**
Net profit	**3,552**	**7,332**	**106%**

Balance sheet ($M)	2020	2050	%change
Cash and short-term investments	10,044	15,807	57%
Accounts receivable	2,068	2,494	21%
Inventory	13,247	14,735	11%
Net PP&E	20,486	19,295	-6%
Other assets	158,020	215,405	36%
Total assets	**203,865**	**267,737**	**31%**
Accounts payable	7,295	8,866	22%
Current portion LT debt/ capital leases	24,143	25,352	5%
Long-term debt/ capital leases	59,378	65,119	10%
Other liabilities	55,162	55,162	0%
Total liabilities	**145,978**	**154,500**	**6%**
Total equity	**57,888**	**113,236**	**96%**

Figure 22: The analysis of an automotive company under NZE2050 (Oliver Wyman/S&P Global, 2022)

Similarly, Aladdin Climate's analysis for one of the companies in the pilot portfolio highlights the potential risks associated with an automotive company's revenue streams in a scenario where net-zero emissions are achieved by 2050. The study reveals a notable decline in the profit potential for ICEVs, which underscores the risks posed by transitioning to EVs. This highlights the need for the automotive sector to shift toward EVs to mitigate transition risks and capitalise on the opportunities presented by a low-carbon economy.

The pilot exercises showed that the dummy portfolio faces several areas of risk. Ortec Finance provides a risk map showing the risk scores of all sectors included in the analysis. As the map shows, the transport manufacturing sector is ranked among the sectors with the highest physical and transition risks. ICE estimates the expected emissions in the transportation sector to sum up to around 210,293 tCO_2e/bUSD for NZE2050, putting the transportation sector assets as the highest emitters.

The Industrials sector in this pilot portfolio has a concentration in airlines, which are vulnerable to transition scenarios with up to -40.0% transition risk-adjusted value under an NZE2050 scenario relative to NGFS 'current policies' counterfactual, based on Aladdin Climate results. Furthermore, when comparing the airline sector, WTW states that one airline has weaker creditworthiness due to higher leverage and debt maturities, despite being less exposed to short-haul flights which are expected to see significant demand losses of 21%. It also highlights that the financial fundamentals of an airline, such as the impact that leverage has on creditworthiness, may have a more significant impact on the reduction in company value under a transition scenario than reductions in passenger numbers.

PWC GmbH WPG's analysis shows an aggregated positive cumulative return of 86.18% for the transportation sector in the NZE2050 scenario, with EV and aviation companies leading in performance across the entire portfolio. The main driver behind this finding is the anticipated demand growth within the 1.5°C scenario because this fosters a positive outlook, especially for the aviation industry. Despite the promising return, it is crucial not to interpret this as an absence of risk. When it comes to a 2.7°C scenario, growth is dampened due to behavioural changes, indicating risk for companies that do not adapt sufficiently or that face potential substitution.

4.2 Hotspot analysis through the highest contributor in the portfolio

The focus on the highest contributors in a portfolio-level assessment is driven by the need to prioritise efforts and resources towards the areas where they will have the greatest impact. By identifying the highest contributors, organisations can target their efforts on reducing emissions from those sources, and thereby achieve the greatest reduction in their overall carbon footprint.

Additionally, focusing on the highest contributors can also help organisations to identify the areas where emissions reductions can be achieved at the lowest cost. This approach also enables organisations to find the most cost-effective solutions for reducing emissions, such as energy efficiency improvements or switching to renewable energy sources. Moreover, the highest contributors expose portfolios to the most significant climate-related risks, such as stranded assets or supply chain disruptions.

In the context of a portfolio-level assessment for climate change, 'low-hanging fruits' refers to the investments or activities that have the potential to deliver the greatest reductions in GHG emissions at the lowest cost.

Examples of low-hanging fruits within the context of a climate initiative include:

- Energy efficiency improvements in buildings and industrial processes
- Switching to renewable energy sources such as solar and wind power
- Investing in low-carbon transportation options, such as EVs or public transportation
- Implementing sustainable agricultural practices
- Investing in reforestation and afforestation projects
- Implementing waste management and recycling programmes
- Investing in CCS technologies

Table 29: Metrics for hotspot analysis by 10 vendors

#	Vendor	Metrics	Hotspot Contributors (redacted)
1	CLIMAFIN	Five holdings with the highest carbon intensity tCO_2e/mil USD	1. Agricultural Chemicals Company: 15,879.28 2. Agricultural Chemicals Company: 4,526.66 3. Agricultural Commodities/Milling Company: 3,694.27 4. Agricultural Commodities/Milling Company: 3,604.02 5. Oil and Gas Refining and Marketing Company: 2,827.3
2	ICE	Five holdings with the highest carbon intensity tCO_2e/mil USD (from a list of top 10)	1. Independent Power Producers and Energy Traders Company: 147,130 2. Independent Power Producers and Energy Traders Company: 104,010 3. Renewable Electricity Company: 83,040 4. Oil and Gas Exploration and Production Company: 80,880 5. Integrated Oil and Gas Company: 53,950
3	ISS ESG	Five holdings with the highest emission exposure, in %	1. Independent Power Producers and Energy Traders Company: 5.37% 2. Renewable Electricity Company: 3.75% 3. Independent Power Producers and Energy Traders Company: 3.50% 4. Electricity Company: 2.97% 5. Agricultural Chemicals Company: 2.93%
4	S&P Global Sustainable1	Five highest carbon to revenue contributors, in tCO_2e/mil USD	1. Independent Power Producers and Energy Traders Company: 10,854 2. Independent Power Producers and Energy Traders Company: 9,315 3. Renewable Electricity Company: 3,380 4. Electricity Company: 3,740 5. Agricultural Commodities/Milling Company: 1,939
5	Ortec Finance	Five holdings with the highest Scope 1 and 2 ITRs, in 2050	1. Electricity Company: 8.4°C 2. Oil and Gas Refining and Marketing Company: 6.7°C 3. Agricultural Chemicals Company: 6.6°C 4. Oil and Gas Storage and Transportation Company: 6.3°C 5. Residential REITs Company: 3.0°C

6	Moody's	Top five holdings with ITR exceeding 2°C (from a list of top 13)	1. Integrated Oil and Gas Company: Above 2°C 2. Integrated Oil and Gas Company: Above 2°C 3. Oil and Gas Exploration and Production Company: Above 2°C 4. Integrated Oil and Gas Company: Above 2°C 5. Oil and Gas Storage and Transportation Company: Above 2°C
7	XDI	Five holdings with the highest value-at-risk in 2100	1. Specialty REITs Company: 4.96% 2. Residential REITs Company: 4.92% 3. Shipping Company: 3.38% 4. Agricultural Commodities/Milling Company: 3.18% 5. Office REITs Company: 3.06%
8	Aladdin Climate	Ranking of REITs by combined physical risks in 2050, under an RCP 4.5 scenario	1. Diversified REITs Company: 3.4% 2. Retail REITs Company: 2.8% 3. Industrial REITs Company: 2.3% 4. Retail REITs Company: 2.1% 5. Residential REITs Company: 1.7%
9	MSCI	Ranking of CVaR contribution under an REMIND 1.5°C scenario[28]	1. Integrated Oil and Gas Company: -100% 2. Aviation Company: -100% 3. Shipping Company: -100% 4. Shipping Company: -100% 5. Integrated Oil and Gas Company: -100%
10	WTW	Ranking of positions with the largest contribution to portfolio CTVaR under a SSP2-RCP2.6 scenario[29]	1. Integrated Oil and Gas Company: -0.15% 2. Oil and Gas Exploration and Production Company: -0.14% 3. Oil and Gas Exploration and Production Company: -0.12% 4. Integrated Oil and Gas Company: -0.12% 5. Integrated Oil and Gas Company: -0.11%

While identifying the highest contributors marks a critical step in a portfolio-level assessment for climate change, it is essential to acknowledge that different vendors may use different parameters to identify these contributors. Comparing the results of different vendors can therefore be challenging and may lead to conflicting conclusions. For instance, one vendor may identify companies with the highest Scope 1 and 2 ITRs, while another may focus on carbon intensity or value impact. As well as complicating the comparison of results, this can make it difficult to prioritise efforts effectively.

Additionally, some vendors do not include critical factors that affect the overall carbon footprint of the portfolio, such as supply chain emissions or indirect emissions. Therefore, organisations should be cautious when selecting vendors and should consider using multiple vendors to gain a more comprehensive understanding of the portfolio's emissions profile.

28 The position of each individual security in the portfolio is multiplied by the aggregated CVaR to establish the CVaR risk contribution of the portfolio.

29 The contribution of each position to the overall portfolio is calculated by multiplying the CTVaR of the position by its weight in the portfolio. The individual CTVaR for the top 5 contributors are -43.8%, -43.6%, -35.6%, -34.8% and -34.0% respectively.

Moreover, while identifying the highest contributors can help organisations prioritise their efforts, emissions reductions should not be limited to these areas alone. Investing in other emissions reduction initiatives, such as CCS technologies or sustainable agricultural practices, can also play a critical role in achieving overall emissions reductions. Therefore, organisations must take a holistic approach to portfolio-level assessments and invest in a range of emissions reduction initiatives.

4.3 Case studies

Climate risk tool providers play a critical role in providing services and products to assist clients in managing credit and climate risk. By leveraging the tools and expertise offered by these vendors, clients can better understand the risks associated with climate change and take appropriate steps to manage them. Ultimately, the services and products provided by financial sector vendors play a crucial role in helping clients achieve their financial objectives while managing risk effectively. This chapter provides case studies to show the unique functions offered by vendors for the financial sector, giving examples of the step-by-step methodologies of credit risk assessments by Munich Re, XDI, and Oliver Wyman/S&P Global.

Munich Re

Overview

Munich RE delivered risk scores that combine the exposure of an asset to natural hazards with the vulnerability of the asset or sector to the selected hazard. The exposure to natural hazards was categorised into acute and chronic stress and was available for selected time horizons and climate scenarios.

Methodology

The combined risk scores were presented for the purpose of this report. The Level 1 risk scores were based on the percentage of individual assets exposed to high physical climate risks, with a global airline being an example. Additionally, the PV (which is the 'discounted' value of the physical risk scores at future time horizons) was calculated and weighted with the expected cash-flow profile derived from the asset type, such as equity or corporate loans. Munich Re employs statistical techniques to develop credit risk models that estimate the probability of default and potential losses that may arise. Munich Re uses various data sources and modelling methods to tailor credit risk models to meet its clients' specific needs. These models assist clients in managing credit risk effectively and making informed decisions regarding financial activities, including lending and investment. Munich Re's clients place a high value on their credit risk modelling expertise, which aids them in navigating the complex world of credit risk management.

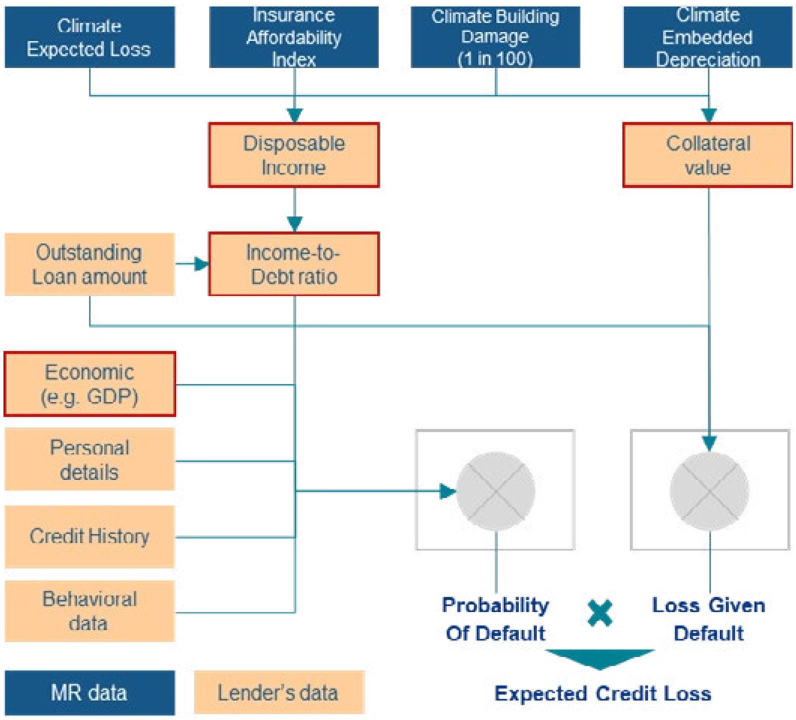


Figure 23: Integrating Munich RE Climate data into credit risk models (Munich RE, 2022)

Results

Table 30: Case studies: credit risk assessment results from Munich RE

Attribute	Results
Company	A global airline
Maturity	2045
Latitude	35.9571
Longitude	110.9400
Risk score combined current	1.00
Risk score acute current	0.9
Risk score chronic current	0.2
Risk score combined RCP 2.6_2030	1.00
Risk score combined RCP 2.6_2050	1.00
Risk score combined RCP 2.6_2100	1.00
Risk score combined RCP 4.5_2030	1.00
Risk score combined RCP 4.5_2050	1.00
Risk score combined RCP 4.5_2100	1.00
Risk score combined RCP8.5_2030	1.00
Risk score combined_RCP8.5_2050	1.00
Risk score combined RCP8.8_2100	1.00
PV Risk score RCP2.6 Combined	1.00

PV Risk score RCP2.6 Acute	0.90
PV Risk score RCP2.6 Chronic	0.30
PV Risk score RCP4.5 Combined	1.00
PV Risk score RCP4.5 Acute	0.90
PV Risk score RCP4.5 Chronic	0.24
PV Risk score RCP8.5 Combined	1.00
PV Risk score RCP8.5 Acute	0.90
PV Risk score RCP8.5 Chronic	0.29

XDI

Overview

XDI employs statistical techniques to develop credit risk models that estimate the probability of default and potential losses that may arise. XDI uses various data sources and modelling methods to tailor credit risk models to meet its clients' specific needs. XDI can assess physical climate risk for a single asset or for a portfolio of assets. Results can be produced at high-level, aggregated insights, right down to sub-asset componentry for deep granularity. These models assist clients in managing credit risk effectively and making informed decisions regarding financial activities, including lending and investment.

Methodology

XDI provided multiple company intelligence for RCP 2.6 and 8.5, covering the years 2020, 2030, 2050, and 2100. In this case study, it focused on a global airline. XDI calculated Value-At-Risk, Failure Probability, and productivity loss per company per country, in five-year intervals from 1990 to 2100 for both RCP8.5 and RCP2.6 scenarios. XDI also discussed the hazard breakdown, which is based on Value-at-Risk, Failure Probability, and Productivity Loss for each of the XDI Hazards, in five-year intervals from 1990 to 2100. For this report, only the summary of the hazard breakdown will be presented. The results were developed by taking each of the built assets owned or operated by the company and undertaking a physical risk assessment at each location. The diagram below illustrates the process undertaken for each asset. These results were then aggregated at the company and country scale.

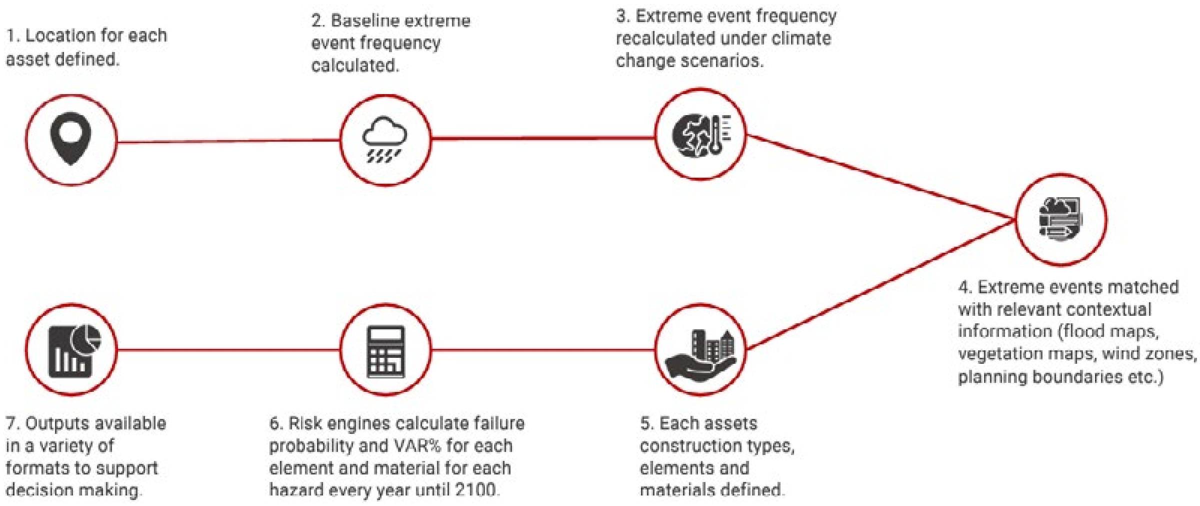


Figure 24: Asset level analysis and climate adjusted insights (XDI, 2022)

Results

Table 31: Case studies: credit risk assessment results from XDI

Scenario	Year	Value-At-Risk	Failure Probability	Productivity Loss	Primary HazMVAR	Secondary HazMVAR
RCP2.6	2020	0.0013597	0.24179371	0.00099887	Coastal Inundation	Riverine Flooding
RCP2.6	2030	0.00161424	0.26519867	0.00112247	Coastal Inundation	Riverine Flooding
RCP2.6	2050	0.00269872	0.32195852	0.00153722	Coastal Inundation	Riverine Flooding
RCP2.6	2100	0.00623951	0.39553457	0.00262746	Coastal Inundation	Riverine Flooding
RCP8.5	2020	0.00144297	0.24932154	0.00104621	Coastal Inundation	Riverine Flooding
RCP8.5	2030	0.00202491	0.30256424	0.00134229	Coastal Inundation	Riverine Flooding
RCP8.5	2050	0.0041448	0.43745233	0.00222719	Coastal Inundation	Riverine Flooding
RCP8.5	2100	0.01190728	0.82305262	0.005292	Coastal Inundation	Riverine Flooding

Oliver Wyman/S&P Global

Overview

Oliver Wyman/S&P Global ran a Climate Credit Analytics analysis for 181 companies with credit exposure provided within the dummy portfolio. The results were run across three NGFS scenarios. This analysis helps FIs assess the impact of a transition to a low-carbon economy on the creditworthiness of their counterparties.

Methodology

Oliver Wyman/S&P Global's Climate Credit Analytics includes a detailed, bottom-up analysis of all non-financial sectors, with an analysis on high-risk sectors such as oil and gas, metals and mining, power generation, car manufacturing, and airlines. A top-down module is also available to extrapolate the results to the rest of the portfolio, thus ensuring a full coverage. Oliver Wyman/S&P Global measures the credit rating notch change annually from 2020 to 2050 across all NGFS scenarios (among others). For each company, it took a bottom-up approach by identifying and assessing key drivers, which it used to then translate the impact of a scenario on a company's financial statements. Thereafter, it developed scenario-adjusted financial statements based on the key drivers and generated scenario-adjusted credit scores.

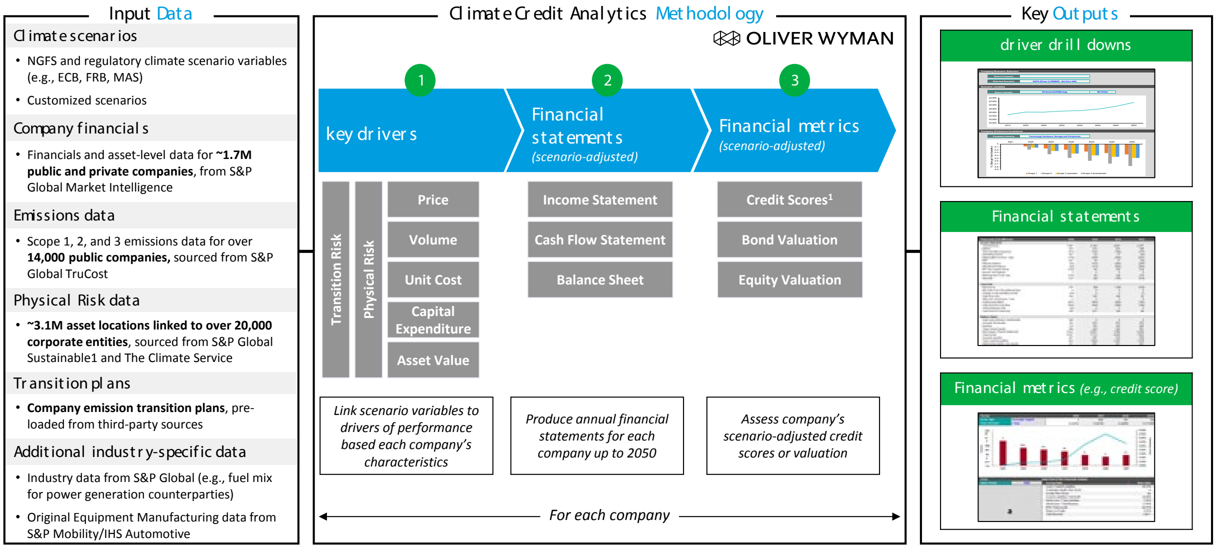


Figure 25: Climate Credit Analytics workflow (Oliver Wyman/S&P Global, 2023)

Results

The results were aggregated at portfolio level to indicate the credit rating notch change over time by scenario. The main portfolio results are summarised as follows:

- In the delayed transition scenario, the downgrade is severe after 2030 as strict measures are put in place
- The Current Policies scenario sees a far less severe impact due to oil and gas demand increasing and then plateauing back to approximately 2020 levels
- The Current Policies and Delayed transition have a short-term improvement as companies recover from the impact of the Covid-19

Table 32: Average credit score change over time by scenario (Oliver Wyman/S&P Global, 2022)

	2020	2025	2030	2035	2040	2045	2050
Current Policies	0.00	0.20	0.19	0.10	-0.21	-0.75	-0.72
Net Zero 2050	0.00	-0.12	-0.87	-1.68	-1.83	-1.92	-1.95
Delayed transition	0.00	0.20	0.17	-0.55	-1.34	-1.61	-1.71

SECTION 5: Concluding remarks

5.1 Maximising the results from the piloting exercise

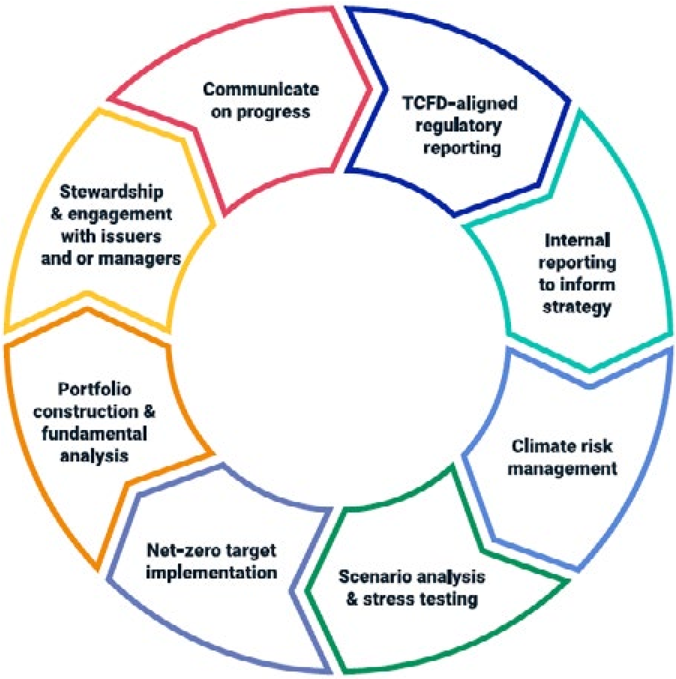


Figure 26: Integrating climate data into the investment process (MSCI, 2022)

Maximising the results from the pilot exercise between UNEP FI, vendors, and banks requires a strategic approach. FIs must identify the most critical metrics to measure their progress towards sustainable capital allocation. These metrics can vary depending on the individual FI's investment strategy and goals. In the context of the pilot exercise, some essential metrics for FIs include carbon performance analytics, implied temperature rise, green and brown share, portfolio value-at-risk, cumulative return, physical risk score, PVaR, and expected loss.

Among the metrics mentioned in this report, it is difficult to single one out as being most significant as each metric has its unique value in evaluating the sustainability of an investment portfolio. However, a combination of metrics is recommended to provide a comprehensive view of a portfolio's financial and sustainability performance. For example, carbon performance analytics and implied temperature rise can provide insights into a portfolio's possible exposure and climate alignment (despite not measuring transition risks directly). At the same time, a physical risk score, PVaR, and expected loss can help identify the potential financial impact of physical climate risks on the portfolio. Green and brown shares can provide additional context on the portfolio's sustainability by measuring the proportion of green or brown assets.

FIs need to determine which metrics align best with their investment strategy and goals. For example, an institution strongly focusing on reducing carbon emissions may prioritise carbon performance analytics and implied temperature rise. In contrast, an institution focusing on minimising financial risks may prioritise portfolio value-at-risk, physical risk score, PVaR, and expected loss.

Integrating climate outputs from vendors into investment or decision-making processes can help FIs make more informed and sustainable investment decisions, as Figure 26 outlines. By incorporating sustainability metrics such as carbon performance analytics, implied temperature rise, and green and brown share into investment or decision-making processes, FIs can ensure that their portfolios align with their sustainability goals. Moreover, integrating sustainability metrics into such processes can help FIs identify and manage potential physical climate risks that could impact their portfolios. By considering metrics such as physical risk score, PVaR, and expected loss, meanwhile, FIs can assess the potential financial impact of physical climate risks and take steps to mitigate them. It is also vital that the sustainability considerations are not treated as a separate or optional component but rather integrated into an institution's core operations.

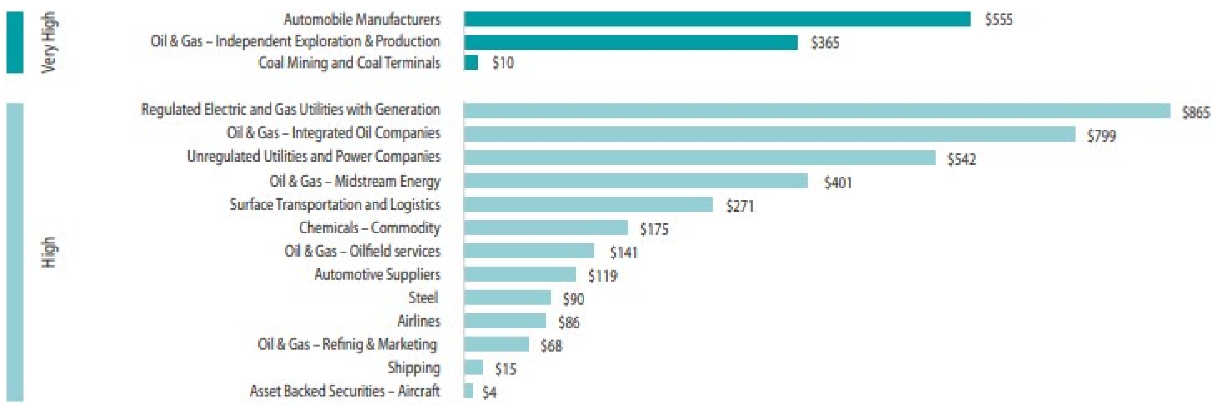
Incorporating climate outputs from vendors directly into internal processes is crucial for FIs to manage sustainability considerations effectively and efficiently. By doing so, they can ensure that sustainability is integrated into an institution's core operations and that financial and sustainability concerns inform investment decisions. As stated by Bingler and Colesanti Senni, 2022, to help clients achieve this, vendors also need to improve model transparency, scenario flexibility, output-related uncertainties, and assumptions communications to ensure their interpretability. Further, they need to ensure that climate risk metric disclosures reflect the underlying assumptions and uncertainties surrounding the analyses.

5.2 Essential features sought by FIs in climate risk assessment tools

Going back to the Roadmap for climate risk tool selection in the 2023 Climate Risk Landscape Report (see Appendix), the last step focuses on the transferability of the tool's results to FI decision-making through effective climate risk management. Once the preceding criterion of the tool is established (i.e. validity, usability, and analysis depth) there is an iterative process between the FIs and vendors to ensure that the tool's results are relevant and can be incorporated into broader firm risk management strategies and portfolio monitoring. The intent of the 2022 piloting exercise was to establish a connection between the desires of FIs and the capabilities of the market for climate risk assessment tools, which will now be explored in more depth. The six key desires identified for FIs seeking to assess climate-related financial risks are based on extensive consultations and webinars that were conducted in the scope of the working group. These desires address specific needs and challenges that FIs face when assessing climate risks and are designed to enable more informed decision-making. By addressing these six key desires presented below, FIs can enhance their ability to effectively manage climate-related financial risk and can contribute to a more sustainable future.

1	2	3	4	5	6
Tailoring to the Risk Profile	Balancing maximum and mean scores of climate risks	Enhancing Comparability Between Sectors and Industries	Incorporating Adaptive Capacity	Secondary Risk Analyses	Data Reliability and Transparency

1. **Tailoring to the risk profile:** In order to establish a climate risk profile, the FI must take steps to set a threshold for investment or lending. These thresholds are rooted in each individual institution's risk tolerance, and therefore customisability must be a key feature of a climate risk tool. When measuring lending portfolios and trading books, providers should have the flexibility to allow FIs to provide their predetermined thresholds as inputs to their assessments. An example of this is the ability to customise algorithms to allow inputs as a vulnerability score. This type of assessment can be done before a lending or investment decision or as part of ongoing portfolio monitoring. This allows FIs to take mitigating measures with respect to a high-risk asset. Such measures include exclusion, divestment, or follow-up requirements, such as the purchase of insurance or the implementation of transition planning.
2. **Balancing maximum and mean scores of climate risks:** An in-depth discussion on whether to use average or maximum risk scores should be held, taking into account the respective trade-offs of each. Maximum risk scores can be useful to identify the most severe risks, but it is important to also consider the benefits of incorporating average risk scores into climate risk assessments. Currently, many providers and platforms in the field tend to prioritise the highest risk score. However, this can lead to an overemphasis on worst-case scenarios and a lack of nuance in assessing overall risk. By including average risk scores, risk assessments can provide a more balanced and comprehensive understanding of the overall risk landscape. This approach also allows FIs to prioritise actions that address a range of different risks and vulnerabilities. In addition, it presents an opportunity to identify instances where there is a significant deviation between average and maximum scores, thus shedding light on crucial vulnerabilities and encouraging targeted interventions.
3. **Enhancing comparability between sectors and industries:** An expanding capability for vendors that FIs find useful are risk classifications across economic sectors and industries. This is typically done through quantitative and qualitative assessments, primarily using sector heatmapping and hot spot analyses. These comparisons can enhance accessibility in understanding portfolio exposures and lead to transferability in future decision-making by firms. An example of a 'transition risk heatmap' by Moody's maps the US dollar amount to sectors exposed to the carbon transition (NGFS, 2022). FIs express demand for more of these kinds of analyses and hope to further expand their applications, as heatmapping gives them a powerful visualisation of high-risk exposure in a portfolio.



Debt numbers as of June 2020.
Source: ESG – Global: Environmental heat map update: Risks rise for oil & gas, chemicals, metals & mining, 27 May 2021.

Figure 27: Environmental Heat Map Update (NGFS, 2022)

4. **Incorporating adaptive capacity:** As tool providers expand capabilities, one area of potential improvement is the better measurement of adaptive capacity to physical climate shocks, such as flood or storm defences in coastal regions. Some providers cover these areas, although they tend to be backward-looking based on previous policies and existing infrastructure. Expanding the scope of adaptive capacity measurements could mean the integration of planned or expected adaptation measures that will reduce physical risk exposures. This should also include supply chain resilience and regional resilience (i.e. how the society and services in a particular location are set up to address disaster risks). This constant monitoring will allow for the continuous repricing of physical assets that may have been otherwise depreciated in forecasted scenarios without adaptive capacity. This would help FIs, for example, to measure credit, equity, and bond impacts of real estate assets more accurately.
5. **Secondary risk analyses:** Assessing the knock-on and concurrent effects of climate events is another area for tool providers to further develop expertise. For example, the Australian bushfires of 2019-2020 were found to cause a measurable drop in GDP of roughly 5% (Moody, 2022). However, providers such as Munich Re are exploring other societal impacts of these events, including changes to air quality, public health, job losses, and income sources. Bushfires caused by a heatwave are also an example of a concurrent climate event, as a heatwave is a combination of heat and drought. Enhanced emphasis should be placed on the intersectionality between physical climate risks and nature/biodiversity risks, particularly within the agricultural and forestry sectors, as these industries are exceptionally vulnerable. These events can cause cascading socioeconomic effects spanning areas of food production, energy, and health. Measuring these second order impacts and incorporating them into climate risk assessments represents the next level of relevant analyses for FIs.
6. **Data reliability and transparency:** Data challenges remain a top priority for both FIs and tool providers in providing the most accurate and verifiable information. As regulatory standards for climate-related information are still developing, reliability and validity of asset level climate data can be challenging. FIs currently can make use of client questionnaires to establish the criteria of necessary collection

during due diligence processes (an illustrative example published by the European Central Bank [ECB] is shown below in Figure 28). However, FIs still require the most accurate and reliable data to properly measure their risk exposures. The Financial Stability Board (FSB) has pinpointed the most relevant gaps in the data relevant for FIs. Its list includes lack of international disclosures standards, inconsistent data of supply chains and ESG ratings, improvement of forward-looking metrics (such as Climate VaR), scenario analysis, and data gaps in emerging markets. Tool providers must continuously improve these areas of expertise to accurately price climate risk into lending portfolios and trading books, as financial flows into climate mitigation and adaptation heavily depend on high-quality data.

Type of data	Data	Description	Targeted risk driver
Quantitative data	Current and projected total GHG emissions	An estimate of the total current and projected GHG emissions of financed assets broken down by Scope 1, 2 and 3 emissions (e.g. tCO2 or tCO2e/t produced product)	Transition risk (e.g. policies and regulations)
	Fossil fuel dependency	Production, processing, distribution, storage, or combustion of fossil fuels (percentage of revenues/production volumes)	Transition risk (e.g. policies and regulations)
	Geographical location data	Granular data on the geographical location of financed assets and/or main client activities (e.g. postal codes)	Physical risk (e.g. flooding)
	Energy consumption intensity	An estimate of the energy consumption of clients (e.g. gigawatt hours – GWh), including a split of the share of (non-)renewable sources	Transition risk (e.g. policies and regulations)
	Water consumption intensity	An estimate of the water consumption of client activities in million m3	Physical risk (e.g. water stress)
	Energy performance certificate	EPC for both residential and commercial real estate	Transition risk (e.g. market sentiment or regulation)
	Sustainable building certificate	Sustainability certificate for construction projects (e.g. BREEAM or LEED)	Transition risk (e.g. market sentiment or regulation)
Qualitative data	Adverse media check	Is debtor involved in controversies related to climate change and/or environmental degradation?	Reputational and liability risk
	Assessment of impact of C&E regulations	Does the debtor assess the impact of upcoming regulations related to climate change and environmental degradation?	Transition risk (e.g. policies and regulation)
	Adherence to sustainability reporting	Does the debtor adhere to sustainability reporting standards (e.g. CSRD)?	Reputational and liability risk
	Implementation of C&E risk policies	Does the debtor have policies in place that address key possible C&E risk issues occurring in its operations?	Transition and physical risks (e.g. biodiversity loss)
	Production, use or disposal of chemicals	Does the debtor produce, use or dispose of chemicals?	Transition risk (e.g. consumer preferences)
	Time-bound emission reduction plans	Does the client have time-bound plans in place to align its GHG emissions with, for example, the Paris Agreement objectives?	Transition risk (e.g. policies and regulations)

Figure 28: Non-exhaustive list of data items to inform risk assessment (ECB, 2022)

By incorporating these requirements, climate risk assessment service providers can better meet the needs of FIs and help them to transfer the assessment results into their general business processes.

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Appendix.
Practical Roadmap for FI Climate Risk Tool Selection

What do you want?
Determining the necessary specifications

1. Asset Class
Decide which asset class will be assessed:

- Make sure that your tool is well developed within your specific asset class.
- There is an increase of coverage of more asset classes (public/private) among many tools.
- Poor coverage of real estate, mortgages & agriculture.

2. Coverage
Identify what to assess:

- Coverage at the asset, sector, firm, or country levels
- Assessment of the portfolio's exposure to current and future GHG emissions
- Physical Hazards, could be both acute/chronic
- Resilience and adaptive capacity
- Transition Risks Orderly/Disorderly
- Company and portfolio exposure
- Portfolio vulnerability

3. Scenario
Provide analysis for the required scenarios:

- Most vendors use the IPCC, IEA or NGFS scenarios.
- IEA and IAMs are typically used for temperature analysis.
- Market movements towards scenarios that capture the speed of transition. Therefore, it is important that banks also look into vendors that provide NGFS scenario analysis(orderly, disorderly, Hothouse).
- Provides different time horizons

4. Output
Output metrics & format:

- Most providers express their output in quantitative or financial terms
- USD, kg GHG emissions
- VaR, Expected Return, PD, Credit Ratings
- Qualitative or report outputs
- Narrative dashboards
- Temperature alignment
- TCFD-aligned automated report features

What do you need?
Evaluation of the analytical tool

1. Validity

Transparency

- Assumptions
- Disclosure of methodology
- Interpretation

Verification & credibility

- Data sources
- Citations & reviews
- Third-party validation

Science-based approach

- Scientific resources supporting its model
- Peer-reviewed

2. Usability

User friendliness

- Clear layout and customised visualization
- Intuitive and explanatory modules for the platform and its structure
- Access to the platform
- Interactivity and possibility of incremental analysis

Flexibility

- Customizable platform according to needs

3. Analysis depth

Output interpretability

- Model structure, scenarios and assumptions reported
- Risk amplification

Uncertainty

- Baseline adaptable
- Scenario-neutral (various risk realisations)
- Probability distribution of input and output

4. Transferability

Transferable results

- The results are feasible to translate into financial measures relevant to the beneficiary

Incorporation

- Output and takeaways from the tool can be used in setting business strategies and portfolio monitoring

UNEP FI, 2023

UN environment programme

finance initiative

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. We've established the world's foremost sustainability frameworks that help the finance industry address global environmental, social and governance (ESG) challenges.

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