MSCI | Clarity Drives Action

# MSCI Physical Risk Guide

For Asset Owners
and Asset Managers

# Authors

## Xinxin Wang

Executive Director

MSCI Research & Development

## Elchin Mammadov

Executive Director

Sectoral Physical Risk Integration Lead, MSCI

## Mathew Lee

Vice President

Senior Energy Sector Researcher, MSCI

## Simone Ruiz-Vergote

Executive Director

MSCI Research & Development

## Katie Towey

Senior Associate

MSCI Research & Development

## Claudio Saffioti

Vice President

MSCI Research & Development, MSCI

## James Edwards

Executive Director

MSCI Research & Development

# Contents

## What this guide provides

This guide provides a practical framework to help institutional investors assess physical climate risk, focusing on five core capabilities:

- Measuring and monitoring portfolio exposure to physical climate hazards
- Assessing financial materiality and prioritizing the most relevant risks
- Integrating physical risk considerations into investment strategy, oversight and risk management
- Evaluating company preparedness and building portfolio resilience
- Supporting alignment with evolving regulatory and stakeholder expectations

## Who should use this guide

Physical risk is rarely owned by a single team. Different functions within asset owner (AO) and asset manager (AM) organizations engage with physical climate risk for different reasons. This guide is written for investment professionals across the institutional investment chain, including:

- Portfolio managers and investment analysts
- Risk officers and quantitative teams
- Stewardship and sustainability specialists
- Chief investment officers and board members
- Chief sustainability officers
- Product specialists and index designers

## How to use this guide

This guide is organized around questions that investors often ask. All readers should start with the Introduction and Chapter 1, which establish the investment case and the framework used throughout. From there, use the table below to follow the reading path most relevant to your role and priorities.

Whether your organization is small (with overlapping roles) or large (with dedicated teams), understanding these roles helps clarify how accountability and execution translate physical risk analysis into effective portfolio decisions.

| Board, CIO or senior management | Investment or portfolio management | Risk management |
|---|---|---|
| Set risk appetite and climate strategy; oversee regulatory disclosure; present to board. | Integrate physical risk into asset allocation; develop risk-adjusted and adaptation solutions products. | Quantify financial losses from hazards; set exposure limits; run scenario stress tests. |
| → Chapters 2, 3, 4, 6, 7 | → Chapters 2, 4, 5, 7 | → Chapters 4, 6, 7 |

| Sustainability and stewardship | Voluntary and compliance reporting | Quantitative research and data |
|---|---|---|
| Prioritize issuer engagement based on exposure and adaptation readiness; escalate when milestones are missed. | Prepare non-financial disclosures; manage audit trail; track progress indicators. | Data integration and validation; metric development; model governance; analytics infrastructure. |
| → Chapters 3, 5, 7 | → Chapters 3, 4, 6, 7 | → Chapter 2 |

These roles are illustrative examples, not an exhaustive classification. In smaller organizations one team may have all three objectives; in larger ones separate working groups may own each. Most roles will engage with additional use cases beyond those shown.

# Introduction

Physical climate risks, including floods, wildfires, extreme heat and tropical cyclones, are measurable and increasingly recognized as financially material. For asset owners and managers, the question is no longer whether to address physical risk, but how to do so systematically and efficiently in a way that supports sound investment decisions.

## Why physical risk demands action now

Physical climate risk is already moving asset prices, appearing in loss estimates, and increasingly visible in the gap between regulatory expectations and corporate disclosures. Four findings from recent MSCI research illustrate why action is warranted now:

- **Physical risk is pricing into equities now, not in future scenarios.** Analysis of listed companies exposed to hurricanes between 2022 and 2024 found that firms with assets in storm paths experienced statistically significant underperformance after controlling for market, sector and style factors. Underperformance deepened among firms with the highest concentration of assets in affected zones, reaching up to 40 basis points for the most exposed quintile by day 30.[1]
- **Loss exposure is larger and structurally different than balance sheets suggest**. MSCI estimates USD 1.3 trillion in potential average annual losses across approximately 9,350 listed companies globally.[2] A significant share of those losses is driven by business interruption rather than direct asset damage. Chronic hazards account for approximately 86% of those losses, led by extreme heat (around USD 600 billion annually), which may erode revenues gradually rather than appearing in catastrophic event disclosures. In addition, USD 181 billion in uninsured natural catastrophe losses in 2024 suggests that the insurance buffer investors have historically assumed is not holding.[3]
- **Geographic concentration may create vulnerabilities**. Analysis of over 9,000 listed companies globally found that 71% of acute and 61% chronic losses among small-and-mid-cap companies' acute losses are concentrated in a single administrative region. Even among mega-caps, 38% of acute and 31% of chronic losses remains geographically concentrated. In another study, we found that 89% of assets in MSCI's asset owner study facing overlapping hazards. Together, these results indicate that physical risk profile of an apparently diversified portfolio can be far more concentrated than it appears at the sector or asset class level.
- **The gap between company risk management and regulatory expectations is creating risk for investors**. Among the most highly exposed companies in asset owner portfolios, only 30% have

[1] Listed companies as represented in the MSCI ACWI Index.

[2] Average annual loss (AAL) is the expected average annual financial loss from physical climate hazards under current climate conditions. It is expressed in dollars or as percentage of revenue (for business interruption) or asset value (for asset damage). AAL represents the mean of the loss distribution. It is used for comparing relative risk across holdings and quantifying expected impacts.

[3] Banerjee, Chandan, Lucia Bevere, Michael Ewald, Erik Lindgren, and Mahesh H. Puttaiah. 2025."Natural Catastrophes: Insured Losses on Trend to USD 145 Billion in 2025." Sigma, no. 1 (April 29, 2025). Swiss Re Institute.

disclosed physical risk management practices. At the same time, regulatory frameworks are evolving rapidly:

- ISSB IFRS S2 standards are being embedded into national regulatory frameworks across multiple jurisdictions;[4]
- The EU's ESRS requires quantified physical risk disclosure with third-party assurance;[5] and
- Asia-Pacific frameworks are evolving toward mandatory compliance.[6]

Investors who rely on improvements in company disclosure before acting may face valuation surprises and regulatory pressure at the same time.

[4] The International Sustainability Standards Board (ISSB) IFRS S2 refers to IFRS S2 Climate-related Disclosures, issued by the ISSB, and applicable to reporting entities where adopted.

[5] ESRS E1 – mandatory EU climate disclosure standard under the CSRD. Revised draft version as proposed by EFRAG to the European Commission in October 2025.

[6] Asia-Pacific: MAS, SFC, FSA, ASIC. MAS, SFC and FSA guidance refers to climate-related supervisory guidance issued by the Monetary Authority of Singapore (Guidelines on Environmental Risk Management for Asset Managers – 2020, Guidelines on Transition Planning for Asset Managers - 2026), the Securities and Futures Commission of Hong Kong (Circular to Licensed Corporations – Management and Disclosure of Climate-related Risks by Fund Managers - 2021), and the Financial Services Agency of Japan (Supervisory Guidance on Climate-related Risk Management and Client Engagement - 2022), setting principles-based expectations. ASIC is the Australian Securities and Investment Commission, which is responsible for administering and enforcing the Australian Sustainability Accounting Standard (AASB S2) issued in 2024.

# Chapter 1: Investor objectives and use cases

Investors approach physical climate risk from different starting points. Whether addressing fiduciary duties by identifying financially material risks, exploring new opportunities, or responding to regulatory expectations, this guide provides a structured framework for assessing physical climate risk integration.

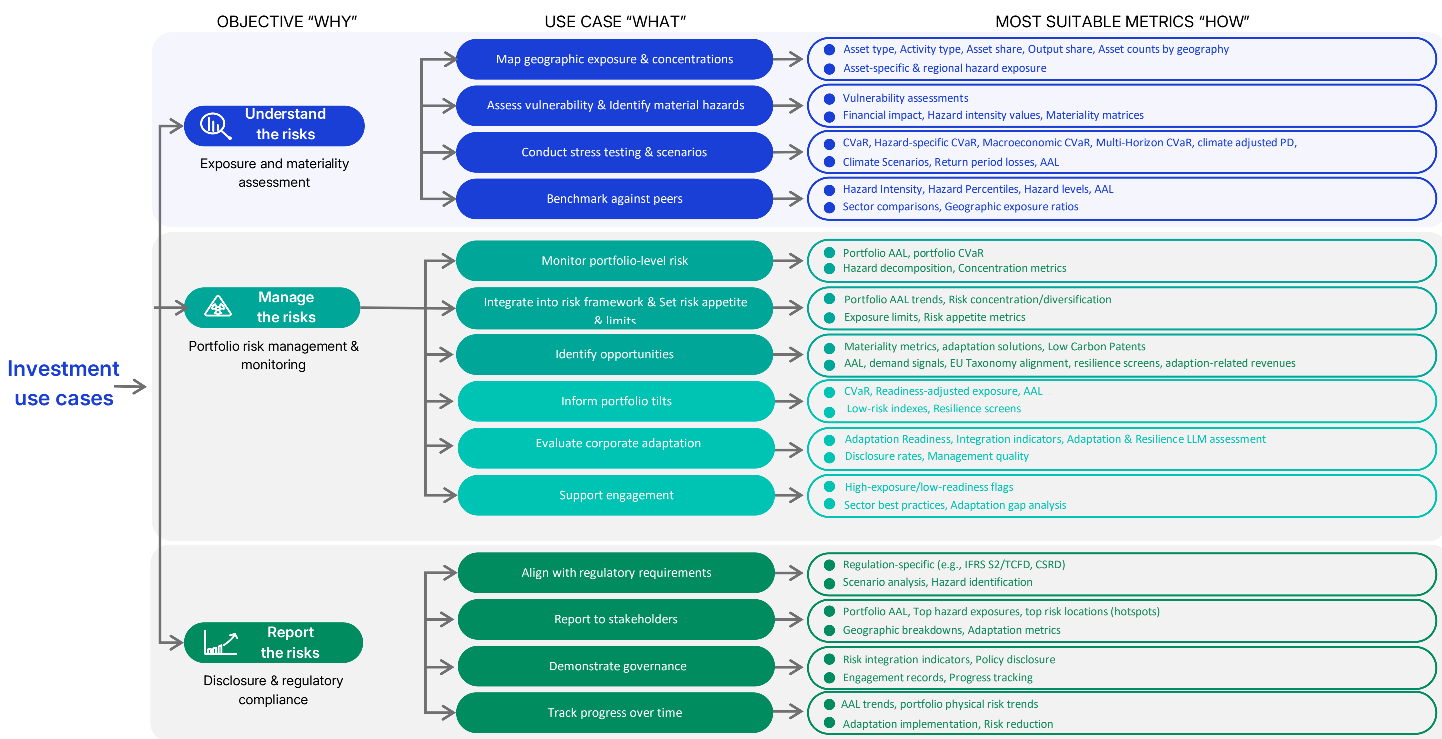
## 1. The investment use case framework

The framework organizes institutional investors' activities around three core objectives:

1. Understanding exposure to physical climate risks
2. Managing those risks across the portfolio, and
3. Reporting on them to meet regulatory and stakeholder expectations.

For each objective, we identify the specific use cases investors typically pursue, the workflow steps required to execute them, and the metrics and data that best support decision-making. These three dimensions — why, what and how — are mapped in the chart below.

**Physical risk use cases**




Three points of orientation: (i) The three objectives are not sequential, most investors work across all three simultaneously, with different teams owning each. (ii) Use cases within each row are also not sequential; starting point depends on where a team is in its program. (iii) The framework is not exhaustive, objectives and use cases can overlap. Chapter 7 (Practical Applications) provides illustrative examples that cut across multiple rows. Source: MSCI Sustainability & Climate Research, March 2026. MSCI Sustainability & Climate products and services are provided by MSCI Solutions LLC in the United States, MSCI Solutions (UK) Limited in the United Kingdom and certain other related entities.

# Chapter 2: MSCI Physical Risk Solutions

This chapter provides the foundation for everything that follows: a map of what MSCI's GeoSpatial Asset Intelligence and physical risk data covers, how it is structured and how its component layers connect.[7]

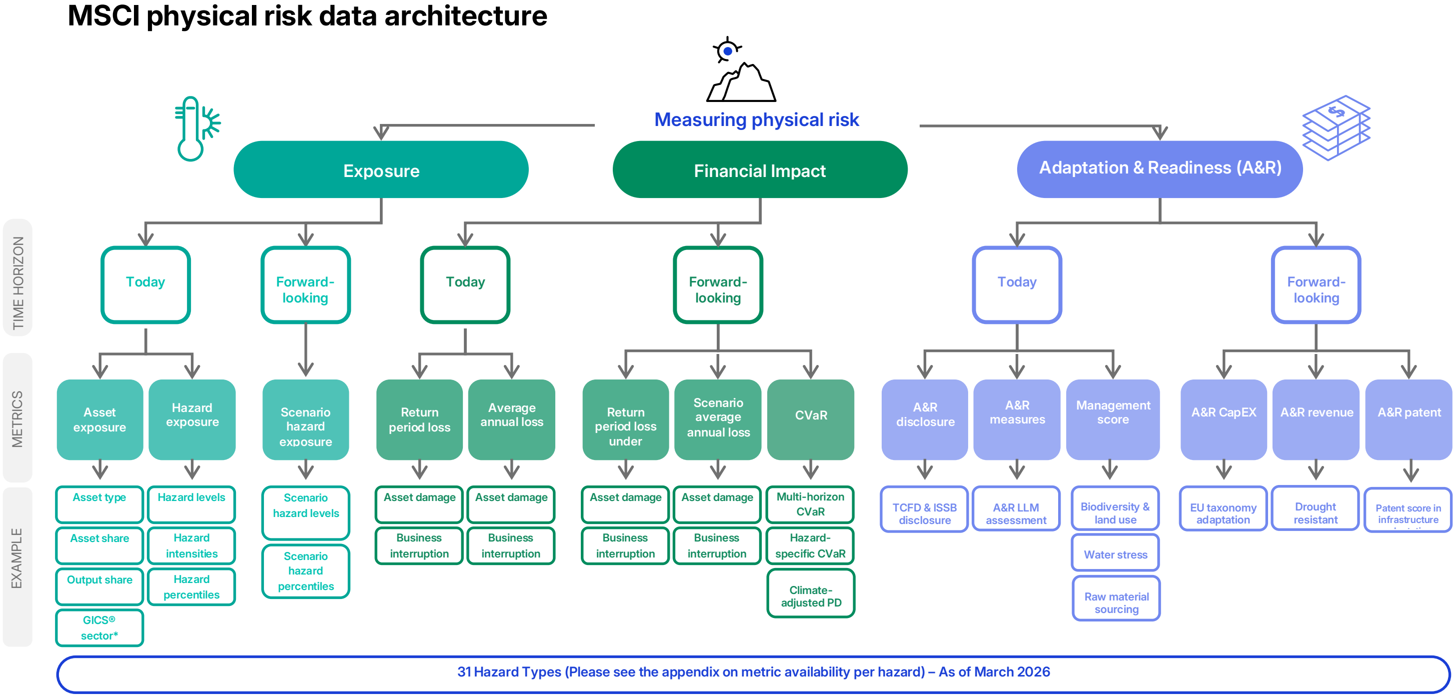
Knowing which metric answers to which question matters not because every user needs to master the methodology, but because it could help prevent the most common analytical errors. The technical detail behind each metric is documented in the MSCI Metric Interpretation Guide and the MSCI Physical Risk Metric Availability by Hazard table in the Appendix. This chapter offers the conceptual context that makes those references useful in practice.

## 2.1 The data architecture: from location to financial impact

MSCI physical risk data products are built on a single, integrated asset-level foundation. Every metric, from a simple hazard indicator to a forward-looking Climate Value-at-Risk (Climate VaR), is derived from the geographic location of individual corporate assets.

This location-first approach enables consistent analysis across investment, risk management, stewardship and disclosure use cases and distinguishes MSCI's approach from portfolio-level or sector-average approximations.

**MSCI physical risk data architecture**




Source: MSCI Sustainability and Climate Research, March 2026.

[7] MSCI Geospatial Asset Intelligence helps financial institutions explore location-specific exposures and quantify financial impact where it matters with drill-down insights into individual asset locations, delivering essential data for risk management, due diligence, regulatory compliance and engagement.

The architecture is constructed on two primary dimensions:

- Time horizon: Current (reflect current climate conditions for near-term assessment) and forward-looking (incorporates climate scenario projections for longer-term strategy and regulatory stress testing)
- Metric category: Exposure, financial impact, adaptation and readiness.

A third dimension — hazard type — applies across both and determines which specific variants are available.

Across metric categories, exposure metrics describe intensity and distribution of physical hazards, financial impact metrics translate exposure into estimated losses and value impacts, and adaptation and readiness metrics assess how prepared companies are to manage these risks.

For detailed navigation examples and metric journeys across the architecture, including data coverage by metric, see the Appendix.

**Overview of MSCI physical risk data architecture**[8]

| Layer | Primary question answered | Key scope and outputs |
|---|---|---|
| **Foundation** | Where are the company's physical assets located? | 708,000+ companies · 4 million+ assets · Sector, activity type, asset and revenue share attribution |
| **Exposure** | Which hazards affect each asset location, and how intensely? | 31 hazards · Intensity scale 0–10 · Current and future climate scenarios · Intergovernmental Panel on Climate Change (IPCC)/NGFS-aligned |
| **Financial Impact** | What are the expected financial losses from those hazards? | Asset damage and business interruption (AAL, 100-yr, 200-yr event) · 4 time horizons · 11 climate scenarios · Hazard × Vulnerability × Exposure |
| **Nature** | How are assets exposed to biodiversity and nature-related risks? | 14 WWF Biodiversity Risk Filter indicators · Water, soil, habitat, wildfire |
| **Portfolio Risk** | What is the portfolio-level financial impact on enterprise value, and over what horizons? | % enterprise value impact · NGFS scenario-specific · Horizons 1–30 yrs (Multi-Horizon) to 2100 · Aggregated from asset-level losses |

[8] As of March 31, 2026.

## 2.2 Exposure metrics vs. financial impact metrics

MSCI's physical risk data distinguishes exposure metrics and financial impact metrics, a distinction with important analytical and regulatory implications.

**Exposure metrics** quantify the physical hazard environment at an asset location. They answer questions such as: how intense is the flood risk here? How many extreme heat days are projected? How does this site compare with global peers? These metrics are a useful tool for initial screening, identifying portfolio hotspots and prioritizing engagement, but do not indicate financial loss. For instance, two assets with identical flood exposure can face different financial outcomes depending on building standards, sector sensitivity and local adaptation measures.

**Financial impact metrics** go one step further by applying a **Hazard × Vulnerability × Exposure** risk equation to estimate the expected monetary loss. The results are expressed as a percentage of asset revenue (for business interruption) or asset replacement value (for asset damage). These metrics are used to assess materiality, that is, how much could a given risk cost, and may support analysis aligned with IFRS S2 and ESRS E1 disclosure requirements.

MSCI's analysis of 18 asset-owner portfolios highlights the importance of this distinction: potential business interruption losses are, on average, 14 times larger than asset damage losses (USD 1.1 trillion vs. USD 76 billion in estimated average annual losses). Focusing only on property damage may therefore significantly underestimate total physical risk exposure.

For detailed definitions, calculation methodologies and metric coverage, see the MSCI Metric Interpretation Guide and MSCI Physical Risk Metric Availability by Hazard table in the Appendix.

# Chapter 3: Disclosure standards and regulatory frameworks

Across all major regulatory frameworks, the physical climate risk questions investors are expected to consider are broadly consistent. Differences arise primarily in the required **level of rigor, granularity and disclosure format**, rather than in the underlying risk concepts.

This chapter outlines key regulatory requirements, while section 7.7 provides an illustrative mapping of MSCI data and tools to these requirements.

## 3.1 Expectations across major regulatory frameworks[9]

**Global baseline:** The International Sustainability Standard Board's (ISSB) IFRS S2 builds on the Task Force on Climate-related Financial Disclosures (TCFD) framework.[10] Where adopted into binding domestic regulation, in-scope entities are required to disclose material climate-related risks and associated financial effects. In other jurisdictions, it serves as a reference standard or voluntary baseline.

**European Union:** The Corporate Sustainability Reporting Directive (CSRD) and its related reporting standard, the European Sustainability Reporting Standard (ESRS), is considered a highly prescriptive regime. While it directly targets in-scope companies, it creates indirect implications for investors through reliance on corporate disclosures.[11]

**United Kingdom:** The U.K. Sustainability Disclosure Requirements (U.K. SDR) framework applies to asset managers at both product and entity level. Products using sustainability-related terms in their name or marketing are subject to mandatory disclosure obligations, and entity-level sustainability reports are required for asset managers above specified assets under management (AUM) thresholds.[12] The framework follows a financial-materiality logic similar to IFRS S2 but is less granular than ESRS in asset-level requirements. Investors above a certain AUM threshold have been required to publish annual TCFD reports since 2022.[13]The U.K. Sustainability Reporting Standards (U.K. SRS S2),[14] adopted February 2026, remain voluntary as of the publication of this report.

**Asia-Pacific: The Monetary Authority of Singapore (MAS), the Securities and Futures Commission (SFC) in Hong Kong and the Financial Services Agency in Japan,** among others, have each issued supervisory guidance for licensed entities (including asset owners and managers), initially referencing TCFD and progressively moving toward ISSB standards.[15] Australia implemented its own IFRS S2-aligned

---

[9] This information is provided "as is" and does not constitute legal advice or any binding interpretation. Any approach to comply with regulatory or policy initiatives should be discussed with your own legal counsel and/or the relevant competent authority, as needed.
[10] The ISSB IFRS S2 refers to IFRS S2 Climate-related Disclosures, applicable to reporting entities where adopted in national law.
[11] Revised draft version as proposed by EFRAG to the European Commission in October 2025.
[12] SDR refers to the U.K. Sustainability Disclosure Requirements.
[13] FCA Handbook ESG Sourcebook.
[14] SRS refers to the U.K. Sustainability Reporting Standards. U.K. SRS was adopted in February 2026 for voluntary use, with the U.K. Financial Conduct Authority (FCA) currently consulting on implementing requirements for listed companies.
[15] MAS, SFC and FSA guidance refers to climate-related supervisory guidance issued by the Monetary Authority of Singapore (Guidelines on Environmental Risk Management for Asset Managers – 2020, Guidelines on Transition Planning for Asset Managers - 2026), the Securities and Futures Commission of Hong Kong (Circular to Licensed Corporations – Management and Disclosure of Climate-related Risks by Fund Managers - 2021), and the Financial Services Agency of Japan (Supervisory Guidance on Climate-related Risk Management and Client Engagement - 2022), setting principles-based expectations. ASIC is the Australian Securities

standard, AASB S2 in 2024. As of July 2026, the rules are scheduled to expand to cover additional financial institutions, including registered schemes and registrable superannuation funds.

### Non-regulatory standards

Investor-led initiatives, including **UN Environment Programme Finance Initiative (UNEP FI)**, the **Principles for Responsible Investment (PRI)** and the **UK Climate Financial Risk Forum** offer practical examples and best practices for integrating physical climate risk into investment processes.[16]

### Common investor requirements

Across jurisdictions, regulators typically expect a documented approach covering five areas:

1. **Exposure mapping**: identifying asset locations and relevant hazards at appropriate geographic granularity
2. **Hazard and vulnerability assessment**: covering both acute (e.g., floods, storms) and chronic (e.g., heat stress, sea-level rise) risks
3. **Scenario analysis**: using multiple forward-looking climate scenarios, typically NGFS/IPCC-based, across multiple time horizons
4. **Financial impact quantification**: where risks are financially material, exposure metrics are typically sufficient for initial screening
5. **Methodology documentation**: transparent, repeatable and defensible analytical processes

and Investment Commission, which is responsible for administering and enforcing the Australian Sustainability Accounting Standard (AASB S2) issued in 2024.

[16] UNEP Finance Initiative (UNEP FI) publishes voluntary guidance translating climate-risk principles into practical risk management and scenario analysis use cases for financial institutions.
The Principles for Responsible Investment (PRI) provide voluntary investor-led guidance on integrating physical climate risk into investment decision-making and stewardship.
The UK Climate Financial Risk Forum (CFRF), convened by the UK Financial Conduct Authority (FCA) and Prudential Regulation Authority (PRA), publishes non-binding guidance on climate risk management.

**Prescriptiveness of physical risk expectations across frameworks [17]**

Legend: ISSB-aligned mandatory; Moving to ISSB; Mandatory (other); Required; Expected; Encouraged

| Standard / Guidance | Asset geolocation | Hazard modelling | Vulnerability assessment | Financial effect | Disclosure status |
|---|---|---|---|---|---|
| ISSB — IFRS S2 framework | [Required] Location-based analysis required where material | [Required] Scenario analysis and models must be described | [Required] Vulnerability and resilience must be assessed | [Required] Current and anticipated financial effects | [ISSB-aligned mandatory] Disclose scenarios, methodology and financial effects on position and performance |
| EU – Draft ESRS E1 standard | [Required] Operating locations & carrying amounts at risk | [Required] Scenario analysis and methodology must be disclosed | [Required] Physical hazards, exposures, sensitivity and resilience | [Required] Carrying amount at risk (€ and %); scenario-based anticipated effects | [Mandatory (other)] Disclose hazards, scenario analysis, assets and revenue at risk. (E1-2, E1-3, E1-11) |
| FCA – ESG Handbook, U.K. SRS | [Expected] Asset- and portfolio-level location analysis | [Expected] Scenario analysis as stipulated by TCFD | [Expected] Physical risk impacts captured | [Expected] Impact on current portfolio must be monitored; no mandated numeric disclosure | [Moving to ISSB] TCFD reporting mandatory for AM/AO >£5bn AUM. ISSB expected to replace TCFD reporting with U.K. SRS. |
| MAS — Singapore ERM & Transition Planning/SGX | [Expected] Location-based assessment at asset & portfolio level, proportionate rules | [Required] Scenario analysis across physical and transition risk | [Required] Physical risk at asset and portfolio level, ongoing monitoring expected | [Expected] Impact on current portfolio must be monitored; no mandated disclosure (except if SGX-listed) | [Moving to ISSB] Transition Planning Guidelines issued March 2026 (effective Sept 2027); ISSB mandatory since FY2025 for SGX-listed |
| SFC — Hong Kong/HKEX | [Required] Asset- and fund-level assessment required | [Expected] Scenario analysis encouraged for larger managers | [Required] Physical risks in investment and risk processes | [Expected] Portfolio exposure at current time must be monitored, no prescriptive format | [Moving to ISSB] Aligned with IFRS S2 since Jan 2025 for HKEX-listed companies |
| FSA — Japan and SSBJ standards | [Expected] Physical risk assessment in portfolios; no asset-level mandate | [Expected] FSA and BOJ run scenario exercises; SSBJ formalizes | [Expected] Physical risk identification and management under TCFD/SSBJ | [Required] Current and anticipated effects on business model and financial planning FY27 | [Moving to ISSB] SSBJ Standards (IFRS S1/S2) adopted in March 2025 apply as of FY2027 |
| ASRS — Australia AASB S2 standard | [Required] Asset-level location assessment required where material | [Required] Scenario analysis mandatory under AASB S2 | [Required] Physical risk vulnerability and resilience required | [Required] Current and anticipated financial effects | [ISSB-aligned mandatory] AASB S2 (IFRS S2-aligned) applies to investment entities with >A$5bn funds under management as of July 1, 2026. |

Source: MSCI Sustainability and Climate Research, March 2026. This information is provided "as is" and does not constitute legal advice or any binding interpretation. Any approach to comply with regulatory or policy initiatives should be discussed with your own legal counsel and/or the relevant competent authority, as needed.

## 3.2 When a financial effects assessment is required

IFRS S2 and ESRS E1 serve as anchor frameworks for understanding when physical climate risks must be translated into financial terms.

**IFRS S2 (ISSB)**, where adopted into binding domestic regulation, requires entities to disclose information on the current and anticipated financial effects of climate-related risks and opportunities across short-, medium- and long-term horizons.

While no specific modeling approach is prescribed, it establishes a clear expectation on investors to be able to link location-specific exposures to forward-looking financial effects where physical climate risks could result in a material adjustment to asset or liability values.

**In practice, this means that:**

- Exposure and hazard indicators are typically sufficient for initial risk identification and portfolio monitoring

[17] ERM Guidelines are the MAS Guidelines on Environmental Risk Management for Asset Managers, released in December 2020 in Singapore. FMCC refers to the climate-related risk requirements under the Fund Manager Code of Conduct in Hong Kong, BOJ is the Bank of Japan, SBBJ refers to Sustainability Standard Boards of Japan.

- Financial impact estimates become relevant where risks are assessed as financially material or where forward-looking disclosures are required.

**ESRS E1 (CSRD)** is more prescriptive. Where physical climate risks are material, it requires disclosure of quantified financial effects using defined monetary metrics, including:

- The carrying amount of assets exposed to material physical climate risks,
- The proportion of those assets addressed by adaptation actions, and
- Net revenue from business activities exposed to material physical climate risks.

ESRS E1 also — if adopted as proposed by European Financial Reporting Advisory Group (EFRAG) — requires entities to explain how these amounts were determined. This includes, where relevant, information on the geographic location of exposed assets, aggregated in a way that supports a faithful representation of risk.

## 3.3 Regulatory disclosure alignment and model defensibility

Regulatory and supervisory scrutiny of sustainability-related claims and processes is increasing. Investors are expected not only to use relevant analytics, but to explain, demonstrate and consistently apply them when challenged by supervisors, auditors, clients or internal governance bodies.

Analytical defensibility in this context does not mean scientific "quality" or predictive superiority of a model. It means whether the analytics used by investors are transparent, traceable and reproducible, and whether results can be understood and justified across decision-making and accountability contexts.

This expectation is most explicit under investor-scope regimes such as the U.K. SDR and SRS frameworks and supervisory guidance across Asia-Pacific markets, and is also relevant where investors rely on issuer disclosures prepared under IFRS S2 or ESRS E1.

The International Auditing and Assurance Standards Board (IAASB) has reinforced this expectation through ISSA 5000, a global assurance standard for sustainability reporting.[18] It establishes clear expectations for the assurance of forward-looking, model-based disclosures. In practice, this means that physical risk assessments — including scenario analysis, hazard modeling and financial impact estimates — are to be supported by documented assumptions, transparent data sources, defined model governance controls and clear articulation of uncertainty. As sustainability disclosures increasingly fall within formal assurance scopes, the robustness and reproducibility of physical risk methodologies become both a regulatory concern and assurance consideration.

[18] International Auditing and Assurance Standards Board (IAASB). 2024. International Standard on Sustainability Assurance (ISSA) 5000: General Requirements for Sustainability Assurance Engagements. November 2024. New York: International Federation of Accountants.

# Chapter 4: Assessing exposure and materiality

Determining which portfolio holdings face financially material physical risks requires a structured approach that connects physical hazard data to company locations, business models and financial characteristics. Exposure can vary significantly across portfolios. Some companies face concentrated, location-specific hazards, while others are geographically diversified or structurally less sensitive to physical impacts. In this guide, physical risk may be considered financially material when it could influence investment decisions, portfolio risk management or stewardship priorities.

Different teams within an asset owner or asset manager organization will view materiality through different lenses. Investment teams focus on valuation and expected returns; risk teams on portfolio concentration and downside outcomes; sustainability teams on engagement, adaptation and disclosure. A single, consistent physical risk assessment can support all decision contexts, with outputs and thresholds tailored to each team's needs. The remainder of this chapter sets out a practical three-step workflow for assessing physical risk materiality.

## 4.1 How do I assess physical risk materiality?

Physical risk materiality assessment follows a structured workflow that links where assets are located, which hazards are relevant, and how physical impacts translate into financial outcomes. Materiality arises from the combination of these steps, not from any one in isolation.

To illustrate this workflow, this section compares two companies with different business models and geographic footprints:

- Duke Energy Corporation (Duke Energy), an electric utilities company domiciled in the United States, and
- Rio Tinto PLC (Rio Tinto), a diversified metals and mining company domiciled in the United Kingdom but with globally distributed operations.

While the analysis is conducted at the company level, the same logic applies to a portfolio assessment. Portfolio analysis typically produces a summary metric intended to capture overall physical risk across constituents. While this aggregation can be useful for comparison and reporting, the resulting portfolio-level metric can obscure important concentrations of risk.

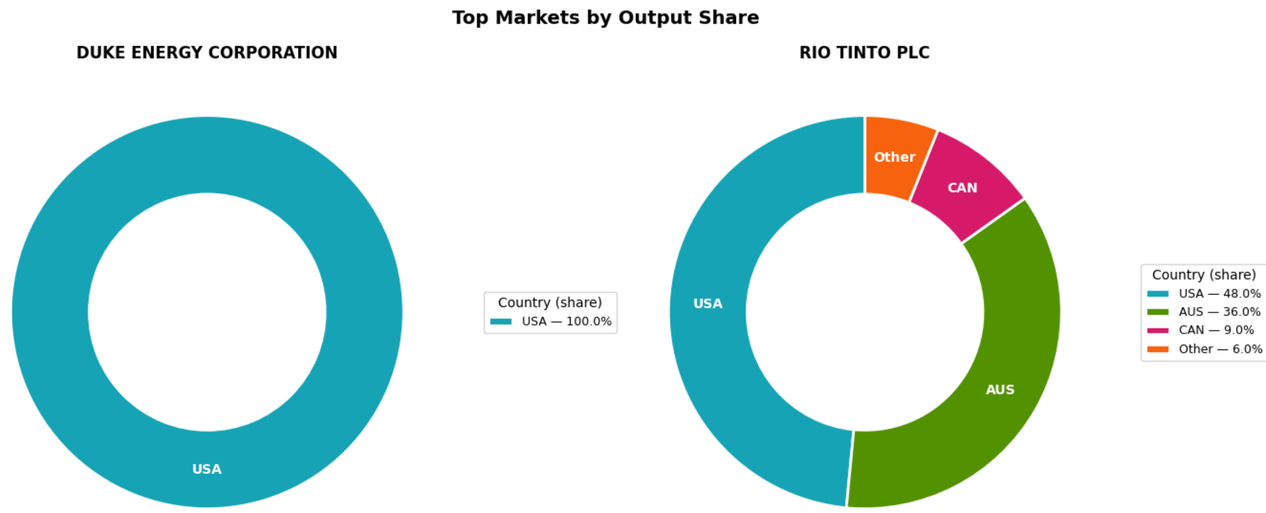
In practice, portfolio-level risk may be driven by a small subset of companies with particularly high exposures. Where those companies also carry significant portfolio weights, they can dominate the portfolio signal. Tracing portfolio risk back to the underlying companies provides important context for determining whether risk is broadly distributed or concentrated, and clarifies which geographies or hazards may be responsible for the portfolio's overall risk.

**Step 1: Map the company geographically**

Physical climate risks are location specific. The first step is to identify where assets are located and where revenues are generated. This may involve site-level mapping where data coverage allows, or regional proxies where it is limited. Section 7.2 covers geographic exposure mapping in more detail.

*Example:*
Duke Energy operates almost exclusively in the U.S., with power plants comprising a significant share of its revenue-generating assets. Rio Tinto, while domiciled in the U.K., has more globally distributed operations, with approximately half of its output generated in the U.S. and a substantial share in Australia. Its assets are mostly industrial, manufacturing and refineries.

### Geographic exposure differences by output share




Source: MSCI Sustainability and Climate Research. Data as of March 2026. This example is for illustrative purposes only, may change as a result of market fluctuations, and is in no way an endorsement of these companies by MSCI.

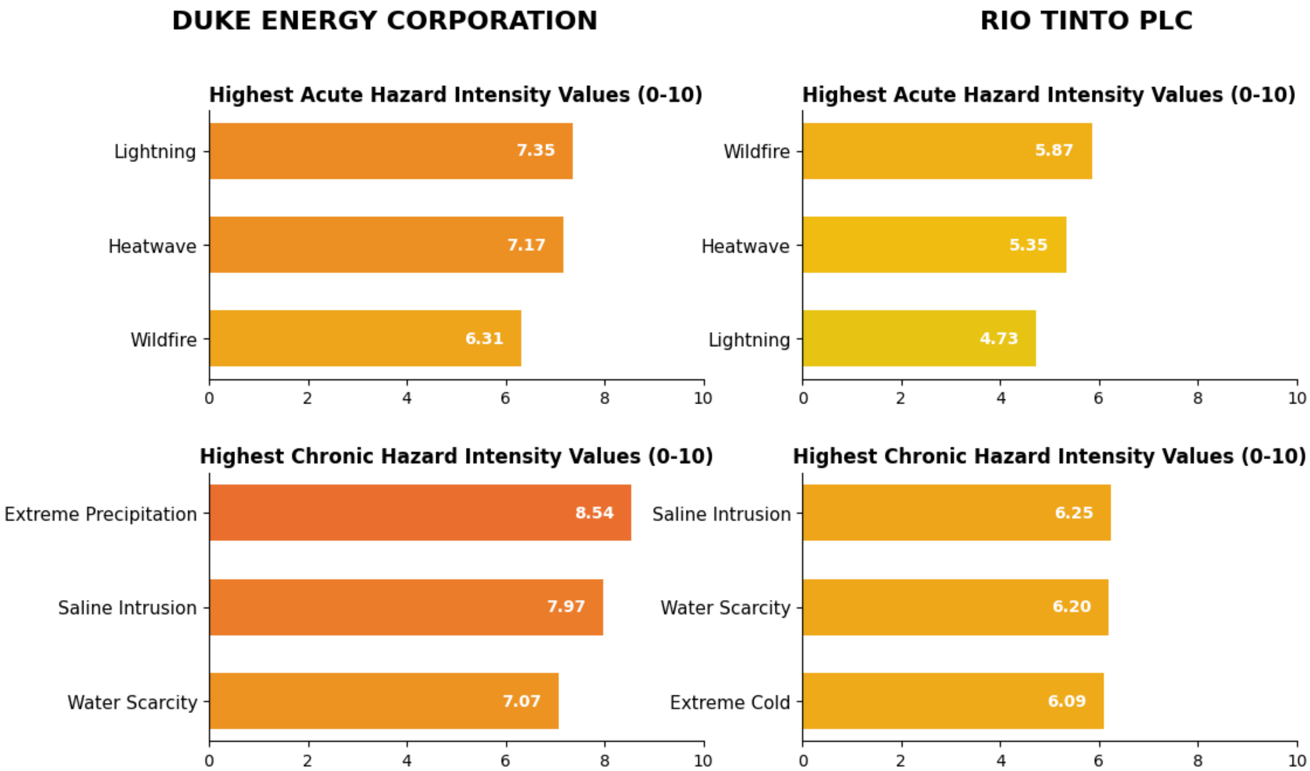
At this stage, the analysis identifies where geographical exposure exists, but not whether that exposure is financially material.

### Step 2: Identify physical hazard exposure

Once asset locations are mapped, the next step is to identify which physical hazards are present at those locations and how their intensity may change over relevant time horizons under current conditions and across climate scenarios. The objective is to map the physical hazards facing each asset location. Hazard indicators describe the relative intensity and prevalence of hazards across company locations; they do not, on their own, determine financial materiality.

*Example:*
For Duke Energy, assets are exposed to a range of physical hazards across its operations, including extreme precipitation, lightning, heatwaves and water scarcity. Flood-related hazards, while not affecting all locations, are particularly prominent at specific sites. Rio Tinto's company-level exposure is highest to water scarcity and wildfires, while many individual locations are also exposed to extreme heat.

**Current acute and chronic hazard exposure comparison**




Source: MSCI Sustainability and Climate Research. Data as of March 2026. This example is for illustrative purposes only, may change as a result of market fluctuations, and is in no way an endorsement of these companies by MSCI.

This step produces a clear picture of which hazards are present based on the physical locations of a company's assets. This information provides a key input for assessing vulnerability and financial materiality in Step 3.

### Step 3: Translate physical exposure into financial impacts

The final step is to determine whether physical hazard exposure could have financial consequences. This involves assessing how facilities and operations are affected by the hazards and how any disruption or damage could affect financial performance, considering asset sensitivity, operational vulnerability and financial relevance.

Different hazards affect companies through different channels. Acute hazards, such as flooding, may lead to direct asset damage and short-term operational disruptions. Chronic hazards, such as extreme heat, may erode productivity over time. Translating exposure into financial terms helps investors to distinguish between hazards that are present but without financially material effects and those that may be relevant to investment decisions.

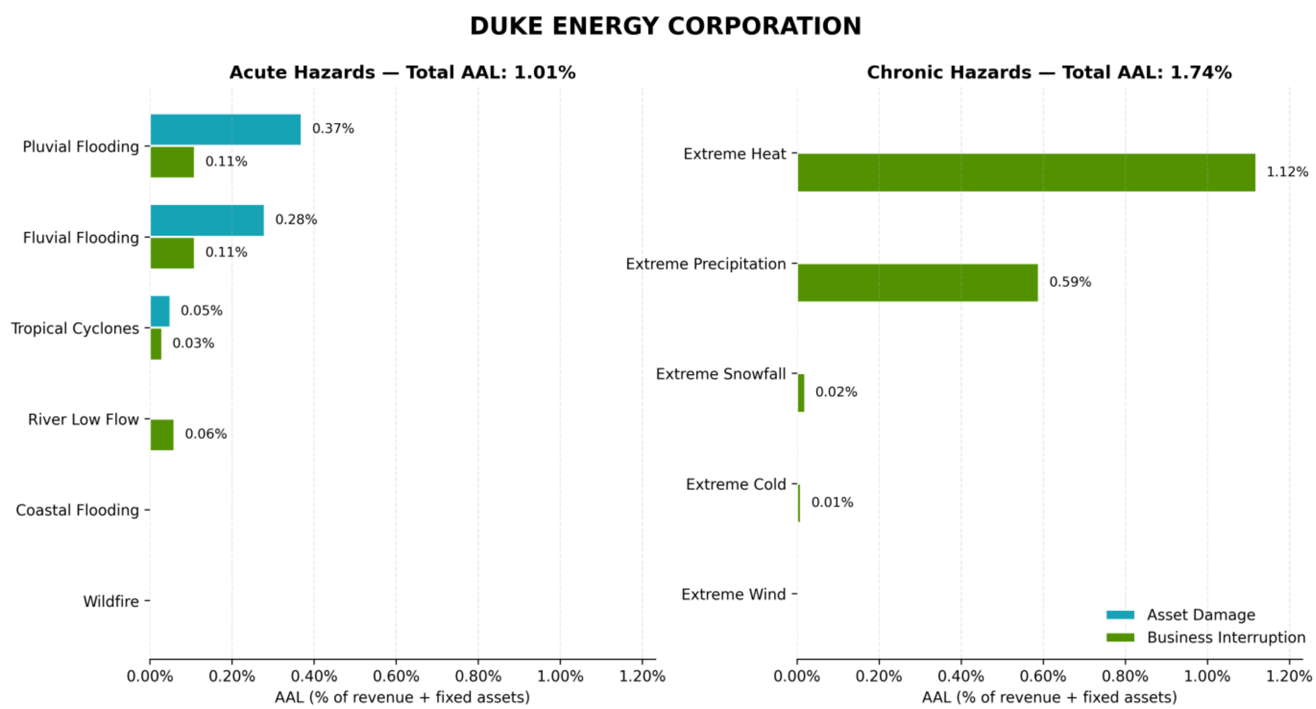
Refer to section 7.3 for a more detailed look into identifying material hazards and quantifying financial impacts for portfolio companies.

*Example:*
For Duke Energy, flood-related hazards drive the largest potential losses among acute risks, representing

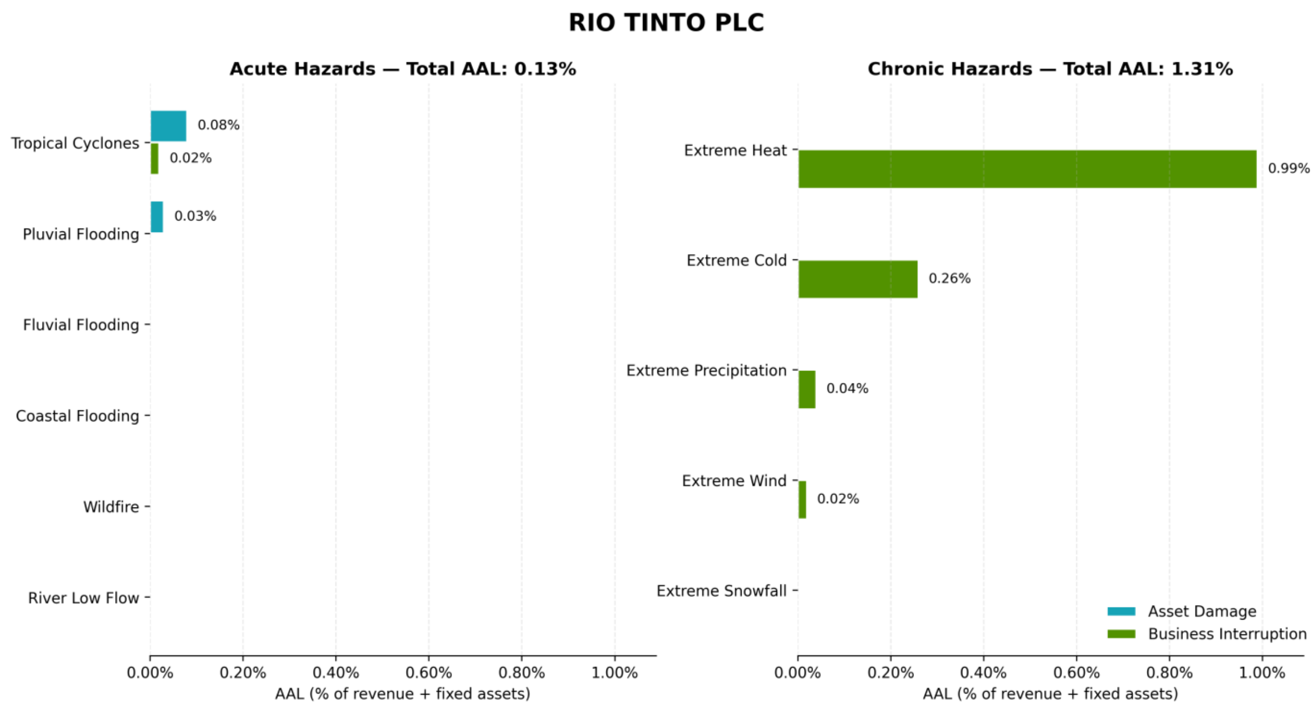
around three-quarters of the total average annual loss (AAL) from acute hazards. Losses are driven primarily by asset damage. Chronic hazards represent the larger overall source of risk, with estimated AAL associated with chronic hazards totaling 1.7%, compared with 1.0% for acute hazards. These chronic losses are dominated by extreme heat followed by extreme precipitation, reflecting the potential for significant productivity impacts.

For Rio Tinto, the pattern differs markedly. Estimated AAL from chronic hazards substantially exceeds acute hazards, at 1.3% compared with 0.1% for acute hazards — roughly ten times higher. Extreme heat drives the majority of chronic losses, reflecting the potential for significant impact to labor productivity across the company's sites. By contrast, acute hazard losses are projected to be comparatively small and concentrated, driven by tropical cyclones and pluvial flooding.

### Current average annual losses by chronic and acute hazards




Source: MSCI Sustainability and Climate Research. Data as of March 2026. Average annual loss (AAL) indicates the expected loss in a given year as a percentage of revenue (business interruption) or fixed asset value (asset damage).




Source: MSCI Sustainability and Climate Research. Data as of March 2026. Average annual loss (AAL) indicates the expected loss in a given year as a percentage of revenue (business interruption) or fixed asset value (asset damage).

This step produces an assessment of which hazards have the potential to be financially material and through which channels. By distinguishing between acute and chronic risks, this analysis clarifies how different physical hazards can become material for different business models, even when exposure exists across multiple hazard types.

## 4.2 Interpreting results: from analysis to decisions

The three-step workflow can be used to directly support investment, risk-management and stewardship decisions, providing a consistent view of geographic exposure, hazard presence and potential financial effects across decision contexts.

- **Investment teams** may use results to assess whether stress-tested physical risk effects could alter valuations or expected returns, informing valuation sensitivity and position sizing.
- **Risk teams** may evaluate how physical risks aggregate across the portfolio, identifying geographic or hazard-based concentrations and contributors to tail risk.
- **Sustainability teams** may use exposure and vulnerability insights to prioritize engagement on resilience, adaptation and disclosure.

Decision thresholds will differ by team and mandate. Assessments will need periodic revision as portfolios, hazards and underlying data evolve. Clear documentation of assumptions, scenarios and limitations supports governance, internal review and consistent interpretation over time.

## 4.3 What this analysis can — and cannot — tell you

This workflow may help asset owners and managers identify where physical risks are relevant and prioritize attention across portfolios. It supports comparative assessments and portfolio-level prioritization at scale. It is not designed to predict specific events or their timing, produce precise loss forecasts or capture all second-order or systemic effects.

Importantly, this analysis assesses exposure to financially material physical risks, but it does not evaluate how companies are managing those risks, such as investing in adaptation and resilience, or insurance coverage. As a result, it identifies where risk may be material based on exposure characteristics, but does not determine whether that risk is mitigated, transferred or strategically managed.

Physical risk materiality can change over time as hazards evolve and companies invest in adaptation and resilience. In many cases, the most relevant question is not whether a company is exposed today, but whether it is positioned to manage and reduce that exposure over time. Chapter 5 addresses how investors can assess company preparedness and identify adaptation-related opportunities.

# Chapter 5: Adaptation and resilience

As physical risks intensify, adaptation and resilience become increasingly important for investors. Adaptation refers to action taken to protect assets from physical hazards, while resilience reflects the ability to withstand and recover from their impacts.

For asset owners, this introduces two complementary perspectives:

- **Risk management**: Which investments face the highest potential losses, and what adaptation and/or resilience options are relevant to consider?
- **Investment opportunity**: Which adaptation and resilience solutions are available and needed, vs. those still commercializing and facing higher demand in the future?

By comparing adaptation data with physical risk exposure, investors can identify priority targets for engagement, as well as potential opportunities in adaptation-related solutions.

## 5.1 Adaptation as risk management

Applying adaptation measures to highest-risk investments can provide downside protection, enable upside capture or deliver broader stakeholder co-benefits. Common metrics to quantify the value of adaptation measures include "avoided losses"[19] and cost-benefit ratios.

**Potential adaptation benefits in a risk management context**

| Downside protection | How the protection materializes | Stakeholder co-benefits |
|---|---|---|
| **Reducing losses on investments** | Potential value creation | Growth of co-benefits with strategic partners |
| **Lower expected average annual losses (AAL)**<br>**Lower insurance premiums**<br>**Less business interruption/asset damage**<br>**Preserved asset valuations** | Improved credit ratings<br>Lower cost of capital<br>Enhanced asset values | Stronger portfolio resilience for Asset Owners<br>Differentiated product offerings for asset managers<br>Better collateral protection for lenders<br>Loss mitigation for insurers<br>Broader systemic resilience |

Source: MSCI Sustainability and Climate Research, IIGCC, UNEP, January 27, 2026.

[19] U.S. Global Change Research Program (USGCRP). 2023. Fifth National Climate Assessment. Washington, DC: U.S. Global Change Research Program, pg. 1576.

## 5.2 Adaptation-related solutions as a thematic investment area

Adaptation can also be considered a thematic investment topic with potential long-term growth drivers, such as increasing demand for climate-resilient infrastructure.[20] Investment, product development and sustainability teams may approach this in several ways, including:

- Investing in adaptation solution providers,
- Tilting portfolios towards more climate-resilient physical assets, and/or
- Issuing adaptation and resilience-specific financial products.

The table below outlines key themes across natural systems, infrastructure, agriculture and social resilience.

### Thematic topics for adaptation related investments

| Delivery mechanisms / Systems being made resilient | 1. Capital and financing<br>*Funding adaptation of assets and services* | 2. Insurance and risk transfer<br>*Pooling, transferring, or pricing physical climate risk* | 3. Physical solutions and enabling technologies<br>*Assets, systems and technologies that directly reduce risk* | 4. Advisory, planning and operational support<br>*Services supporting adaptation outcomes* |
|---|---|---|---|---|
| **A. Natural systems and landscape resilience**<br>***Ecosystems that reduce physical climate risk*** | Mangrove, wetland and coastal ecosystem finance<br>Reforestation and afforestation<br>Debt-for-nature swaps<br>Natural capital funds | Parametric insurance linked to ecosystem outcomes | Erosion-control materials<br>Living shorelines and nature-based flood buffers | Ecosystem risk mapping and valuation.<br>Biodiversity and land-use analytics<br>Nature-based solution performance assessment |
| **B. Food, water and agricultural system resilience**<br>***Water availability, food production and supply chains*** | Irrigation, water supply and desalination<br>Wastewater and reuse<br>Climate-smart agriculture<br>Cold-chain logistics | Crop insurance<br>Weather-linked agricultural insurance | Precision irrigation systems<br>Water treatment and reuse technologies<br>Desalination facilities<br>Climate-resilient seeds and crop systems<br>Cold storage and refrigeration | Agricultural early-warning systems<br>Drought and crop-stress modeling<br>Water-resource analytics<br>Post-disaster farm recovery support |

[20] Wong, De Rui, and Kee Bum Kim. 2025. Sizing the Climate Adaptation Opportunity. Singapore: GIC.

| | | | | |
|---|---|---|---|---|
| **C. Built environment, infrastructure and urban resilience**<br>***Buildings, energy, transport and cities*** | Green building and retrofit<br>Flood, stormwater and drainage infrastructure<br>Port and coastal infrastructure<br>Energy storage and grid-resilience | Property and mortgage hazard insurance<br>Wildfire and catastrophe insurance | HVAC and cooling systems<br>Data center liquid cooling<br>Thermal insulation and cool roofs<br>Battery storage and backup power<br>Flood barriers and drainage systems<br>Sensors, meters and monitoring hardware | Climate risk analytics for assets<br>Urban flood and storm modeling<br>Infrastructure stress testing<br>Emergency response coordination<br>Business continuity and recovery support |
| **D. Social systems and human resilience**<br>***People, safety, access and social capacity*** | Financial inclusion for climate-vulnerable populations<br>Emergency credit and liquidity facilities<br>Health, shelter and essential services | Micro-insurance and parametric cover for households<br>Disaster and livelihood protection | Wearable cooling devices<br>Personal fans and heat-stress mitigation tools<br>Portable flood barriers and pumps<br>Air purifiers and smoke filtration<br>Personal safety and alert devices | Disaster risk communication and early warning<br>Emergency services and response systems<br>Public health surveillance<br>Community resilience planning<br>Social protection and recovery services |

Source: *"The Hidden Adaptation Economy", MSCI Institute, March 18, 2026.*

## 5.3 Towards a materiality-based approach: introducing the hazard adaptation matrix

Two investments exposed to the same hazards (e.g., tropical cyclones) can experience different levels of damage depending on whether relevant adaptation measures have been implemented (e.g., installation of galvanized steel roof ties).[21] Investors can apply frameworks such as a **hazard adaptation matrix (HAM)** to identify these differences.

Applying this materiality lens also allows investors to validate whether adaptation initiatives adopted by investee companies align with the hazards to which those companies are most exposed.

[21] "Determinants of Risk: Exposure and Vulnerability", In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, *Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC)*, March 2012, page 72.

**How adaptation metrics improve physical risk analysis using a hazard adaptation matrix (HAM)**

| | Low/no current physical hazard exposure (Low exposure) | High current physical hazard exposure (High exposure) |
|---|---|---|
| **Low/no adaptation implemented (Low preparedness)** | Lower risk to investments. | Highest risk. Primary candidates for engagement. |
| **Adaptation actions implemented (High preparedness)** | Assess whether measures remain relevant as hazard levels evolve. | High risk mitigated by evidence of adaptation. |

Source: MSCI Sustainability and Climate Research, January 27, 2026.

Investments identified as **high exposure, low preparedness (HELP)** emerge as natural priorities for engagement, as they indicate where adaptation measures are inadequate. Assessing whether adaptation actions address the vulnerabilities through which hazard exposure can lead to financially material losses can serve as a "no-regrets" first step for investors.[22]

The HAM framework can also be used to identify areas of potential investment opportunity. The HELP category may highlight gaps in currently commercial technologies, while areas with both high physical risk exposure and active adaptation measures (e.g., flood defenses ranging from early warning systems to flood barriers) may indicate more mature, commercially deployable solutions.

**Assessing adaptation opportunities for availability and demand (HELP)**

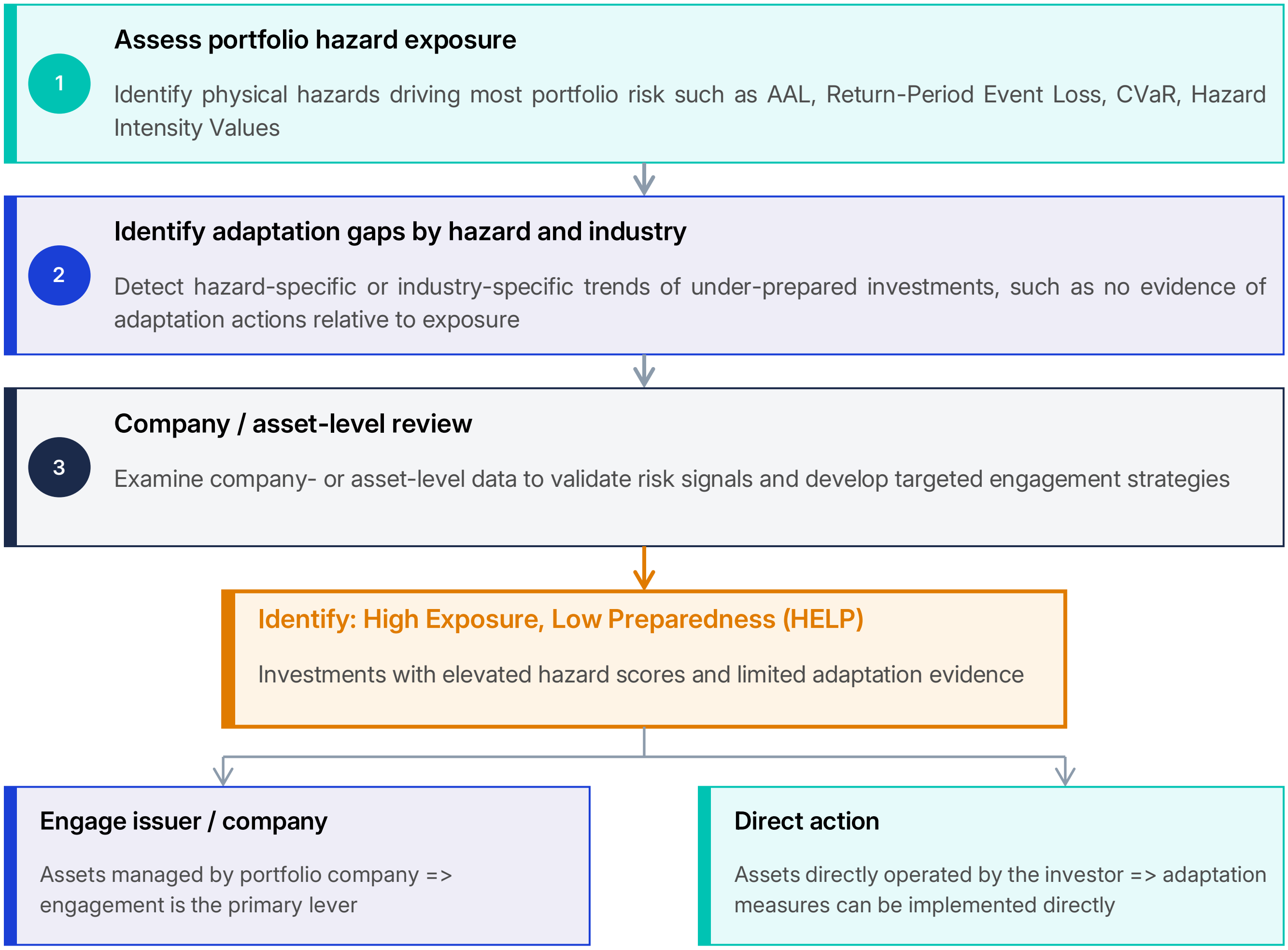
| | Low/no current physical hazard exposure (low exposure) | High current physical hazard exposure (high exposure) |
|---|---|---|
| **Low/no adaptation implemented (low preparedness)** | Limited current demand for adaptation solutions. | High opportunity due to limited adoption of existing solutions. |
| **Adaptation actions implemented (high preparedness)** | Existing solutions are available or adequate for most hazard exposures. | Growing opportunity, with existing approaches and technologies. |

Source: MSCI Sustainability and Climate Research, January 27, 2026.

The portfolio level is often the starting point for identifying hotspots (i.e. HELP investments). Next steps depend on the extent to which investors directly control the underlying assets. Where physical assets are managed by a portfolio company or issuer, engagement is typically the most practical course of action.

[22] "Decision-Making Options for Managing Risk." In Climate Change 2022: Impacts, Adaptation and Vulnerability. *Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by Hans-Otto Pörtner, Debra C. Roberts, Melinda M. B. Tignor, et al., June 2023, page 2543.

**Incorporating adaptation into physical risk assessment**




Incorporating the HAM framework into a broader physical risk assessment involves three steps:

- Begin by assessing which physical hazards drive the most portfolio risk, using metrics such as average annual loss (AAL), return period event loss, Climate VaR or Hazard Intensity Value.[23]
- Next, identify hazard- or industry-specific trends of under-prepared investments, where there is limited or no evidence of adaptation.
- Finally, examine company- or asset-level data and validate risk signals to inform engagement strategies.

In addition to the following table, more questions are available in section 7.4.

[23] "MSCI in Practice Physical Risk Investor Guide Presentation", MSCI Research, March 2026.

**Key investor insights and questions on adaptation from different levels of analysis**

| | Key insights for investors | Key questions/adaptation metrics for investors to evaluate |
|---|---|---|
| **Portfolio level** | Identify hotspots driven by investments with high hazard exposure and limited or no evidence of adaptation measures. | What hazard intensity threshold should be used for initial portfolio screening?<br>What types of adaptation evidence are available?<br>What characteristics (sectors, geographics, types of physical assets) define HELP investments in the portfolio? |
| **Sector level** | Compare industry protocols and practices to identify potential gaps in HELP investments. | Which practices and infrastructure investments are widely adopted adaptation measures? |
| **Issuer level** | Assess firm-wide policies, investments and practices against specific hazard exposure.<br>Define engagement priorities and approaches with investee companies. | What adaptation measures can be identified from company disclosures (relevant information can often be embedded across operational resilience, preparedness and innovation related materials)? |
| **Asset/project level** | Identify or implement on-site operational protocols and investments to address the most exposed hazards. | What building characteristics, attributes and output data are available to support precise cost-benefit analysis and prioritization of adaptation actions? |

## 5.4 Navigating an unstructured, qualitative data landscape

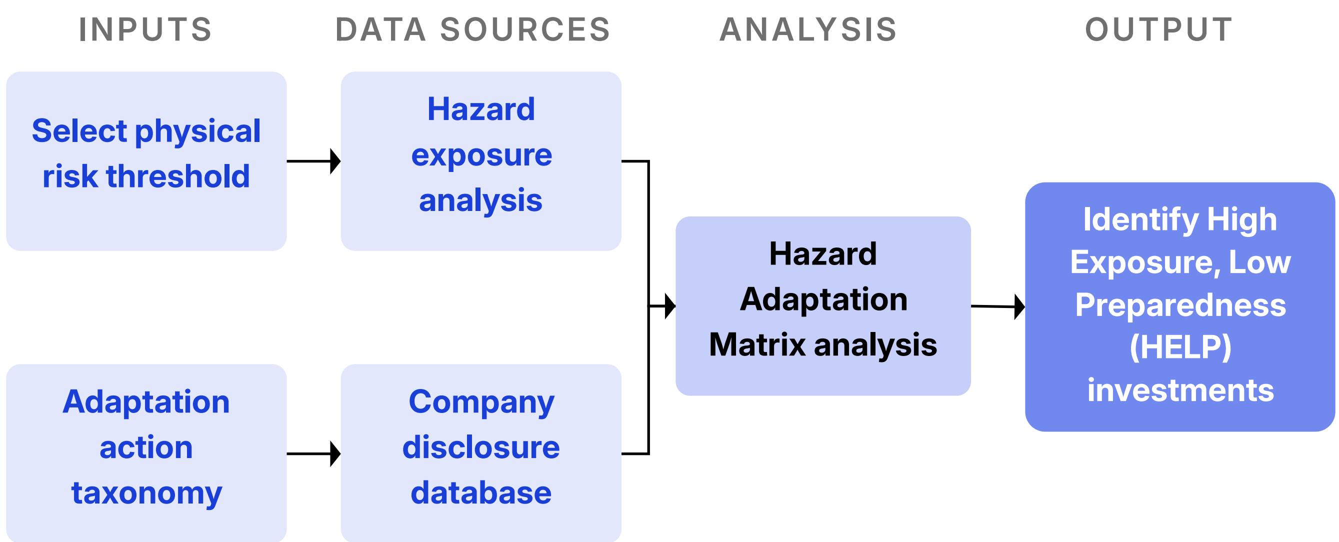
A major challenge for investors is that adaptation-related information is often not explicitly labeled or organized within company disclosures. MSCI research has found the sources of relevant data to be scattered. For example, infrastructure hardening initiatives may be mentioned in sustainability reports, while business model changes or insurance risk transfer schemes may appear in annual reports or earnings call transcripts.

A more comprehensive analysis can be conducted by combining:

- An assessment of physical hazard exposure and potential losses to identify material risks
- A taxonomy of adaptation actions to screen for
- A database of company disclosures

Large language models (LLMs), combined with retrieval-augmented generation (RAG) techniques, can support this process.[24] They can be used to identify adaptation actions by querying disclosures against the taxonomy, and to assess their relevance by comparing them with hazard exposure. This enables a HAM analysis, helping investors identify HELP companies for further investigation.

**Example workflow to identify highest risk investments from adaptation data using LLMs**




Source: MSCI Sustainability and Climate Research, February 26, 2026.

As adaptation grows in prominence for both investors and regulators, more standardized reporting frameworks for companies are likely to emerge. As of March 2026, existing standards applicable across different stages of the investment process are summarized in the Appendix.

[24] Lewis, Patrick, Ethan Perez, Aleksandra Piktus, Fabio Petroni, Vladimir Karpukhin, Naman Goyal, Heinrich Küttler, et al. 2020. "Retrieval-Augmented Generation for Knowledge-Intensive NLP Tasks." In Proceedings of the 34th International Conference on Neural Information Processing Systems (NeurIPS 2020). Red Hook, NY: Curran Associates

# Chapter 6: Scenario analysis and stress testing

## 6.1 Why scenario analysis is used in physical risk assessment

Physical risk forecasting faces a fundamental challenge: the range of possible futures is wide, and the probability of each outcome is hard to quantify. Scenario analysis addresses this by defining a set of plausible futures, modeling how each would affect a portfolio, and using that range of outcomes to inform decisions today.

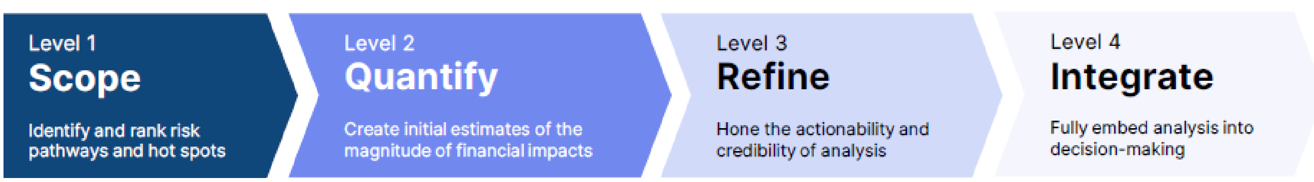
Investors typically approach scenario analysis for two reinforcing reasons.

- The first is financial risk management. Understanding how a range of climate futures might affect portfolio value, even where the probability of individual outcomes is uncertain.
- The second is regulatory compliance, as outlined in Chapter 3. ISSB-aligned disclosure standards and supervisory stress-testing regimes administered by central banks and financial regulators increasingly require formal scenario analysis as a component of climate risk governance.

These rationales are complementary. The implementation framework in section 6.2 through 6.6 reflects both, and section 6.3 sets out the specific regulatory requirements in detail.

## 6.2 Implementing a program of scenario analysis

This section provides a practical framework for integrating physical risk scenario analysis into investment processes.[25] Implementation is best understood as a progression rather than a single technical leap. Mapping exposure pathways and ranking risk using narrative scenarios is a valid and useful starting point; more quantitative analysis can be layered on over time.




## 6.3 Regulatory requirements to conduct scenario analysis

The foundations established by Task Force on Climate-related Financial Disclosures (TCFD) and formalized through ISSB standards position scenario analysis as an expected component for understanding climate-related financial impacts.

[25] For a more detailed discussion about implementing climate scenario analysis, please refer to MSCI Sustainability Institute. 2023. "How Can I Use Climate Scenarios? A Practical Guide."

### TCFD Principles and ISSB Integration

The TCFD established scenario analysis as central to climate risk assessment, recommending that organizations describe the resilience of their strategies under different climate scenarios, including a 2C or lower scenario. These principles have been incorporated into IFRS S2 Climate-related Disclosures, which now serves as the global baseline for climate-related disclosures.

Under ISSB standards, organizations are expected to use scenario analysis to inform their understanding of climate resilience across both transition and physical risks, with flexibility in approach based on available skills, capabilities and resources.

### Regulatory applications

Beyond disclosure requirements, financial regulators increasingly use scenario analysis for supervisory stress testing.[26] The Network for Greening the Financial System (NGFS) has developed a suite of scenarios specifically designed for this purpose.[27]

## 6.4 Building blocks of scenario analysis: scenarios and metrics

The two key building blocks of scenario analysis are the scenarios themselves and the metrics that translate these scenarios into scenario-contingent financial outcomes.  In this section, we answer key questions about these building blocks.

### Which types of physical scenarios should I use?

The set of scenarios employed should span across the range of plausible futures, with an emphasis on those likely to put the portfolio at high risk of financial loss.  For physical risk, high-loss scenarios include large acute events in the short term (tropical cyclones, floods, and wildfires), and pathways with upper end of warming trajectories in the long term, leading to higher risks from both acute and chronic hazards.

Scenario selection should also reflect the institution's current financial modeling and technical sophistication. Four types of scenarios are available, in order of increasing complexity:

- **Fully narrative** scenarios develop a written narrative of a potential climate future. They support qualitative, expert-driven analysis of likely portfolio impacts.
- **Quantified narrative** scenarios translate a potential climate future into quantitative data (macro forecasts, asset class returns, regional physical damage) through an informed expert-driven approach. This quantitative output can be put into existing quantitative financial models at relatively low cost.

---

[26] Examples include: European Central Bank. 2022. 2022 Climate Risk Stress Test. Frankfurt: European Central Bank; Bank of England. 2022. Results of the 2021 Climate Biennial Exploratory Scenario (CBES). London: Bank of England; Board of Governors of the Federal Reserve System. 2023. Pilot Climate Scenario Analysis Exercise. Washington, DC: Federal Reserve; Monetary Authority of Singapore. 2022. Industry-Wide Stress Test 2022: Climate Scenario Analysis. Singapore: Monetary Authority of Singapore; Office of the Superintendent of Financial Institutions (OSFI). 2023. Guideline B-15: Climate Risk Management. Ottawa: OSFI.

[27] Network for Greening the Financial System (NGFS). NGFS Climate Scenarios Technical Documentation. V5.0. Paris: NGFS, November 2024.

- **Model-driven** scenarios feed a defined set of assumptions about future economic environment (policy, technology, socioeconomics) into a linked economic-environment model such as an integrated assessment model (IAM) to estimate required scenario output. The outputs are more objective but come with higher implementation cost and greater sensitivity to modeling assumptions.
- **Probabilistic** scenarios combine one or more forecasts with estimates of probability, variance and covariance to form conditional or full distributions of potential climate outcomes. These approaches require sophisticated analysis tools and are typically only used in specific use cases such as forecasting insurance losses.

Two key sets of model-driven scenarios that are often used as the basis for regulatory exercises are the scenarios provided by the NGFS and Intergovernmental Panel on Climate Change (IPCC).

As of publication of this report, the NGFS provides six core scenarios organized into four categories:

- Orderly scenarios (Net Zero 2050, Below 2°C, Low Demand)
- Disorderly scenario (Delayed Transition)
- Hot house world scenarios (NDCs, Current Policies)
- Too little-too late scenario (Fragmented World)

The key output from these scenarios for physical risk assessment is a future global temperature path, from which increases in physical hazard rates may be derived.

The IPCC's Representative of Concentration Pathways (RCP) and Shared Socioeconomic Pathways (SSP) also provide temperature pathways that can be used for scenario analysis.[28]

**What metrics translate scenario output into financial outcomes?**

Translating scenario outcomes into portfolio impacts requires two steps: converting scenario outcomes into financial outcomes at the physical assets and company level, and then aggregating those impacts into security valuation impacts.

MSCI provides several metrics to enable practitioners to translate model-driven NGFS and IPCC scenarios into the financial effects of physical risk. All these metrics are built on underlying models that forecast annual costs incurred by firms due to physical risk within each scenario.

- At the most granular level, **MSCI Geospatial Asset Intelligence** provides annual forecasts of scenario-contingent physical damage and business interruption losses for specific physical assets, expressed as average annual losses (AAL) and return period losses.
- **MSCI Physical Risk Metrics – Issuer Level** aggregates those asset-level losses to the company level.

[28] Intergovernmental Panel on Climate Change (IPCC). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, 2021.

- Finally, **MSCI Climate Value-at-Risk** (Climate VaR) provides a single forward-looking metric of physical risk exposure by aggregating the discounted value of all future marginal physical risk losses (relative to the current day baseline) to understand the company's total potential exposure to future physical risk-driven costs.[29]

Climate VaR metrics are available at the company level for debt and equity instruments, for real estate assets and on demand for private names. At the portfolio level, Climate VaR aggregates security-level impacts using weighted averages to provide a consolidated view of risk. Multi-Horizon Climate VaR extends this analysis across six time horizons (1, 3, 5, 10, 20 and 30 years), enabling both long-term resilience assessment and regulatory stress testing within defined time boundaries. MSCI Climate-Adjusted Probability of Default (PD) translates Climate VaR company devaluation into credit risk shocks, providing a view of how physical risk affects default probability at the company level.[30]

**When should I use AAL and return period loss metrics vs. using Climate VaR?**

Average annual losses (AAL) and return period losses are the building blocks of physical risk forecasting. Climate VaR builds on these by aggregating, discounting and scaling projected annual losses into a single forward-looking metric that represents a firm's or instrument's physical cost exposure over a defined time horizon.

The choice between them is primarily one of granularity versus aggregation. Annual loss data provides a transparent, year-by-year view of loss exposure across scenarios, making it intuitive and auditable. It is particularly well suited for deep, issue-specific analysis, such as materiality assessments, company engagement or other cases where understanding the timing and evolution of risk is critical. It is also the appropriate metric when exposure in a specific year (current or future) needs to be evaluated, such as for short-term investment strategies or certain regulatory reporting requirements.

Annual loss data does not aggregate easily to assess total portfolio-level exposure, however, and the volume of yearly data points may become difficult to manage. Climate VaR addresses both limitations: it condenses projected losses into a single metric over a selected horizon and, because it is expressed as a percentage of company or security value, can be readily aggregated across holdings to provide a portfolio-level view of risk. This makes Climate VaR particularly useful for internal and regulatory stress testing, as well as portfolio-level reporting and risk management applications.

The limitations of Climate VaR also stem from aggregation. By condensing losses into a single metric, it reduces transparency around when costs are expected to materialize. It is also a relatively new concept and can be misread as an expected-return forecast rather than a measure of future physical risk-driven cost exposure (or a maximum potential devaluation).

---

[29] This present value of future costs, reported in Climate VaR as a percentage of the company's current EVIC, can be interpreted as a relative measure of physical cost exposure between companies, and also the maximum devaluation potential of a company due to possible future "pricing in" of subsequent climate costs.

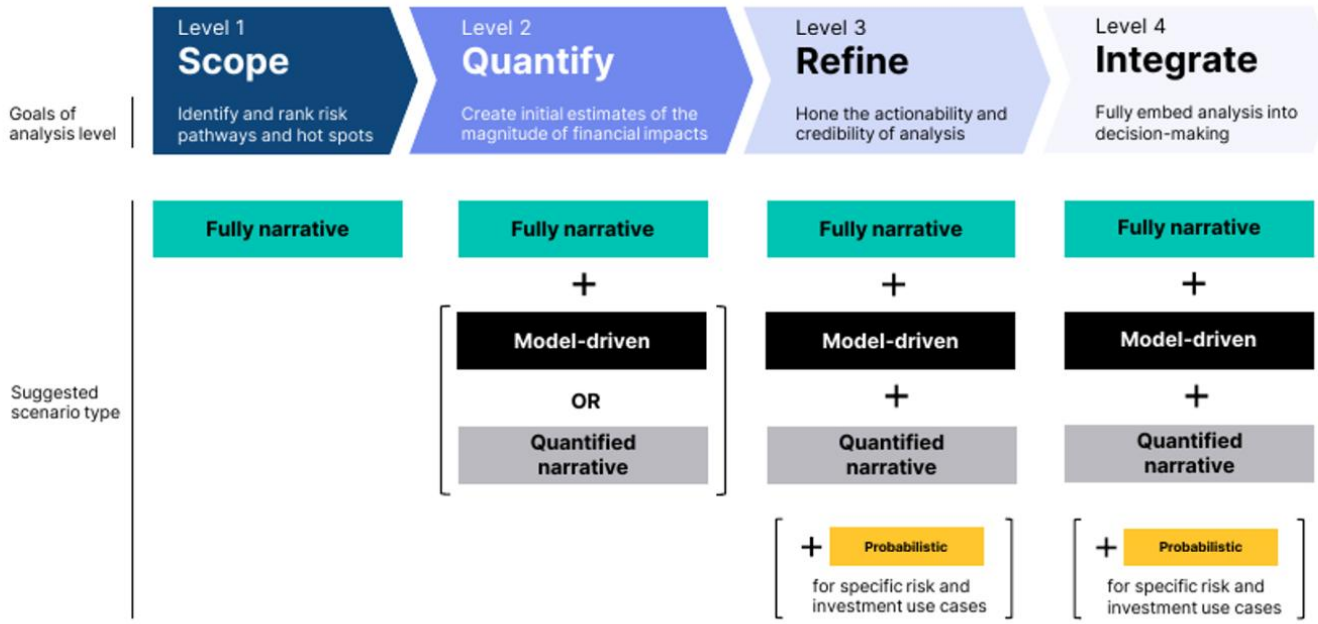
[30] MSCI Climate-Adjusted Probability of Default is a credit risk metric that adjusts a company's probability of default to reflect the present value of climate-related financial impacts (including physical risk), translated into credit risk using financial modeling frameworks such as the Merton model.

### AAL/return period loss metrics vs Climate VaR

| | Asset-level loss metrics (AAL /return period losses) | Physical Climate VaR |
|---|---|---|
| **What does it measure?** | Expected annual loss or tail-event loss from physical hazards at the asset level | Present value of total projected physical climate costs relative to enterprise value |
| **Unit of expression** | % of asset revenue (business interruption) or % of asset replacement value (asset damage) | % of enterprise value (EVIC) |
| **Time horizon** | Current conditions; or future scenarios at 2030, 2050, 2100 | Present value of costs to 2100 (standard); 1–30 year cutoffs (Multi-Horizon) |
| **Level of granularity** | Asset and issuer | Issuer and portfolio |
| **Primary use cases** | Materiality assessment, engagement, regulatory disclosure (IFRS S2 / ESRS E1), stress testing | Stress testing, governance reporting, benchmarking |
| **Key strengths** | Specific, auditable, supports issuer-level investigation | Comparable across holdings; enterprise-value framing; scenario-ready |
| **Key limitations** | Large volume of data points, requires aggregation methodology to generate portfolio-level view | Not a return forecast; difficult to understand when risk is occurring |

## 6.5 A concrete framework for implementation

**Suggested scenario types for each level of scenario analysis**



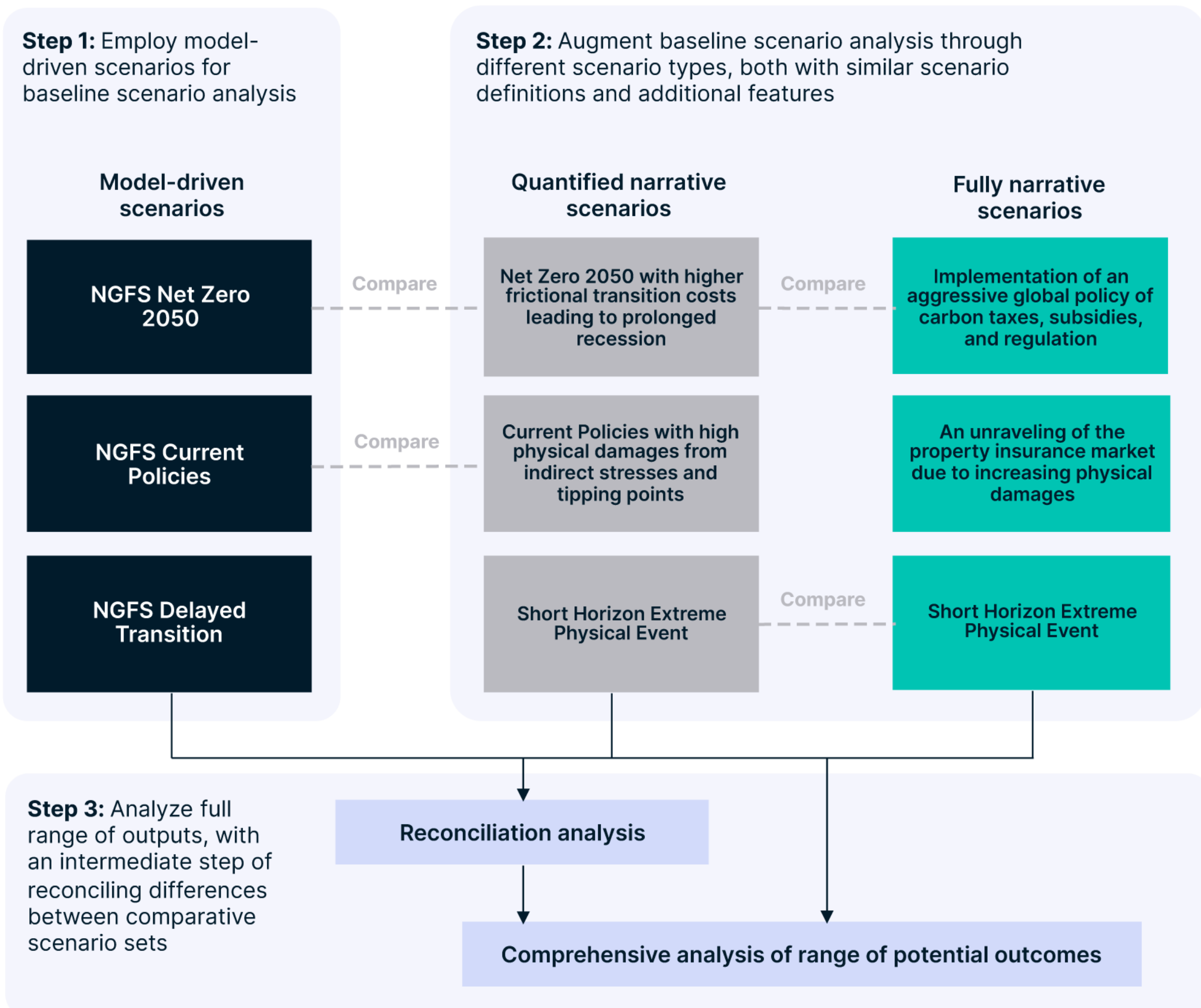

Source: MSCI Sustainability Institute, December 2024

Implementation of scenario analysis at an institution is typically a progressive process. The figure above maps four implementation levels to the scenarios types presented in section 6.4.

- At Level 1, where the goal is to scope hot spots and rank exposure across different risk pathways and holdings, fully narrative scenarios typically suffice.
- At Level 2, where the goal is to quantify initial estimates of risk magnitudes, bringing in either model-driven or quantified narrative scenarios can be integral. The choice between these two approaches depends on the institution's technical expertise and the requirements of the analysis.
- Level 3 expands initial risk estimates to test sensitivities to key assumptions. Running model-driven, quantified narrative and fully narrative scenarios side-by-side allows teams to compare outputs and stress-test modeling assumptions, which also strengthens the credibility of findings with a wider audience.
- Level 4 represents a more advanced stage in which the mature analysis from Level 3 is integrated in investment decision-making across the institution.

The figure below is an example of a mature scenario analysis implementation from Level 3 and 4. In this example, model-driven scenarios are used as a baseline, as may be required by specific regulatory disclosure requirements. Quantified narrative and fully narrative scenarios are used alongside them to test sensitivity to key assumptions and explore futures that are hard to model with quantitative economic and climate models. After analysis of each scenario is performed (preferably by independent teams or analysts), the results of comparative scenarios are reconciled to final conclusions for each scenario set. Finally, a comprehensive summary of analysis is performed as a capstone step.

**Example complementary framework combining scenario types**




Source: MSCI Sustainability Institute, December 2024

## 6.6 Practical considerations for implementation

The approach detailed allows institutions to build analytical capability incrementally while generating value at each stage. To maximize and communicate value within your institution, keep in mind:

- **Communication is as important as the analysis.** Scenario analysis and the multiple outputs they produce are often an unfamiliar concept to key stakeholders (executives, internal investment teams, or external asset managers). Presenting ranges across multiple scenarios, emphasizing relative comparisons and linking results directly to investment decisions can help contextualize findings. Framing results in accessible language and highlighting the key metrics that stakeholders require to make better financial decisions is important.
- **Scenario selection should reflect both regulatory requirements and investment objectives.** Regulatory disclosure requirements may specify particular scenarios, while internal risk management frameworks may warrant exploration of more severe tail risks. Investors should balance comprehensiveness with stakeholder clarity, and ensure that scenario time horizons are aligned with investment periods.
- **Data quality remains an important constraint.** Asset-level location information is improving through systematic collection efforts such as MSCI GeoSpatial Asset Intelligence, but coverage still varies by region and sector.

# Chapter 7: Practical applications

## 7.1 Introduction: How to make use of this chapter

Physical risk analysis becomes useful for investment decision-making when it answers concrete questions: Where am I exposed? How big is the potential loss? What do I do about it? This chapter demonstrates how the frameworks, data and analytical approaches introduced in earlier chapters come together in practice.

The chapter is organized around seven practical applications. Each demonstrates how to use MSCI physical risk data and tools to move from portfolio-level mapping through to potential investment action and reporting. The table below shows how each practical application connects with the use cases introduced in Chapter 1.

**Practical applications of MSCI physical risk data**

| Section | Practical application | Use cases | Outcome examples |
|---|---|---|---|
| 7.2 | Mapping geographic exposure and concentrations | All use cases (foundational) | Map geographic footprint of companies' physical assets (noting that distribution of fixed asset value and revenue may differ from portfolio AUM allocation by market); identify coverage gaps; flag concentration hotspots. |
| 7.3 | Identifying material hazards and quantifying financial impacts for portfolio companies | Risk management and scenario analysis; strategy and oversight | Rank issuers by hazard exposure; identify primary risk drivers by hazard and region; quantify financial impacts at issuer and portfolio level; run scenario analysis. |
| 7.4 | Evaluating corporate adaptation and resilience: risk management and opportunities | Portfolio construction and product development | Screen for adaptation-linked revenue and innovation exposure; flag solution providers and readiness leaders for portfolio tilting. |
| 7.5 | Monitoring portfolio-level risk outcomes across scenarios | Portfolio construction and product development; risk management and scenario analysis; measuring, monitoring and reporting | Aggregate issuer-level physical risk results into a portfolio-wide view; decompose exposure by sector, geography and hazard; identify top risk contributors and concentration clusters; compare portfolio risk profile against benchmark across scenarios. |
| 7.6 | Integrating physical risk data into index- | Portfolio construction and product development; risk management and scenario analysis | Set and monitor physical risk reduction targets; generate risk-based tilting |

| | | | |
|---|---|---|---|
| | based equity strategies | | signals; produce tail-risk concentration profiles. |
| 7.7 | Supporting engagement with high-risk companies | Stewardship and engagement | Prioritize high exposure, low preparedness (HELP) companies for engagement; set time-bound adaptation milestones; track progress as companies move from HELP to high-preparedness quadrant. |
| 7.8 | Meeting regulatory requirements and reporting to stakeholders | Measuring, monitoring and reporting | Compile disclosure-ready outputs; address regulatory requirements. |

## Practical applications by investor roles

| Section | Practical application | Risk teams | Investment teams | Sustainability teams |
|---|---|---|---|---|
| 7.2 | Mapping geographic exposure and concentrations | *Risk Management & Scenario Analysis*<br>Map geographic footprint; identify coverage gaps and concentration hotspots; produce input data for stress testing and monitoring. | *Portfolio Construction & Product Development; Strategy & Oversight*<br>Issuer research prioritization and engagement; creation of watchlists; definition of portfolio tilts. | *Measuring, Monitoring & Reporting; Stewardship & Engagement*<br>ISSB-aligned climate reporting; engagement scoping (which sites matter); evidence packs for stewardship and disclosure. |
| 7.3 | Identifying material hazards and quantifying financial impacts for portfolio companies | *Risk Management & Scenario Analysis; Strategy & Oversight*<br>Assess vulnerability and identify material hazards; conduct stress testing and scenario analysis; benchmark against peers. | *Portfolio Construction & Product Development; Strategy & Oversight*<br>Translate location-driven risk signals into issuer research priorities and portfolio actions. | — |
| 7.4 | Evaluating corporate adaptation and resilience: risk management and opportunities | *Risk Management & Scenario Analysis*<br>Evaluate corporate adaptation by complementing hazard/impact outputs with preparedness indicators; identify investments with highest potential losses and relevant adaptation options. | *Portfolio Construction & Product Development; Strategy & Oversight*<br>Identify adaptation/resilience opportunities; screen for solution providers and innovation leaders; use readiness indicators as quality overlay for portfolio tilting and index design. | *Stewardship & Engagement; Measuring, Monitoring & Reporting*<br>Assess whether issuers embed physical risk in governance and risk management; support engagement and disclosure narratives. |
| 7.5 | Monitoring portfolio-level risk outcomes across scenarios | *Risk Management & Scenario Analysis; Strategy & Oversight*<br>Monitor portfolio-level risk via physical risk dashboards; | *Portfolio Construction & Product Development; Strategy & Oversight*<br>Identify sectors and regions driving aggregate physical risk vs. benchmark; support | *Measuring, Monitoring & Reporting; Stewardship & Engagement*<br>Compile portfolio-level physical risk aggregates for regulatory and client |

| | | | | |
|---|---|---|---|---|
| | | identify concentration risks; set risk appetite and limits; supply aggregated input for stress testing. | allocation decisions and research prioritization based on portfolio-level diagnostics. | reporting; track year-on-year changes; provide quantitative context for engagement narratives. |
| 7.6 | Integrating physical risk data into index-based equity strategies | *Risk Management & Scenario Analysis; Strategy & Oversight*<br>Portfolio diagnostics surfacing issuers driving tail-risk exposure; concentration analysis identifying geographic and sector clusters. | *Portfolio Construction & Product Development*<br>Inform portfolio tilts through climate index design; integrate physical risk constraints into quantitative equity strategies. | – |
| 7.7 | Supporting engagement with high-risk companies | *Risk Management & Scenario Analysis*<br>Understand which portfolio risks can be mitigated through engagement vs. portfolio action. | *Strategy & Oversight*<br>Support manager selection due diligence by assessing whether portfolio companies manage physical risks effectively. | *Stewardship & Engagement; Measuring, Monitoring & Reporting*<br>Engagement scoping; evidence packs for stewardship conversations; adaptation gap analysis; tracking engagement outcomes over time. |
| 7.8 | Meeting regulatory requirements and reporting to stakeholders | *Risk Management & Scenario Analysis; Strategy & Oversight; Measuring, Monitoring & Reporting*<br>Contribute scenario analysis results to internal and external reporting; demonstrate governance through risk integration indicators and policy disclosure; track progress through AAL trends, adaptation implementation, and risk reduction metrics. | *Strategy & Oversight; Measuring, Monitoring & Reporting*<br>Demonstrate how physical risk informs capital allocation and product design decisions. | *Measuring, Monitoring & Reporting*<br>Compile disclosures aligned with ISSB IFRS S2 or ESRS E1; reporting to stakeholders on top hazard exposures and risk locations; provide audit-ready documentation of data quality, assumptions and limitations. |

The MSCI Metric Interpretation Guide in the Appendix provides further information on how to understand and use key metrics presented in this chapter.

## 7.2 Mapping geographic exposure and concentration

Physical risk analysis typically begins with identifying where investee companies' owned and operated assets are located, what types of assets they are and whether exposure is concentrated in a small number of critical sites or regions. Domicile- or sector-based views can miss these operating footprints and understate location-driven risk, including indirect effects through supply chains. Before assessing hazards or financial outcomes, establishing the geographic foundation is essential. The results of all subsequent steps depend on the quality of this mapping.

The analysis can be extended to cover supply chain dependencies and other indirect transmission channels, though the focus of this section is on the direct operational footprint.

As Chapter 4 illustrates with Duke Energy and Rio Tinto, portfolio mapping reveals how similar-seeming companies can have fundamentally different geographic risk profiles. Duke Energy's assets are concentrated almost exclusively in the U.S., with power plants as a significant share of revenue-generating assets. Rio Tinto, while domiciled in the U.K., has a globally distributed footprint with approximately half of output generated in the U.S. and a substantial share in Australia. These differences become decision-relevant only when hazard identification and financial translation are applied. The mapping step establishes the foundation for those assessments.

**Investor questions**

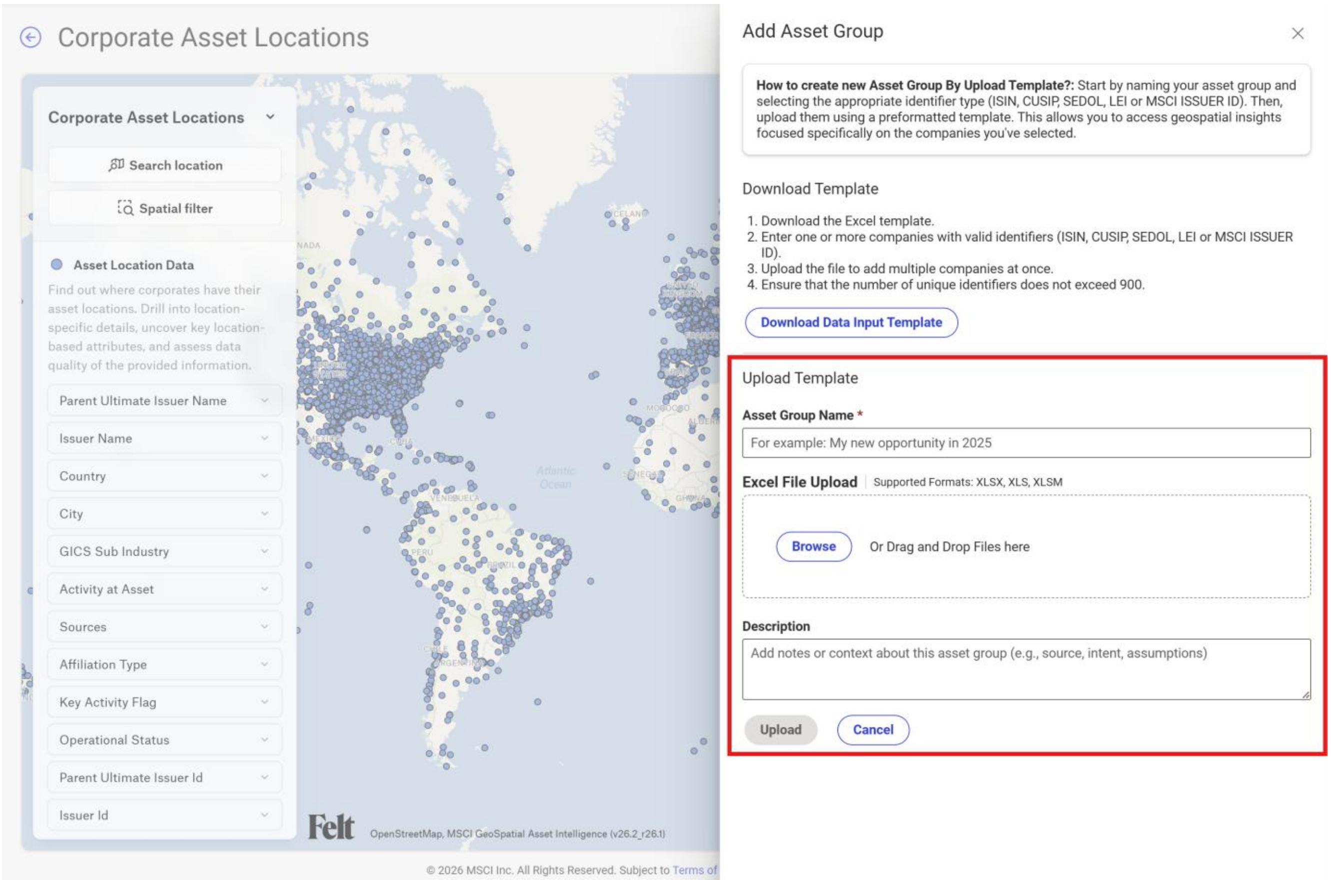
- What asset types are in the portfolio, and which are mission-critical to issuers' operations and cash flows?
- How are fixed-asset value and revenue distributed across locations, and where does that create concentration risks?
- Which issuers and assets contribute the most to these hotspots?
- Where could disruption propagate into the portfolio through logistics bottlenecks, or operational dependencies, even where investee company sites appear less exposed?

**Implementation example**

- **Assemble holdings universe.** Compile portfolio and benchmark, include issuer identifiers such as ISINs, CUSIPs, SEDOLs, LEIs, MSCI ISSUER IDs [31] and holding values and weights.
- **Map issuers to asset locations.** Use MSCI GeoSpatial Asset Intelligence to map each issuers' operations to physical asset locations and review coverage and quality flags where available. Portfolio data can be uploaded via the Asset Group functionality in GeoSpatial Insight on MSCI ONE, or data can be retrieved via Snowflake. Start by naming your asset group and selecting the appropriate identifier type (such as ISIN or MSCI ISSUER ID). Then, upload the file using a preformatted template.

[31] ISINs (International Securities Identification Numbers), CUSIPs (Committee on Uniform Securities Identification Procedures), and SEDOLs (Stock Exchange Daily Official List) identify individual securities; LEIs (Legal Entity Identifiers) identify legal entities; and MSCI Issuer IDs are MSCI's proprietary identifiers that facilitate linking issuer-level ESG and financial data across MSCI's analytical tools and datasets.

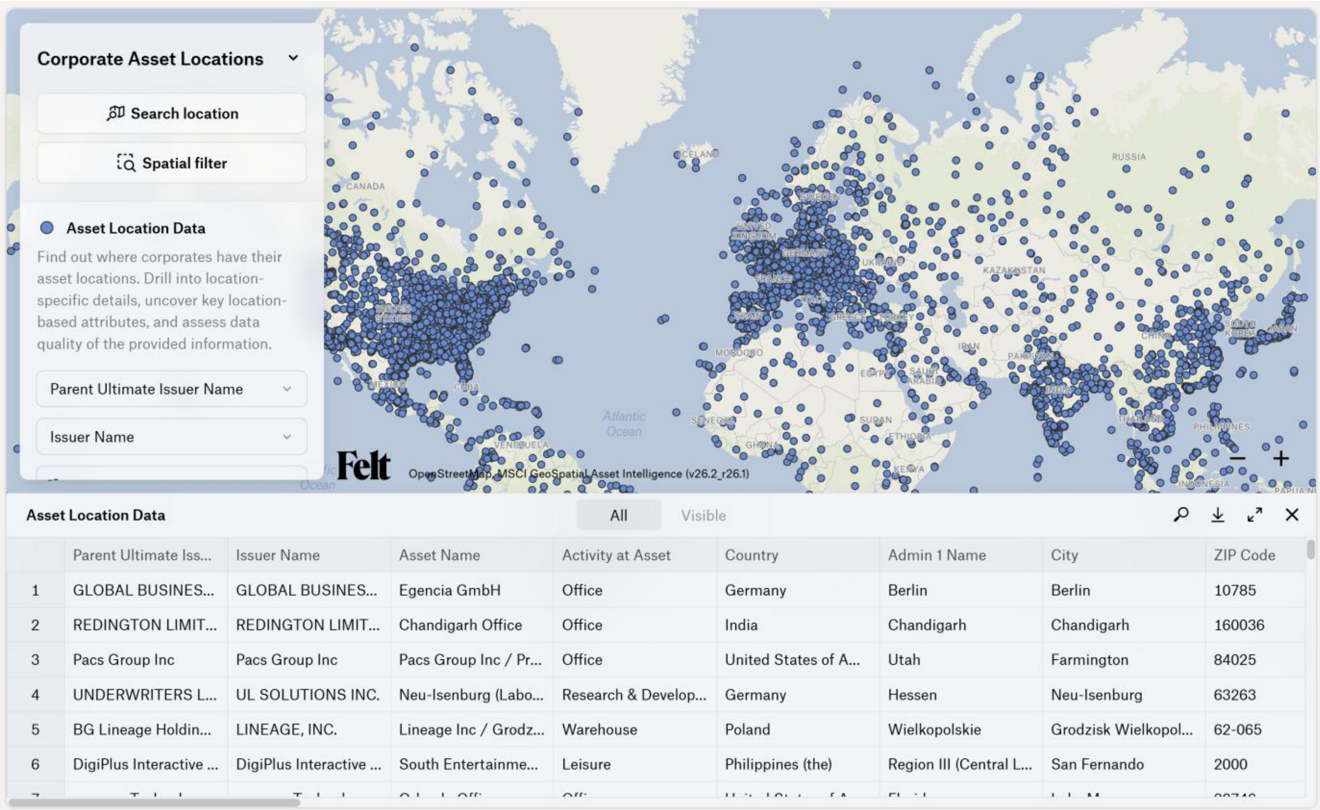
**Portfolio upload function in MSCI GeoSpatial Insights**




Source: MSCI Sustainability and Climate Research, March 2026

- **Visualize asset distribution on a map.** Asset information is also available in tabular format and downloaded for further analysis.

### Asset-level data available in MSCI GeoSpatial Insights




Source: MSCI Sustainability and Climate Research, March 2026.

- **Assess coverage and quality.** Review the share of portfolio value successfully mapped to asset locations. Identify gaps in coverage by issuer, sector or region.

### Illustrative results

The metrics below are available in MSCI GeoSpatial Asset Intelligence, ESG Manager and via Snowflake. Capitalized metric names correspond to field names on these platforms.

- **Mapped coverage:** number of issuers and % of portfolio value mapped to physical asset locations.
  - **Issuer identifier (ISSUERID):** confirms which holdings are mapped and supports aggregation back to issuer and portfolio view.
  - **Issuer name (ISSUER_NAME):** label used to validate mapping results and quickly spot mismatches or unexpected entities.
- **Asset count and distribution:** number of identified locations by geography and asset types.
  - **Activity at an asset level (ACTIVITY_AT_ASSET):** describes what the site is, e.g., office, warehouse, solar power plant, enabling distribution by asset type rather than by sector labels alone.
- **Concentration flags:** clusters of critical assets by value and output across locations.

- Fixed asset value share (ASSET_SHARE): estimated share of an issuer's total fixed asset value tied to a site, highlighting financially material clusters.
- Revenue share (OUTPUT_SHARE): estimated share of issuer revenue attributed to the location, highlighting where disruption could translate into outsized operational and revenue effects.
- Key activity indicator (KEY_ACTIVITY_FLAG): flags sites aligned with the issuer's core business activity, separating operationally critical footprints from peripheral locations.

## 7.3 Identifying material hazards and quantifying financial impacts for portfolio companies

This section builds on portfolio mapping by moving from "where are the assets?" to "what do those locations imply for risk?" Once operating sites, asset types and concentrations are established, investors can assess physical risks across hazards, regions and scenarios and translate them into issuer-level signals. The goal is to identify which companies and locations drive the portfolio's risk profile, support scenario analysis and prioritize actions for risk oversight and investment decision-making.

Chapter 4 used Duke Energy and Rio Tinto to illustrate how the same materiality framework produces different conclusions for different business models. For Duke Energy, flood-related hazards account for 88% of total AAL from acute hazards, driven primarily by asset damage. Relative to constituents of the MSCI ACWI Index, losses from pluvial and fluvial flooding are in the 98th and 95th percentiles, respectively. This profile suggests Duke Energy could be a candidate for further assessment and potential engagement in flood-related adaptation measures. For Rio Tinto, by contrast, financial impacts from chronic hazards are materially larger than from acute hazards (0.6% vs. 0.1% AAL). These impacts reflect sustained effects on labor productivity across multiple industrial operations. This profile could inform different management actions, focused on operational resilience to heat stress and water scarcity rather than event-driven damage.

For an investor holding both names, the screening and materiality steps produce different risk drivers, priority hazards and downstream actions — despite both companies being flagged as having elevated physical risk in the initial mapping stage.

**Investor questions**

- How exposed are portfolio companies to physical risks across regions, sectors and asset types?
- Which hazards pose the greatest threat to issuers' operations under current conditions and future climate scenarios?
- Which issuers and locations account for the largest share of the portfolio's potential impact on asset damage and business interruption?

**Implementation example**

1. **Set the analysis frame**. Define the relevant time horizons and climate scenarios for comparison and establish the reference benchmark for the analysis (e.g., MSCI ACWI Investable Markets Index (IMI)).

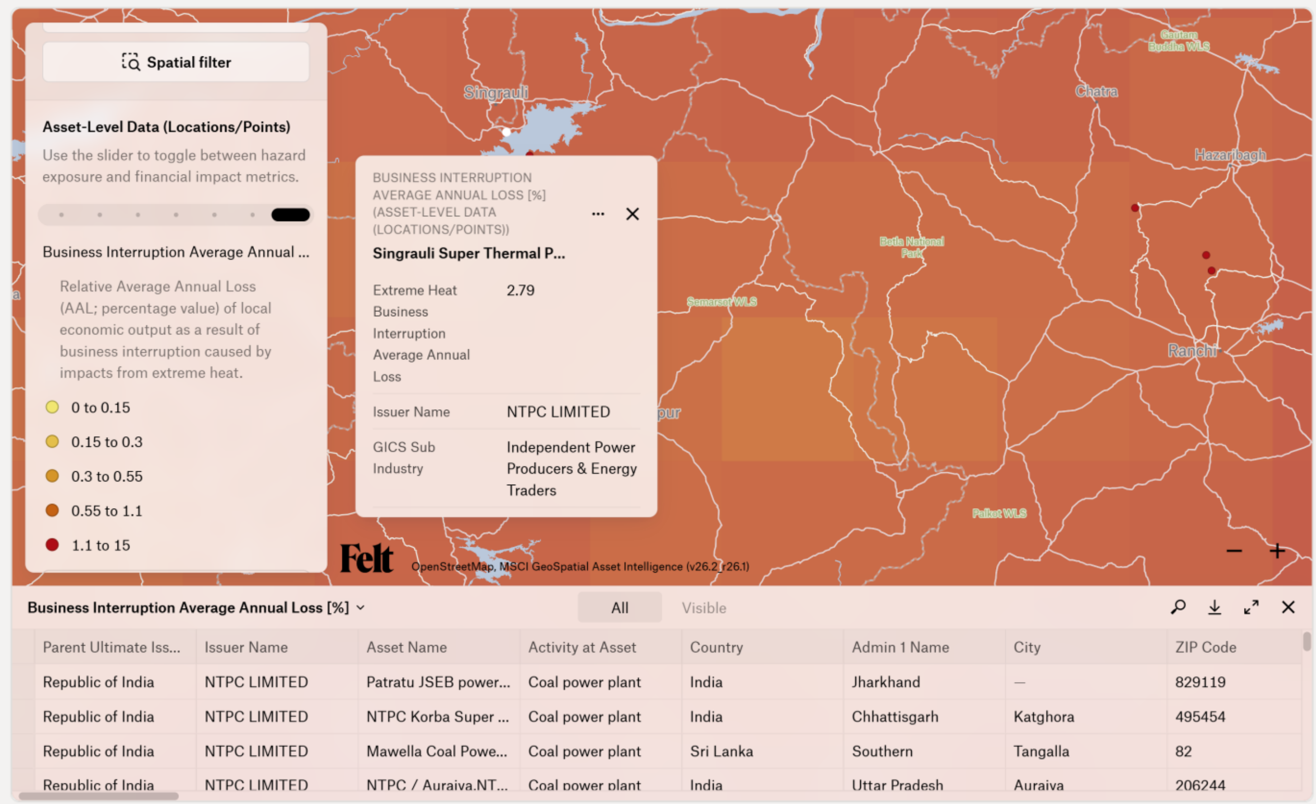
2. **Identify asset-level exposure and risk drivers.** Using the mapped operating footprint from section 7.2, apply MSCI GeoSpatial Asset Intelligence to evaluate hazard levels for each asset and compare results across time horizons and climate scenarios.

**Excerpt of asset-level data available in MSCI GeoSpatial Insights shown in a tabular format**

| Issuer Name | Asset Name | Activity at Asset | Scenario | Timestep | Outcome | Extreme Heat Percentile ... | Extreme Heat Intensity Value |
|---|---|---|---|---|---|---|---|
| JERA Co., Inc. | Atsumi Ther... | Geothermal po... | CURRENT | 2024 | Average | 68.3 | 6.37 |
| JERA Co., Inc. | Formosa 1 o... | Wind power plant | CURRENT | 2024 | Average | 86.1 | 8.11 |
| JERA America... | Canal power ... | Gas power plant | CURRENT | 2024 | Average | 42.2 | 4.39 |
| JERA Co., Inc. | Hirono Ther... | Powerplant | CURRENT | 2024 | Average | 47.0 | 4.84 |
| JERA Co., Inc. | East Japan B... | Office | CURRENT | 2024 | Average | 66.2 | 6.22 |

Source: MSCI Sustainability and Climate. This example is for illustrative purposes only and is in no way an endorsement of this company by MSCI.

3. **Translate hazard levels into financial impacts.** Select appropriate impact measures for asset damage and business interruption — for example AAL — and derive comparable impact views across assets and regions. This information is available for current conditions and 11 climate scenarios (NGFS and IPCC) for years 2030, 2050, 2100. Additionally, the Physical Risk and Macroeconomic Physical Risk components of MSCI Climate Value-at-Risk (Climate VaR) estimate the potential impact of physical risks on company valuation, providing a comparable metric across issuers and scenarios. Direct physical risk costs capture asset damage and business interruption estimated at the asset level, whereas macroeconomic physical costs, estimates how climate-driven GDP losses in each country translate into company-level profit impacts through indirect channels such as reduced consumer demand, labor migration costs and lower capital investment. MSCI's Climate-Adjusted Probabilities of Default model estimates how changing physical and transition risk levels may affect companies' probability of default.




Source: MSCI Sustainability and Climate Research, March 2026. This example is for illustrative purposes only, may change as a result of market fluctuations, and is in no way an endorsement of this company by MSCI.

4. **Identify concentration and single points of failure.** Highlight issuers whose exposure and/or impacts are dominated by a small set of sites, and clusters of similar assets within tight geographies (relevant for correlated disruption).

5. **Feed results into oversight and portfolio actions.** The analyses above produce a rich set of issuer-level risk signals that can inform ongoing decision-making across teams. Risk teams can use them to define monitoring triggers, for example, when a company's AAL exceeds a percentile threshold against its benchmark, establish escalation protocols and prioritize issuers for stress testing. Investment teams can use the same results to build watchlists, conduct research deep-dives on concentrated risk drivers, identify rebalancing candidates where hazard profiles have shifted materially across scenarios and targeted engagement on adaptation gaps.

### Illustrative results

- **The starting point:** issuer-level hazard levels to quantify present-day exposures.
- **Hazard Intensity Value (0–10):** a standardized indicator of hazard intensity or frequency at the location level, supporting cross-hazard and cross-region comparison.

- **Company Hazard Percentile (0–100):** benchmarks an issuer's hazard exposure against MSCI ACWI constituents; useful for ranking issuers and tracking how rankings shift across scenarios and time horizons.
- **Quantification of present-day financial impacts at the issuer-level:** absolute ($ amount) and relative AAL for asset damage and business interruption, with hazard breakdown to identify the primary drivers.
- **AAL values:** expected annual loss estimate, provided for all hazards combined (e.g., TOTAL_AAL_RELATIVELOSS_AVG, TOTAL_ASSETDAMAGE_AAL_RELATIVELOSS_AVG, TOTAL_BUSINESSINTERRUPTION_AAL_RELATIVELOSS_AVG) and by hazard (e.g., TROPICALCYCLONES_ASSETDAMAGE_AAL_RELATIVELOSS_AVG, TROPICALCYCLONES_BUSINESSINTERRUPTION_AAL_ABSOLUTELOSS_AVG) available in GeoSpatial Asset Intelligence and via Snowflake.
- **Geographic attribution:** identify which countries drive hazard levels and financial impacts for each issuer. Example of relevant metrics include the following:
  - TROPICALCYCLONES_100YEAR_WINDSPEED_INTENSITYVALUE_CURRENT_COUNTRY and TROPICALCYCLONES_ASSETDAMAGE_AAL_RELATIVELOSS_ISSUER_COUNTRY, available in MSCI Physical Risk Metrics – Issuer Level).
- **Asset-level losses:** expected and tail-event loss estimates for asset damage, business interruption, and combined. This information is available for current conditions and 11 climate scenarios (NGFS and IPCC) for years 2030, 2050, 2100.
- **Return-period losses:** loss estimates associated with low-probability, high-severity events at 100-year and 200-year return periods, available for acute hazard (e.g., TROPICALCYCLONES_ASSETDAMAGE_AAL_RELATIVELOSS, TROPICALCYCLONES_ASSETDAMAGE_100YEAR_RELATIVELOSS, TROPICALCYCLONES_ASSETDAMAGE_200EAR_RELATIVELOSS in GeoSpatial Asset Intelligence).
- **Scenario and time horizon comparisons** (what changes, and when, for which issuers and assets): Such analyses can leverage many of the above-mentioned metrics. Scenario analysis can also rely on the physical risk component of Climate VaR, including both its direct and macroeconomic cost components, to compare potential valuation impacts. Examples of relevant metrics include the following (available in ESG Manager):
  - VAR_EXW_3DEG_CURRENT_AVG_COMBINED_COMPANY (3°C Aggregated Physical Risk Company Climate VaR, REMIND Current Policies Average outcome)
  - VAR_MACROECONOMIC_EXW_3DEG_CURRENT_NGFS_AVG_ENTERPRISE (3°C Macroeconomic Physical Risk Company Climate VaR, REMIND Current Policies Average outcome).

The MSCI Metric Interpretation Guide in the Appendix provides guidance on how to interpret hazard intensities, hazard percentiles and financial impact metrics.

## 7.4 Evaluating corporate adaptation and resilience: risk management and opportunities

Issuer-level indicators connect physical risk assessment to investment opportunities in adaptation and resilience. Following the Hazard-Adaptation Matrix (HAM) and High Exposure, Low Preparedness (HELP) frameworks introduced in Chapter 5, this section organizes indicators around viewing adaptation and resilience as risk management (i.e. assessing corporate preparedness and downside protection) and a potential investment opportunity (i.e. identifying companies positioned to benefit from rising adaptation spending).

The approach combines process-based readiness signals (whether companies integrate physical risk into governance and risk management) with indicators of potential upside, including adaptation-linked revenues and innovation signals.

The readiness indicators in this section complement the HAM framework introduced in . Companies classified as HELP may lack both process-based readiness and adaptation-linked revenue, making them primary candidates for engagement. Conversely, companies combining high readiness with adaptation revenue exposure may be candidates for portfolio tilting analysis, as discussed in the investment opportunity application in section 5.2.

**Investor questions**

Risk management

- How do I identify issuers that demonstrate climate-specific processes for managing physical risk?
- Which investments face the highest potential losses, and what adaptation or resilience options are relevant?

Investment opportunity

- How do I identify companies generating adaptation-linked revenues, and size my exposure to those opportunity sets?
- How do I identify companies with adaptation-related patent activity and track them over time?

**Implementation example**

Risk management

1. **Establish the issuer-level readiness baseline**: use MSCI Physical Risk Metrics – Issuer Level, available via MSCI ONE, ESG Manager or Snowflake, to assess how issuers address physical risk across multiple dimensions of governance and risk management. This draws on company reporting and publicly stated commitments, supporting comparability across issuers.

**Examples of readiness and adaptation metrics available in the MSCI Physical Risk Metrics – Issuer Level dashboard**

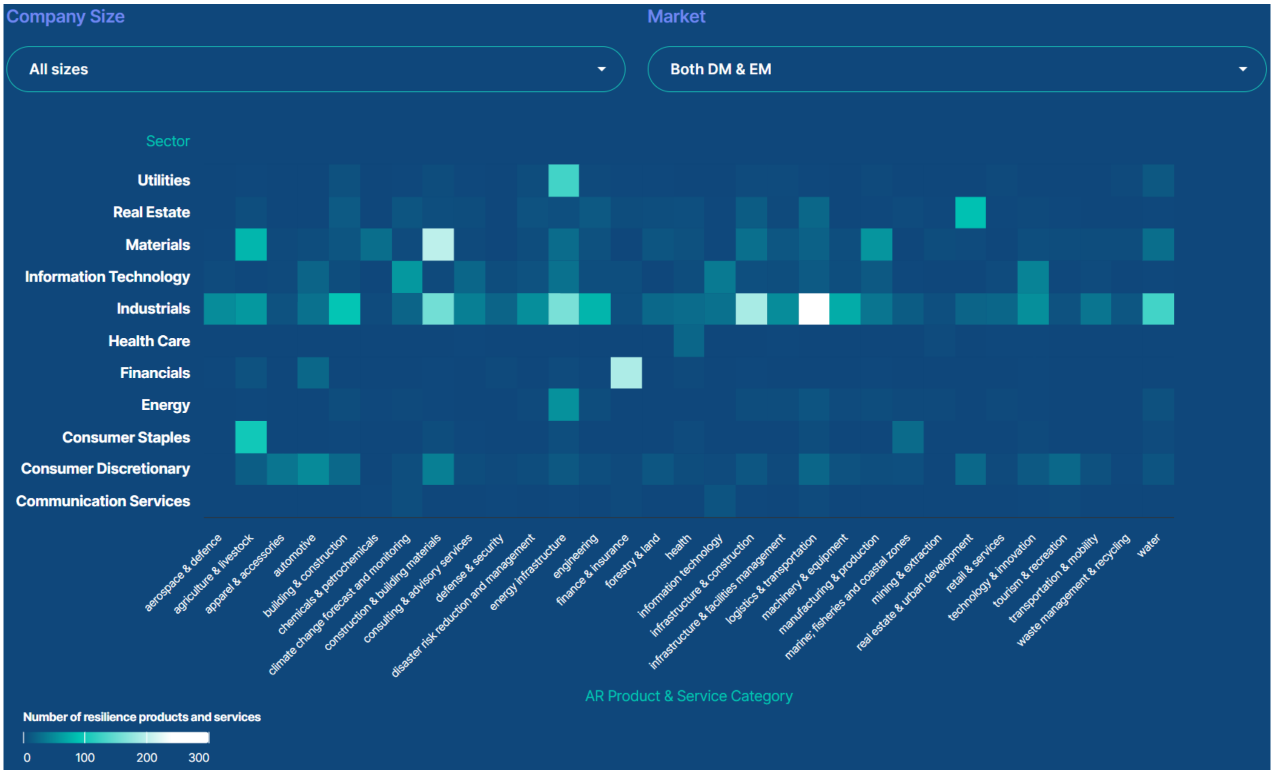

Source: MSCI Sustainability and Climate Research

2. **Assess water-related risk management**: review issuer-level indicators on water risk management practices to identify whether water is treated as a material operational and strategic risk.

Investment opportunity

1. **Identify adaptation opportunity exposure**: use issuer-level indicators of revenues linked to adaptation and resilience solutions to identify companies already generating economic activity in relevant categories.
2. **Assess innovation and optionality**: use patent-based indicators to identify issuers investing in adaptation-related innovation, providing a forward-looking signal of potential upside from technologies and services that support resilience.
3. **Translate results into investment-relevant segments**: combine readiness and opportunity signals to create practical issuer groupings (e.g., readiness leaders, solution providers, innovation leaders, limited-evidence issuers) and generate shortlists for research, product design, or engagement.

**Dashboard showing adaptation and resilience solutions companies by size and sector**




Source: MSCI Institute, How to Make Climate Adaptation and Resilience Investable, March 2024.

### Illustrative results

Risk management

- Evidence that a company identifies and assesses physical risks as part of its risk management approach (CLIM_RSK_MGMT_PROC_DESC_TS).
- Evidence that climate risks are integrated into broader business risk processes (CLIM_RISK_INT_BUS_RSK_TS)
- Evidence of a climate-specific risk management process in place (CLIM_RSK_MGMT_PROC_TS).

Investment opportunity

- Support issuer screening and segmentation for adaptation opportunity strategies, using readiness as a quality overlay.
- Adaptation-linked revenue coverage across multiple solution areas to help identify potential beneficiaries of resilience investment (MSCI covers 13 categories). Examples of indicators include rainwater-related water solutions (CT_SUST_WATER_RAINWATER_MAX_REV), water recycling and smart grids.
- Patent coverage across multiple adaptation technology categories to track innovation and potential upside (MSCI uses 12 patent categories). Examples include patent-based indicators of innovation in

relevant fields intended as a forward-looking signal of technology positioning, such as infrastructure adaptation (GREEN_PAT_VAL_INFRASTRUCTURE). Other examples include insulation, cooling and desalination.

## 7.5 Monitoring portfolio-level risk outcomes across climate scenarios

The analyses in section 7.2 through 7.4 produce asset- and issuer-level outputs: mapped locations, hazard exposures, financial impact estimates and readiness indicators. A portfolio-level view builds on these outputs to support risk committees, investment oversight boards and regulatory reporting teams that require a consolidated picture of what physical risk means for the portfolio as a whole and how it changes across time horizons and future warming pathways.

This section addresses the step between issuer-level analysis and portfolio-level action, building on the climate scenario analysis framework introduced in Chapter 6. It describes how to aggregate issuer-level physical risk results into a portfolio-level picture across time horizons and warming pathways, diagnose which sectors, geographies, and hazards drive that picture, and compare the portfolio's risk profile against a benchmark. The resulting portfolio view may serve as an analytical input for the actions described in the remainder of this chapter: index-based strategies, engagement prioritization, and regulatory reporting.

Portfolio-level aggregation of physical risk metrics may raise methodological questions that differ from standard financial risk aggregation. As of the publication of this report, MSCI is developing a dedicated client-facing methodology for portfolio-level aggregation of physical risk metrics.[32] The implementation guidance below is designed to be compatible with the forthcoming aggregation framework while remaining actionable with the issuer-level data available.

**Investor questions**

- What is the portfolio’s overall exposure to physical risk, and how does it compare to the benchmark?
- How does the portfolio’s physical risk profile change across climate scenarios and time horizons and which issuers drive the largest shifts?
- Which sectors, geographies and hazards contribute the most to the portfolio’s aggregate physical risk profile, and how concentrated are those contributions?
- Which issuers account for a disproportionate share of the portfolio’s physical risk, and do they represent deliberate active positions or unintended exposures?

**Implementation example**

1. **Define the portfolio and benchmark scope**: assemble the portfolio holdings universe and the reference benchmark (e.g., MSCI ACWI IMI), including issuer identifiers and holding weights.

[32] All information provided is prospective and is subject to change. The product roadmap should not be construed as a guarantee of delivery of capabilities. MSCI routinely reviews product plans with clients and may, at our discretion, modify the product roadmap and release dates. MSCI does not guarantee the future release of any product or product feature.

2. **Establish the time horizons and climate scenarios**: select the scenarios and time horizons to be used for comparison, consistent with the analysis frame defined in section 7.3. In many circumstances, it is reasonable to choose a range of scenarios spanning different warming levels to capture the breadth of plausible physical risk outcomes and identify where portfolio risk is most sensitive to scenario assumptions.

   **For more on this, refer to:**

   Chapter 6: provides a structured framework for scenarios selection.

   Section 6.5: the maturity progression offers a guide on how sophisticated this scenario comparison should be, from initial baseline estimates to full sensitivity analysis across multiple dimensions.

3. **Compile issuer-level results and aggregate to portfolio level**: gather issuer-level outputs from sections 7.3 and 7.4, including the physical risk (for direct costs associated with physical hazards) and macroeconomic physical risk (reflecting climate-driven GDP impacts on company profits) components of Climate VaR . Compute portfolio-level Climate VaR summaries across time horizons and climate scenarios.

   As MSCI's portfolio-level aggregation methodology for MSCI Physical Risk Metrics – Issuer Level becomes available, it will describe enhanced approaches to account for changing physical risk levels across time horizons and climate scenarios.

4. **Decompose by sector and geography**: break down the portfolio's aggregate physical risk by sector, region and hazard type. This decomposition reveals whether the portfolio's risk profile is concentrated in a few sectors or geographies, or broadly distributed. Compare against the benchmark to identify where active allocation decisions may be adding or reducing physical risk relative to the market.

5. **Identify top contributors and concentration risk:** rank issuers by their contribution to the portfolio's aggregate physical risk. Identify clusters of issuers with assets in the same hazard-prone geography, as these represent correlated exposure that could amplify losses.

6. **Compare against the benchmark across scenarios**: evaluate how the portfolio's physical risk profile compares to its benchmark under current conditions and forward-looking scenarios at 2030 and 2050, using scenario-specific Climate VaR estimates alongside hazard and loss metrics. Identify which issuers and sectors drive the divergence from the benchmark and how the gap evolves across warming pathways and time horizons.

7. **Overlay readiness and adaptation signals:** complement the physical risk aggregation with readiness and adaptation indicators from section 7.4. Assess the share of portfolio value held in issuers with evidence of climate-specific risk management processes and the share exposed to adaptation-linked revenue opportunities.

8. **Establish monitoring and escalation protocols**: define how frequently the portfolio-level physical risk view should be refreshed (e.g., aligned with rebalancing cycles or scenario updates), which

thresholds would trigger escalation to risk committees or investment oversight, and how the portfolio-level results feed into the downstream actions covered in sections 7.6, 7.7 and 7.8.

**Illustrative results**

- **Portfolio-level physical risk across time horizons and climate scenarios:** Climate VaR (both its physical risk and macroeconomic physical risk components) provides a forward-looking view on potential portfolio valuation shocks across scenarios, supporting high-level benchmarking and stress testing. Aggregations of issuer-level physical risk metrics offer a more granular view of changing hazard levels and expected financial impacts across time horizon and scenarios. As MSCI's portfolio aggregation methodology is released, additional details on portfolio-level physical risk metrics will become available.[33]
- Valuation impact across asset classes: Climate VaR can be used to quantify the potential valuation impacts of physical risks across listed equity, corporate bonds and real estate assets to support asset-class-specific risk budgeting and allocation decisions.[34]
- Sector and geographic decomposition: breakdown of aggregate physical risk by sector and by country or region, identifying where exposure is concentrated and how patterns compare to the benchmark.
- Top contributors and concentration risk: ranked issuers by contribution to portfolio-level physical risk, flagging disproportionate drivers of aggregate losses. Identification of geographic and sectoral clusters where multiple holdings share exposure to the same hazard zones.
- Benchmark-relative diagnostics: identification of where active positions increase or reduce physical risk exposure relative to the benchmark.
- Readiness overlay: share of portfolio value in issuers with evidence of climate-specific risk management processes and adaptation-linked revenue exposure, drawn from section 7.4. Portfolio versus benchmark exposure to adaptation-linked revenue streams and innovation signals, highlighting relative positioning on resilience-related growth themes.

**Results of a portfolio scenario analysis using Climate VaR as presented in MSCI's Climate Risk Report**

| | 2°C NGFS Orderly | | | 1.5° REMIND NGFS Orderly | | | 1.5° REMIND NGFS Disorderly | | | 2° REMIND NGFS Orderly | | | 3° REMIND NGFS NDC | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Portfolio | Benchmark | Active | Portfolio | Benchmark | Active | Portfolio | Benchmark | Active | Portfolio | Benchmark | Active | Portfolio | Benchmark | Active |
| Policy Climate Var (Scope 1,2,3) | -0.5% | -2.0% | 1.5% | -3.2% | -8.4% | 5.2% | -4.0% | -10.2% | 6.2% | -0.5% | -2.0% | 1.5% | -0.4% | -1.9% | 1.5% |
| Technology Opportunities Climate VaR | 0.6% | 0.3% | 0.3% | 2.6% | 1.2% | 1.4% | 3.6% | 1.7% | 1.9% | 0.6% | 0.3% | 0.3% | 0.4% | 0.2% | 0.2% |
| Physical Climate VaR Aggressive | -1.4% | -2.1% | 0.7% | -0.9% | -1.4% | 0.5% | -0.9% | -1.4% | 0.5% | -1.4% | -2.1% | 0.7% | -1.7% | -2.7% | 1.0% |
| Aggregated Climate VaR | **-1.2%** | **-3.7%** | **2.5%** | **-1.5%** | **-8.6%** | **7.1%** | **-1.3%** | **-9.9%** | **8.6%** | **-1.2%** | **-3.7%** | **2.5%** | **-1.8%** | **-4.4%** | **2.6%** |

[33] All information provided is prospective and is subject to change. The product roadmap should not be construed as a guarantee of delivery of capabilities. MSCI routinely reviews product plans with clients and may, at our discretion, modify the product roadmap and release dates. MSCI does not guarantee the future release of any product or product feature.

[34] Note that MSCI Sovereign Climate Value-at-Risk model provides Climate VaR estimates for sovereign bonds primarily based on transition risk estimates.

## 7.6 Integrating physical risk data into index-based equity strategies

Rules-based investment strategies may incorporate location-specific physical risk insights to reweight constituents and strengthen portfolio resilience without compromising systematic portfolio characteristics. Asset-, company- and portfolio-level hazard and loss metrics (as described in sections 7.2 through 7.5) may be integrated into index design and portfolio optimization to reduce exposure to climate-sensitive locations while preserving objectives, such as sector balance, factor exposure and tracking error.

Physical risks can affect equity returns across sectors and regions, as demonstrated outlined in the Introduction. However, distribution of exposure may be uneven. Within a single index universe, hazard percentiles can vary significantly across issuers, and the sector composition of the most exposed companies may differ from market-cap weights. This may create scope for systematic exclusion and/or reweighting rules in index construction, aimed at reducing physical risk while maintaining other investment characteristics.

The availability and quality of asset-level data are critical for implementing such approaches. In practice, this includes the use of proxy estimates to address coverage gaps where asset-level data is incomplete, and accuracy filters to ensure assets are reliably linked to the companies that own or operate them. These inputs could be used to construct signals that could capture physical risk exposure and near-term trends, maximize the use of factual data over modeling assumptions, and support plausible, real-world outcomes suitable for systematic integration.

**Investor questions**

- How do I identify which issuers and locations drive portfolio-level physical risk, and how concentrated is that exposure across sectors?
- How do I integrate physical risk metrics into index construction — through exclusion screens, reweighting or optimization constraints — without materially altering the strategy's systematic characteristics (e.g., sector weights, factor tilts, tracking error)?
- Which metrics are most appropriate for rules-based integration: hazard exposure indicators, financial loss estimates or hybrid approaches that combine both?
- How do I set and monitor a physical risk reduction target for an index product?
- What level of asset data coverage and mapping accuracy is needed before physical risk signals are reliable enough for index construction?

**Implementation example**

1. **Estimate issuer-level physical risk impacts**: using hazard exposure indicators and financial loss metrics such as AAL (see section 7.3) to estimate potential impacts at the issuer level. Where relevant, scenario-based measures can complement these core metrics to capture longer-term risks under different climate pathways.
2. **Map issuer operations to asset locations**: using MSCI GeoSpatial Asset Intelligence (section 7.2), map operations to physical asset locations and quantify exposure to both chronic and acute hazards

to distinguish asset-level physical risk analysis from issuer-level estimates. Apply mapping accuracy filters to exclude low-confidence associations, and weight assets based on their financial relevance to the issuer.

3. **Address coverage gaps using proxies:** where asset-level coverage is incomplete, apply proxy estimates based on activity and geography averages. This helps ensure that the physical risk signals are not biased toward the subset of mapped assets and that issuers with limited asset coverage are appropriately represented.
4. **Identify issuers driving portfolio-level physical risk:** use issuer-level hazard and loss metrics (section 7.3) to rank issuers by their contribution to portfolio-level risk and identify concentrations, including tail-risk exposures.
5. **Integrate physical risk into index construction**: incorporate hazard and loss metrics as screens, constraints or objective terms to reduce portfolio exposure to climate-sensitive locations. This may involve underweighting or excluding issuers above defined thresholds, or targeting a specified reduction in portfolio-level physical risk metrics relative to the parent benchmark.
6. **Preserve systematic design characteristics:** combine physical risk constraints with sector balance, style exposure and tracking-error limits to ensure the resulting index maintains the diversification and factor balance needed.
7. **Set and monitor physical-risk reduction targets:** define measurable targets relative to the parent benchmark, such as a reduction in portfolio-weighted AAL or aggregate hazard exposure. Monitor the target on each rebalancing date and report results alongside other index characteristics.

**Illustrative results**

- Risk-based tilting signals: use issuer-level physical risk indicators (e.g. AAL, hazard intensity values) to identify candidates for exclusion above defined thresholds, or to drive systematic under-weights of high-exposure issuers and over-weights of lower-exposure alternatives within the same sector.
- Tail-risk concentration profiles: identify issuers contributing disproportionately to portfolio-level extreme loss potential, using high AAL values to highlight potential single points of failure.
- Physical risk reduction tracking: compare portfolio-level physical risk metrics (e.g., weighted average Physical Climate VaR, portfolio-level AAL) between the climate index and its parent benchmark at each rebalancing, and track progress against defined risk reduction targets.
- Data quality dashboards: report coverage ratios, mapping accuracy scores and proxy usage rates alongside index characteristics, to provide transparency on the maturity and reliability of underlying physical risk data at each rebalancing.

## 7.7 Supporting engagement with high-risk companies

For many asset owners and asset managers, engagement may be used to address physical risk exposures. Where exposed assets are managed by a portfolio company, stewardship may be an impactful lever available to investors.

This section demonstrates how the hazard-adaptation matrix (HAM) framework translates into a practical engagement workflow. As noted in Chapter 1, stewardship teams can use this approach to define adaptation action plans and apply escalation strategies where time-bound milestones are not met.

For example, an electric utility with high flood exposure (pluvial flooding AAL in the 95th percentile) but no evidence of flood-related adaptation measures, such as infrastructure hardening, flood-resistant design standards, or emergency response protocols would be flagged as a HELP company. The same company may show stronger preparedness for other hazards, such as heat, through measures like grid resilience investments or vegetation management programs, highlighting that adaptation varies by hazard.

**Investor questions**

- Which portfolio companies face the highest combination of physical risk exposure and limited evidence of adaptation and should be prioritized for engagement?
- What specific adaptation actions should engagement conversations focus on, given each company's hazard profile?
- How do I track whether engagement is translating into reduced portfolio risk over time?

**Implementation example**

1. **Classify portfolio holdings using the HAM framework:** combine the hazard exposure and financial impact analysis (section 7.3) with the company-level readiness and adaptation and resilience indicators presented (section 7.4) to assign holdings to the four HAM quadrants. These metrics are available in ESG Manager and the MSCI Physical Risk Metrics — Issuer Level module.
2. **Identify HELP companies**: Prioritize holdings with high hazard exposure and limited evidence of adaptation for engagement. Hazard intensity values, hazard percentiles and AAL values can help define thresholds for "high exposure" based on the portfolio's risk appetite (e.g., issuers above the 75th percentile for their sector on combined AAL).
3. **Diagnose hazard-specific resilience gaps:** for each HELP company, compare the hazards driving exposure (section 7.3) with disclosed adaptation actions (Chapter 5). This identifies not only whether a company is underprepared, but which specific hazards are insufficiently addressed.
4. **Develop engagement objectives:** translate identified gaps into targeted engagement actions, drawing on the adaptation taxonomy in Appendix. Structure engagement around the three dimensions of adaptive capacity: preparedness, hazard resistance and recoverability.
5. **Set milestones and escalation protocols:** define measurable, time-bound milestones for engagement targets (e.g., completion of site-level flood risk assessment for top 10 assets by

revenue within 12 months) and establish escalation pathways if milestones are not met (e.g., voting against management, collaborative engagement or divestment as a last resort).

6. **Track engagement outcomes:** monitor changes in adaptation readiness over time using the HAM framework. Track the proportion of HELP companies transitioning to higher preparedness, and assess whether the portfolio's overall exposure to the HELP declines.

**Illustrative results**

- Support issuer screening and segmentation for adaptation strategies, using readiness as a quality overlay.
- Assess evidence of physical risk management practices, including
  - Identification and assessment of physical risks within risk management processes (CLIM_RSK_MGMT_PROC_DESC_TS).
  - Integration of climate risks into broader business risk processes (CLIM_RISK_INT_BUS_RSK_TS).
  - Existence of a dedicated climate-specific risk management process (CLIM_RSK_MGMT_PROC_TS).

## 7.8 Meeting regulatory requirements and reporting to stakeholders

The analyses conducted in section 7.2 through 7.7 generate output that may support reporting requirements. This section demonstrates how physical risk assessment results map to the disclosure expectations described in Chapter 3, using ISSB IFRS S2 requirements as an example.

Effective physical risk disclosure requires more than presenting numbers. Regulators and stakeholders expect investors to demonstrate how physical risk insights are embedded in governance, strategy, risk management and investment processes.

The table below identifies examples of metrics from section 7.2 through 7.6 aligned with ISSB IFRS S2 requirements, and highlights where additional analysis or narrative may be needed.

**Mapping Chapter 7 results to Chapter 3 regulatory dimensions**

| Ch. 2 analytical dimension | What regulators expect | Relevant output from Ch. 7 | Metric examples |
|---|---|---|---|
| 1. Asset geolocation | Where exposures are located; geographic concentration | Sections 7.2 and 7.5: mapped asset count and distribution, concentration flags | ACTIVITY_AT_ASSET, ASSET_SHARE, OUTPUT_SHARE |
| 2. Hazard identification | Assessment uses recognized scenarios and assumptions | Sections 7.3 and 7.5: Hazard Intensity Values, percentile rankings across scenarios | Hazard-specific intensity value and percentile metrics (Physical Risk Metrics—Issuer Level) |
| 3. Vulnerability assessment | How asset sensitivity and resilience are considered | Sections 7.3 through 7.5: sector-specific financial impacts and adaptation and resilience; : readiness indicators | Vulnerability embedded in AAL calculations; CLIM_RSK_MGMT_PROC_TS |
| 4. Financial impact | Potential asset damage and business interruption where material | Sections 7.3 and 7.5: AAL, return period losses, scenario-based comparisons | TOTAL_AAL_ABSOLUTELOSS_ISSUER, TOTAL_AAL_RELATIVELOSS_ISSUER; 100-year and 200-year return period losses; physical risk component of Climate VaR (direct + macroeconomic) |
| 5. Strategy and disclosure | Governance integration and link to decisions | Sections 7.4 and 7.7: engagement programs; : portfolio construction | Engagement scorecards; HAM classifications |

### Investor questions

- How do I translate physical risk assessment outputs into disclosures aligned with reporting frameworks?
- How do I document analytical assumptions, scenario selections and data limitations in a way that is defensible under regulatory, supervisory or audit scrutiny?
- How do I demonstrate that physical risk analysis is integrated into governance and investment decision-making, rather than presented as a standalone reporting exercise?

### Implementation example

1. **Select climate change scenarios**: choose scenarios aligned with reporting requirements, and, where possible, widely recognized scenarios such as NGFS and IPCC. Clearly document the rationale for selection, including regulatory relevance, materiality to the portfolio and stakeholder expectations. Disclosures should explain which scenarios were used and how results differ across them.

2. **Map assessment results to regulatory requirements:** aggregate issuer-level metrics into portfolio-level outputs suitable for reporting. Core disclosure metrics may include geographic concentration metrics and the physical risk component of Climate VaR across scenario and time horizons, as calculated in the MSCI Climate Risk Report.

**Example of Physical Climate Value-at-Risk portfolio results from MSCI Climate Risk Report**

*Selected Scenario :* Aggressive

**Chronic Risks (0.5° global grid)**

| Extreme Heat | Extreme Cold | Wind Gusts | Heavy Snowfall | Heavy Precipitation |
|---|---|---|---|---|
| -0.6% | 0.1% | 0.0% | 0.0% | -0.1% |

**Acute Risk (high res)**

| Tropical Cyclones | Coastal Flooding | Fluvial Flooding | River Low Flow | Wildfires |
|---|---|---|---|---|
| -0.2% | -0.6% | 0.0% | -2.8% | 0.0% |

| Aggregate Physical Climate VaR | Benchmark Aggregate Physical Climate VaR |
|---|---|
| -1.4% | -2.1% |

Source: MSCI Sustainability and Climate Research, March 2026

3. **Align outputs with ISSB IFRS S2 disclosure pillars:** Structure outputs to support the four disclosure pillars (governance, strategy, risk management and metrics), as illustrated in the table below.

**How Chapter 7 analyses can support ISSB-aligned climate disclosures**

| IFRS S2 pillar | How Chapter 7 analysis supports disclosure |
|---|---|
| **Governance** | Evidence that physical risk is integrated into investment oversight, including board or committee-level review of physical risk assessment results (sections 7.2 and 7.3) and engagement program governance (section 7.7). |
| **Strategy** | Demonstration of how physical risk informs capital allocation, portfolio construction and product development decisions (section 7.2 and through to 7.4), including scenario analysis results showing portfolio resilience under different climate futures (section 7.5). |
| **Risk management** | Describes the processes used to identify, assess and manage physical risks, including portfolio mapping (section 7.2), materiality assessment (Chapter 4), HAM-based engagement prioritization (section 7.7) and adaptation readiness evaluation (section 7.4). |
| **Metrics and targets** | Quantified metrics including portfolio-level AAL, the physical risk component of Climate VaR, hazard percentiles and adaptation-linked revenue exposures, with time-series tracking to demonstrate how risk profiles evolve (section 7.5). |

4. **Document assumptions and establish governance**: Ensure disclosures are transparent, traceable and reproducible. Documentation should cover data sources and coverage (including known gaps), scenario assumptions and scope limitations, key methodological choices and interpretation context. Investors should also define how disclosures are maintained over time and demonstrate whether management actions are reducing modelled exposures.

**Illustrative results**

- **Disclosure-ready metrics:** portfolio-level AAL (current and forward-looking), Climate VaR by scenario and time horizon, geographic concentration metrics and adaptation readiness rates, formatted for inclusion in ISSB-aligned or ESRS-aligned reporting.
  - Key data points include the following (available via MSCI ONE, ESG Manager, and via Snowflake):
- ASSET_SHARE and OUTPUT_SHARE by geography (section 7.2), TOTAL_AAL_RELATIVELOSS_AVG
- Climate VaR by scenario (section 7.3 and 7.5)
- CLIM_RSK_MGMT_PROC_TS coverage rate (section 7.4).
- **Scenario analysis summary:** quantified comparison of portfolio risk under selected scenarios. Examples include:
  - Physical risk component of Climate VaR, such as VAR_EXW_3DEG_NDC_AVG_COMBINED_COMPANY (3°C Aggregated Physical Risk Company Climate VaR (REMIND NDC Average outcome).

  - Macroeconomic physical risk component of Climate VaR, such as VAR_MACROECONOMIC_EXW_3DEG_CURRENT_NGFS_AVG_ENTERPRISE (3°C Macroeconomic Physical Risk Company Climate VaR, REMIND Current Policies Average outcome).
- **Engagement and stewardship reporting:** Tracking of HELP companies, milestones set and achieved, and changes in portfolio HAM distribution year-on-year.
- **Adaptation readiness rates**: drawn from section 7.4, such as CLIM_RSK_MGMT_PROC_TS, CLIM_RISK_INT_BUS_RSK_TS), indicating the share of holdings with evidence of climate-specific risk management processes.

# Appendix

## Glossary of key terms

This glossary defines technical terms, metrics and acronyms used throughout this guide. Terms are organized alphabetically for quick reference.

### A

| | |
|---|---|
| **Acute hazards** | Sudden, event-driven climate risks that occur with varying frequency and intensity, such as tropical cyclones, floods, wildfires and heat waves. Acute hazards typically cause immediate damage and disruption, though effects can persist. Contrast with chronic hazards.<br>*Related: Chronic Hazards, Hazard Intensity Value* |
| **Adaptation** | Actions taken by companies or investors to reduce vulnerability to physical climate risks. Examples include infrastructure hardening (flood barriers, storm-resistant design), operational changes (business continuity planning, supply chain diversification) and strategic measures (geographic diversification, climate-informed capital allocation). Adaptation can be structural (engineering solutions) or non-structural (operational and financial measures).<br>*Related: Resilience, Vulnerability, Maladaptation* |
| **Asset damage** | Physical harm to buildings, equipment and infrastructure caused by climate hazards, resulting in repair or replacement costs. Typically represents a smaller portion of total climate-related losses compared to business interruption.<br>*Related: Business Interruption, Average Annual Loss (AAL)* |
| **Average annual loss (AAL)** | Expected average annual financial loss from physical climate hazards under current and future climate conditions. Expressed in dollars or as a percentage of revenue (for business interruption) or asset value (for asset damage). AAL represents the mean of the loss distribution. Used for comparing relative risk across holdings and quantifying expected impacts.<br>*Related: Climate Value-at-Risk (Climate VaR), Tail Risk, Return Period* |
| **Avoided losses** | Financial losses mitigated by investing in physical risk adaptation measures.<br>*Related: Adaptation, Asset Damage, Average Annual Loss (AAL)* |

## B

| | |
|---|---|
| **Business interruption** | Lost revenue and increased operational costs resulting from climate hazard impacts, even when physical damage is limited. Includes production stoppages, supply chain disruptions, workforce displacement and utility service interruptions. MSCI research shows business interruption losses are typically 14 times larger than asset damage costs.[35]<br>*Related: Asset Damage, Average Annual Loss (AAL), Operational Costs* |

## C-D

| | |
|---|---|
| **Chronic hazards** | Slow-onset climate risks that persist or gradually worsen over time, such as rising temperatures, sea level rise, water stress, drought and changing precipitation patterns. Chronic hazards typically erode productivity and asset values incrementally rather than causing sudden damage.<br>*Related: Acute Hazards, Exceedance Days* |
| **Climate scenario** | A plausible representation of future climate conditions based on specific assumptions about greenhouse gas emissions, policy responses and socioeconomic development. Scenarios are not forecasts or predictions but explore a range of possible outcomes. Used for forward-looking risk assessment and stress testing. See NGFS scenarios.<br>*Related: NGFS Scenarios, Scenario Analysis, RCP, SSP* |
| **Climate value-at-risk (Climate VaR)** | Estimated maximum potential impact on investment value under a specific climate scenario and time horizon (e.g., 2030, 2050, 1.5°C NGFS REMIND — Orderly), expressed as a percentage of enterprise value. Climate VaR captures both physical risk and transition risk impacts. Represents both the average (expected) annual loss and an outcome defined as the 95th percentile of the modeled cost distribution. Used for scenario analysis and stress testing.<br>*Related: Average Annual Loss (AAL), NGFS Scenarios, Tail Risk* |
| **CSRD** | Corporate Sustainability Reporting Directive (EU). |
| **Double materiality** | A comprehensive assessment approach that considers both financial materiality (how climate risks affect the company financially) and impact materiality (how the company's activities affect climate, environment, and society). Required under the EU's Corporate Sustainability Reporting Directive (CSRD) and increasingly adopted by investors seeking holistic risk assessment.<br>*Related: Financial Materiality, Impact Materiality* |

[35] Hidden in Plain Sight: Physical Risk in Asset Owners' Portfolios | MSCI

## E-F

| | |
|---|---|
| **ESRS E1** | European Sustainability Reporting Standard E1 on Climate Change, part of the Corporate Sustainability Reporting Directive (CSRD). More prescriptive than ISSB S2, requiring quantified disclosure of assets at material physical risk, detailed adaptation plans and third-party assurance. Mandatory for EU companies and large non-EU companies with significant EU operations.<br>*Related: ISSB IFRS S2, TCFD, CSRD* |
| **Exceedance days** | Number of days per year when a chronic hazard exceeds a defined threshold (e.g., extreme heat days above 35°C). Used to measure the frequency and persistence of chronic climate stresses. Higher exceedance days indicate greater operational disruption risk.<br>*Related: Chronic Hazards, Extreme Heat, Water Stress* |
| **Exposure** | The presence of assets, operations or investments in locations subject to physical climate hazards. Measured through asset geolocation and hazard mapping. High exposure does not automatically mean high risk — it must be combined with vulnerability and adaptation assessments to determine materiality.<br>*Related: Vulnerability, Hazard Intensity Value, Materiality* |
| **Financial materiality** | Physical climate risks are financially material when they could reasonably trigger material effects on a company's financial performance, position, cash flows, access to finance or cost of capital over the short, medium or long term. Represents the "outside-in" perspective of how climate hazards affect enterprise value and investment returns.<br>*Related: Impact Materiality, Double Materiality* |

## G - H

| | |
|---|---|
| **GeoSpatial Asset Intelligence** | MSCI's proprietary database mapping physical asset locations for 708,000 companies (4+ million facilities globally), as of February 2026. Includes asset coordinates, facility types, size estimates and activity classifications. Forms the foundation for physical risk assessment by enabling location-specific hazard exposure analysis.<br>*Related: Physical Risk Metrics, Hazard Exposure Module* |
| **Hazard** | A climate-related physical event or condition that can cause damage or disruption. MSCI's framework covers 31 hazards across four categories: temperature-related (heat, cold, wildfires), water-related (flooding, precipitation, drought), wind-related (tropical cyclones, tornadoes) and solid mass-related (earthquakes, landslides).<br>*Related: Acute Hazards, Chronic Hazards, Hazard Intensity Value* |

| | |
|---|---|
| **Hazard intensity value** | Scaled measure from 0 to 10 reflecting the severity or frequency of a specific climate hazard at a given location relative to global distribution. Calculated using logarithmic transformation of raw hazard levels, with 1 representing low exposure (<10th percentile globally) and 10 representing high exposure (>90th percentile globally).<br>*Related: Hazard Percentile Score, Exposure, Materiality* |
| **Hazard percentile score** | Alternative expression of hazard exposure showing where a location or company ranks against the MSCI ACWI Index as a global reference dataset. A 90th percentile score means the location has higher exposure than 90% of asset locations for companies in the MSCI ACWI Index. Complements Hazard Intensity Values for risk communication.<br>*Related: Hazard Intensity Value* |

## I

| | |
|---|---|
| **Impact materiality** | A company's or investor's activities have impact materiality when they create material positive or negative effects on people, the environment and society related to climate change and adaptation. Represents the "inside-out" perspective of how business operations and financing decisions affect environmental and social outcomes beyond financial returns.<br>*Related: Financial Materiality, Double Materiality* |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **ISSB IFRS S2** | International Sustainability Standards Board's climate-related disclosure standard (IFRS S2), which supersedes TCFD recommendations. Requires companies to disclose material climate-related risks and opportunities, conduct scenario analysis and report quantified financial impacts. Becoming mandatory regulation in 40+ jurisdictions globally.<br>*Related: TCFD, ESRS E1, Scenario Analysis* |

## M-N

| | |
|---|---|
| **Materiality** | The significance of a climate risk to investment value or company operations. Determined by combining exposure and vulnerability. A hazard is material when it could reasonably affect investment decisions, asset valuations or financial performance. Both impact materiality (effect on company) and financial materiality (effect on investors) should be considered.<br>*Related: Exposure, Vulnerability, Average Annual Loss (AAL)* |
| **NGFS scenarios** | Climate scenarios developed by the Network for Greening the Financial System, widely used for regulatory stress testing and disclosure. Include orderly transition scenarios (Net Zero 2050, Below 2°C), disorderly transitions |

| | |
|---|---|
| | (Delayed Transition, Divergent Net Zero) and high physical risk scenarios (Current Policies, NDCs). Provide both climate projections (temperature, precipitation) and macroeconomic impacts.<br>*Related: Climate Scenario, Scenario Analysis, RCP, SSP* |
| **P** | |
| **Physical climate risk** | Financial and operational risks arising from physical impacts of climate change, including both acute hazards (storms, floods, fires) and chronic changes (temperature rise, sea level rise, water stress). Distinct from transition risk, which arises from the shift to a low-carbon economy. Also referred to as "physical risk" throughout this guide.<br>*Related: Transition Risk, Acute Hazards, Chronic Hazards* |
| **Physical Risk Metrics** | MSCI's suite of climate hazard exposure and financial impact data at issuer. Includes Hazard Intensity Values, average annual loss (AAL) estimates, tail risk metrics (100-year, 200-year return periods) and adaptation readiness indicators. Full product name: "MSCI Physical Risk Metrics - Issuer Level" for company-aggregated data.<br>*Related: GeoSpatial Asset Intelligence, Climate Value-at-Risk (Climate VaR)* |
| **R** | |
| **RCP (representative concentration pathway)** | Climate modeling framework describing greenhouse gas concentration trajectories. Common RCPs include RCP 2.6 (~1.5°C warming), RCP 4.5 (~2°C) and RCP 8.5 (~4°C by 2100). Being superseded by SSP scenarios but still widely referenced in physical risk literature and older climate models.<br>*Related: SSP, NGFS Scenarios, Climate Scenario* |
| **Resilience** | The capacity of a system, company or portfolio to anticipate, absorb, recover from and adapt to climate-related disruptions. Combines preparedness (early warning systems, scenario planning), resistance (protective infrastructure, redundancies) and recoverability (rapid restoration, business continuity). Related to but broader than adaptation.<br>*Related: Adaptation, Vulnerability, Adaptive Capacity* |
| **Return period** | A statistical measure of how often an event of a certain intensity is expected to occur on average. A 100-year return period event has a 1% probability of occurring in any given year (not once every 100 years exactly). Used to characterize tail risk and extreme climate events. MSCI provides AAL estimates and return period losses for 100-year and 200-year return periods.<br>*Related: Tail Risk, Average Annual Loss (AAL), Extreme Events* |

## S

| | |
|---|---|
| **Scenario analysis** | Forward-looking assessment of how different potential climate futures could affect portfolios or investments. Typically involves selecting 2-3 climate scenarios (e.g., Net Zero 2050, Current Policies), modeling physical risk impacts under each scenario across multiple time horizons and comparing outcomes to inform strategy and risk management. Required by TCFD, ISSB S2 and ESRS E1.<br>*Related: Climate Scenario, NGFS Scenarios, Climate Value-at-Risk (Climate VaR)* |
| **SSP (shared socioeconomic pathway)** | Climate modeling framework describing possible socioeconomic futures combined with emissions scenarios. SSP1-2.6 represents sustainable development with low emissions (~1.5-2°C), while SSP3-7.0 and SSP5-8.5 represent high-emissions pathways (~3-4°C+). NGFS scenarios are based on SSP frameworks.<br>*Related: RCP, NGFS Scenarios, Climate Scenario* |

## T

| | |
|---|---|
| **Tail risk** | The risk of extreme physical hazard events (i.e., tropical cyclones) that lie in the far end of the hazard distribution and produce disproportionately large financial, operational or systemic impacts.<br>*Related: Return Period, Average Annual Loss (AAL), Extreme Events* |
| **TCFD** | Task Force on Climate-related Financial Disclosures, established by the Financial Stability Board in 2015. Created foundational framework for climate risk disclosure including governance, strategy, risk management and metrics. Now superseded by ISSB IFRS S2 which builds on TCFD's principles with more detailed requirements.<br>*Related: ISSB IFRS S2, ESRS E1, Scenario Analysis* |
| **Transition risk** | Financial risks arising from the shift to a low-carbon economy, including policy changes, technological disruption, market shifts and reputational impacts. Distinct from physical climate risk. This guide focuses on physical risk; see MSCI's separate transition risk resources for transition-related guidance.<br>*Related: Physical Climate Risk* |

## V

| | |
|---|---|
| **Vulnerability** | The degree to which an asset, company or portfolio is susceptible to damage or disruption from climate hazards. High exposure combined with high vulnerability indicates material risk.<br>*Related: Exposure, Materiality, Adaptation, Resilience* |

## MSCI metric interpretation guide

This appendix is a practical reference for reading MSCI physical risk data outputs. It covers the four metrics investors are most likely to encounter first – hazard intensity values, hazard percentiles, average annual loss and physical Climate VaR – and explains what each number means, what it does not mean, and which question it is designed to answer.

For technical definitions, calculation methodology and the full range of available outputs across hazards and time horizons, refer to the **MSCI GeoSpatial Asset Intelligence Methodology documents, the MSCI Climate VaR Methodology** and **Multi-Horizon Climate VaR Methodology**, listed in Appendix Key Methodology Documents.

### Hazard intensity values (0–10 scale)

The hazard intensity value is a normalized, unitless score that reflects how intense or frequent a specific physical hazard is at a given asset location relative to the global distribution of that hazard across economically active locations. Values run from 0 to 10. A score of 0 means the hazard is not applicable at that location. A score of 1 indicates exposure at or below the 10th percentile of the global distribution, effectively no meaningful exposure. A score of 10 indicates exposure at or above the 90th percentile, among the most highly exposed locations globally.

The score is calculated by applying a logarithmic transformation to the raw hazard level at a location, calibrated against the 10th and 90th percentiles of the global distribution of that hazard across approximately 11 million economically active locations. The logarithmic approach ensures meaningful differentiation even at lower exposure levels, where raw hazard data distributions tend to be heavily skewed.

An important constraint on interpretation: a score of 7 for tropical cyclone exposure cannot be compared to a score of 7 for extreme heat exposure. The scale is hazard-specific, it ranks a location within the global distribution of **that hazard**, not across hazards. The hazard intensity value is the right tool for ranking how exposed a location is to a particular hazard relative to global peers; it is not a universal severity scale across different hazard types. Similarly, the intensity value reflects current climate conditions only, it does not incorporate future scenario projections.

**In practice:** Use hazard intensity values to answer questions such as "where within the global distribution does this asset sit for flood risk?" or "which of our holdings has the highest relative tropical cyclone exposure?" Combine with financial impact metrics (AAL) to move from exposure ranking to loss estimation.

### Hazard percentiles (0–100)

The hazard percentile provides a benchmarked comparison of an asset location's hazard exposure against the asset locations of all companies in the MSCI ACWI Index. A hazard percentile of 80 for coastal flooding means the location's coastal flood exposure is higher than 80% of ACWI-constituent asset locations under current climate conditions.

Where the hazard intensity value situates an asset within the global distribution of economically active locations, the hazard percentile situates it specifically within the MSCI ACWI Index investable universe. For institutional investors whose mandates reference the MSCI ACWI Index or comparable equity benchmarks, this makes the hazard percentile a more directly actionable screening tool: it answers the question "relative to the companies I can invest in, how exposed is this asset?"

Hazard percentiles are available for the current climate and for future time horizons (2030, 2050, 2100) across 11 climate scenarios. Percentiles at future time horizons are calculated relative to current climate levels, which means they indicate how much worse an asset's exposure becomes over time compared to where it sits today — not how it ranks among peers in the future.

**In practice:** Use hazard percentiles to screen and rank portfolio holdings by relative hazard exposure within the investment universe, or to identify companies in the top quartile of flood or heat exposure for further investigation. Hazard percentiles are appropriate for benchmarking and engagement prioritization; they do not indicate the financial magnitude of loss.

**Financial impact metrics**

MSCI assesses financial impact through two complementary metrics: average annual loss (AAL) and return-period (RP) losses. AAL captures expected losses in a typical year; RP losses capture the magnitude of rare but plausible extreme events. Both are available in two dimensions: business interruption (expressed as a share of annual revenue) and asset damage (expressed as a share of fixed asset value).

Average annual loss (AAL) represents the expected loss from physical hazards in a typical year, aggregated across the full probability distribution of possible hazard events, from very small, frequent losses to large but rare ones. Because AAL averages across all events in the loss distribution, it captures the ongoing, chronic drag from hazards that erode revenue and productivity, while also incorporating the probability-adjusted contribution of more extreme events. A company with a business interruption AAL of 0.5% from extreme heat is losing, in expectation, the equivalent of 0.5% of its annual revenue to heat-related productivity impairment every year, even if no dramatic event occurs in a given year.

AAL is available for current climate conditions and for future climate scenarios at 2030, 2050 and 2100 across 11 NGFS and IPCC scenarios. It covers up to 13 hazard types at the asset level, both chronic and acute, for all hazards where MSCI assesses financial impact. It is the metric most directly linked to financial materiality assessment and is relevant to regulatory disclosures under ESRS E1 and IFRS S2 where physical risks are material.

RP losses complement AAL for tail risk assessment. The 100-year return-period loss estimates the loss associated with an event that has a 1% probability of occurring in any given year; the 200-year RP loss estimates the equivalent for a 0.5% probability event. These metrics are particularly relevant for long-lived assets, project finance and any application where a single extreme event could be existentially significant, such as infrastructure stress testing or insurance-linked analysis. RP losses are assessed for acute hazards only, reflecting the event-driven nature of return period analysis.

RP losses are available at the asset level for four acute hazards: coastal flooding, fluvial flooding, pluvial flooding and tropical cyclones, the hazards for which event-based probabilistic modeling is sufficiently robust to support return period estimation. They are provided for current climate conditions and for future climate scenarios at 2030, 2050 and 2100 across 11 NGFS and IPCC scenarios. Note that for windstorms and convective storms, only AAL estimates are currently available; RP losses are not provided for those hazards due to the modeling approach used.

**Reading the numbers:** A company with a combined AAL of 0.1% of revenue faces a different order of materiality than one at 2.0%. Absolute thresholds should be interpreted alongside sector norms, revenue concentration in high-risk locations, and the specific hazard types driving losses, with awareness that these are model estimates, not guaranteed outcomes.

**Physical Climate Value-at-Risk (VaR)**

Physical Climate VaR is an estimate of the present value of all projected physical climate costs facing a company under a specific climate scenario, expressed as a percentage of the company's current enterprise value (EVIC). A physical climate VaR of −3% means that the expected present value of physical risk costs, discounted to today, is equivalent to 3% of the company's current market capitalization plus debt.

Two features of this metric shape how it should be read. First, it is **scenario-specific**: the same company will show different Climate VaR under Net Zero 2050, Below 2°C and Current Policies scenarios, because each scenario implies a different trajectory of hazard intensification. Presenting climate VaR across multiple scenarios is standard practice, not optional — a single-scenario number gives an incomplete and potentially misleading picture of the range of outcomes.

Second, Climate VaR is **not a return forecast**. It represents an upper bound on potential devaluation under the specific and restrictive assumptions that climate costs are fully priced in instantaneously and that investors have perfect foresight about which scenario will materialize. In reality, neither condition holds. The metric's primary value is in **comparing relative risk** across holdings and scenarios, not in predicting a specific future price change.

Physical Climate VaR covers costs through 2100, which makes it the most complete long-run measure of climate cost exposure. For investors with shorter planning horizons, **multi-horizon Climate VaR** provides the same metric calculated to cutoff points of 1, 3, 5, 10, 20 and 30 years, useful for matching physical risk estimates to specific investment or regulatory time windows. Empirically, physical risks materialize later than transition risks: costs incurred within the first 10 years typically represent less than one-fifth of the total standard Climate VaR to 2100.

**Reading the numbers:** Company A with a physical Climate VaR of −0.8% has lower estimated long-run physical risk exposure than Company B at −4.2%, all else equal. This ranking is meaningful even though neither number predicts a specific loss. Always compare Climate VaR across scenarios and, where relevant, use multi-horizon Climate VaR to understand how much of the total cost burden falls within your investment horizon.

**A note on metric assumptions and limitations**

**Key assumptions**

**Climate models provide projections of future hazard intensity and frequency under a given climate scenario.** MSCI Sustainability & Climate (S&C) uses a combination of climate-model projections, reanalysis and scenario modeling to produce hazard data, which is a key input for our physical risk model. By nature, this type of modeling is based on assumptions. Climate models, for example, will always be a simplified representation of all the extremely complex dynamics and interactions of the Earth's processes. Yet it is generally accepted that climate models can provide accurate projections of some climate variables that are used to derive reliable hazard intensities and frequencies under different climate scenarios. The uncertainty evaluation of climate model projections is done by comparing outputs from different climate models running the same scenario.

**Hazard intensity and frequency are correlated with global mean temperature**. To provide consistent hazard-specific physical risks for the same scenario, MSCI S&C uses an established mapping approach: it builds on the observation that robust, projected geographical patterns of many climate variables can be identified at a given level of global warming, common to all scenarios considered and independent of the timing when the global warming level is reached. In other words, it is assumed that a certain level of global warming will lead to the same physical impact even if it is reached at different points in time.

**MSCI S&C assumes the typical period of 30 years as the time horizon that is needed to obtain average values of climate metrics that are independent of natural variability, which is defined by the World Meteorological Organization (WMO)**. The scientific term "climate" refers to the average (long-term) behavior of typical meteorological quantities like temperature, wind and precipitation. This 30-year time frame stems from the observation that this period is, in most cases, the shortest decadal period to yield constant results for averages. However, the classical period of 30 years sometimes does not capture the full extent of climate change, whereas a shorter period may suffer from statistical problems related to natural variability. MSCI S&C analysis sometimes uses sub-30-year averages when datasets are not long enough, with the intent to find the best compromise in time frames.

**Limitations**

The MSCI GeoSpatial dataset underpins our physical risk assessment for physical corporate assets. We use third-party data and manual collection to obtain detailed information on asset locations. Not all corporate asset locations are covered; therefore, missing data may be estimated. MSCI GeoSpatial does not include data for every physical asset of every company in coverage.

Climate projections are not predictions of the future. Climate scenario analysis is the current standard to evaluate potential changes in hazard exposure under climate change. Projections from climate models can be used to answer "what if" questions such as "what physical risks from weather extremes could we face, if the world were to warm by 2°C as compared to 5°C?"

Depending on the hazard, financial impacts only are assessed for direct asset damage, business interruption, rental income loss and operational cost. Other sources of financial impacts that can be caused by physical hazards, such as supply chain disturbance, economy-level supply-and-demand effects, extreme weather-related worker absences, migration and public unrest, are not covered by the model.

For specific assumptions, coverage flags and methodology details, refer to the Key Methodology Documents in the Appendix.

**MSCI physical risk metric availability by hazard**

## Physical Risk Metrics – chronic hazards

✓ Available
✗ Not Available
⊖ Not Applicable

| Hazard Type | Hazard Exposure Data | | | | | Physical Risk Financial Impact | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Current Exposure | | | Future Exposure | | Current Financial Impact | | Future Financial Impact | | |
| | Levels* | Percentiles | Intensity Values | Levels* | Percentiles | Average Annual Loss | Return Period Loss | Average Annual Loss | Return Period Loss | Climate Value-at-Risk** |
| Extreme Heat | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ⊖ | ✓ | ⊖ | ✓ |
| Extreme Cold | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ⊖ | ✓ | ⊖ | ✓ |
| Heavy Rain | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ⊖ | ✓ | ⊖ | ✓ |
| Heavy Snowfall | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ⊖ | ✓ | ⊖ | ✓ |
| Extreme Wind | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ⊖ | ✓ | ⊖ | ✓ |
| Water Scarcity | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ⊖ | ✗ | ⊖ | ✗ |
| Permafrost Thawing | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ | ⊖ | ✗ | ⊖ | ✗ |
| Saline Intrusion | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ | ⊖ | ✗ | ⊖ | ✗ |
| Ocean Acidification* | ✓ | ✗ | ✓ | ✗ | ✗ | ✗ | ⊖ | ✗ | ⊖ | ✗ |
| Groundwater Table Decline | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ | ⊖ | ✗ | ⊖ | ✗ |
| Solifluction | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ | ⊖ | ✗ | ⊖ | ✗ |

# Physical Risk Metrics – acute hazards

✓ Available
✗ Not Available
⊖ Not Applicable

| Hazard Type | Hazard Exposure Data | | | | | Physical Risk Financial Impact | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Current Exposure | | | Future Exposure | | Current Financial Impact | | Future Financial Impact | | |
| | Levels* | Percentiles | Intensity Values | Levels* | Percentiles | Average Annual Loss | Return Period Loss | Average Annual Loss | Return Period Loss | Climate Value-at-Risk** |
| Tropical Cyclones | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Coastal Flooding | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Fluvial Flooding | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Pluvial Flooding | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| River Low Flow | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Wildfires | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✗ | ✓ |
| Hail | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Tornado | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Heat Wave | ✗ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Tsunami | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Glacial Lake Outburst | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Convective Storm | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ | ✓ | ✗ | ✗ | ✗ |
| Windstorm | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ | ✓ | ✗ | ✗ | ✗ |
| Earthquake Bedrock Conditions | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Earthquake Local Soil Conditions | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Landslide | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Volcanic Ashfall | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Subsidence | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Avalanche | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Lightning | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |

## Summary of existing adaptation related taxonomies and frameworks

| Framework | Primary purpose | Target users | Core focus | Key components | Decision level | Potential limitations |
|---|---|---|---|---|---|---|
| **Climate Bonds Initiative Climate Resilience Taxonomy** | Classify eligible climate-resilient investments | Issuers, banks, investors | What qualifies as a resilient investment | Forward-looking physical risk assessment; resilience objectives; robust, location-specific adaptation measures | Project / asset | Eligibility-focused; does not optimize or price adaptation |
| **IIGCC Climate Resilience Investment Framework (CRIF)** | Integrate resilience into investment decision-making | Asset owners, asset managers | Investment-lifecycle integration of resilience | Physical risk assessment; capital allocation; stewardship; monitoring & learning | Portfolio / firm | Principles-based; requires internal capability |
| **EU Taxonomy – Climate Change Adaptation** | Regulatory classification of adaptation-aligned activities | Asset managers, banks, insurers, investors (EU) | Eligibility and resilience of economic activities | Physical climate risk assessment; substantial contribution to adaptation or resilience to climate risks; DNSH | Activity / asset | Complex; compliance-heavy; limited guidance on optimization |

| | | | | | | |
|---|---|---|---|---|---|---|
| **MDB / EBRD Climate Resilience Frameworks** | Ensure resilience of financed projects | Banks, investors, insurers, DFIs | Investment-grade project-level adaptation | Mandatory climate risk screening; adaptation measures; monitoring & evaluation | Project | Hard to scale across portfolios |
| **NGFS Climate Risk & Adaptation Frameworks** | Set supervisory expectations for adaptation | Banks, insurers, supervisors | Prudential management of physical risk | Scenario analysis; risk management expectations; adaptation considerations | Institution / system | Not an investment or eligibility framework |
| **ISSB (IFRS S2 – Physical Risk)** | Standardized reporting of physical climate risk | Investors, banks, insurers, asset managers | Financial materiality of physical risk | Forward-looking physical risk identification; financial impacts | Organization / portfolio | Disclosure first; limited adaptation guidance |

Source: MSCI Sustainability and Climate Research, March 15, 2026.

## Scenario analysis technical foundations

This appendix provides technical details on scenario construction, climate VaR methodology and aggregation approaches.

**NGFS scenario framework**

NGFS Phase 4 scenarios provide comprehensive coverage through six core scenarios:

- **Net-Zero 2050 (1.5C):** Immediate policy response achieving global net-zero CO2 by 2050. Limited physical risks, significant transition costs.
- **Below 2C (1.7-1.8C):** Gradual policy stringency, 67% probability below 2C. Moderate physical risks.
- **Low Demand (1.5C):** Achieves Net Zero through demand-side changes rather than technology.
- **Delayed Transition (<2C):** Emissions rise until 2030, then sharp policy response. High transition risk.
- **Fragmented World (2.5-3C):** Delayed divergent responses globally. High physical and transition risks.
- **Current Policies (3C+):** Continuation without additional action. Severe physical risks.

For physical risk, investors typically analyze Net Zero 2050, Below 2C and Current Policies to span plausible futures.

**Time horizons:**

- Short-term (1-5 years): Primarily acute hazard events
- Medium-term (5-15 years): Mix of acute and emerging chronic changes
- Long-term (15-30+ years): Chronic shifts dominant with intensified acute events

### Climate VaR: Technical overview

Physical Risk Climate VaR quantifies present value of impacts through four stages:

- **Stage 1: Asset location mapping**
  MSCI GeoSpatial Asset Intelligence combines disclosed data, commercial databases, satellite imagery and verification algorithms.
- **Stage 2: Hazard exposure assessment**
  Hazard models project exposure levels combining GCMs, hydrological models and vulnerability thresholds.
- **Stage 3: Financial impact modeling**
  Damage functions translate physical damages to financial impacts considering:
  - Direct asset damage
  - Business interruption
  - Chronic productivity impacts
- **Stage 4: Present Value Calculation**
  Future impacts discounted to present value. Standard methodology uses 30-year horizon, with multi-horizon variants at 1, 3, 5, 10, 20, 30 years.
- **Portfolio aggregation:** Portfolio Climate VaR = Sum(Security Climate VaR × Weight) / Sum(Covered Weights)

**Important limitation:** NGFS scenarios incorporate chronic GDP impacts but have limited acute event representation. Phase 4 likely underestimates full physical impacts.

### Aggregation and Correlation

**Hazard-level:** Individual hazards additive under central estimate. Aggressive outcome (95th percentile) accounts for correlations.

**Security-level:** NOT additive due to Merton model non-linearity. Component present values summed at company level, then translated.

**Portfolio-level:** Weighted average of security-level VaRs, assuming independence.

**Physical + transition:** Treated as additive at portfolio level, though interactions may exist.

**Missing data:** Set to zero for aggregation. Coverage metrics indicate data availability.

Sovereign bond climate VaR uses a different methodology (yield curve shocks) and should not be aggregated with corporate climate VaR.

## Key methodology documents and user guides

| Document | Date | What it covers |
|---|---|---|
| **MSCI GeoSpatial Asset Intelligence Methodology – Corporate Asset Locations (Module 1)** | October 2025 | Asset location identification, data sourcing, geocoding, asset-to-issuer linkage and quality assurance across ~11 million corporate and real estate locations |
| **MSCI GeoSpatial Asset Intelligence Methodology – Physical Risk – Hazard Exposure (Module 2a)** | October 2025 | Hazard intensity modeling and scoring across 31 hazards; hazard percentile calculations and exceedance day metrics across time horizons and climate scenarios |
| **MSCI GeoSpatial Asset Intelligence Methodology – Physical Risk – Financial Impact (Module 2b)** | October 2025 | Translation of hazard exposure into financial losses; asset damage and business interruption estimates (AAL, return period losses, CVaR inputs); damage functions by sector and region |
| **MSCI GeoSpatial Asset Intelligence Methodology – Nature Exposure and Impact (Module 3)** | April 2025 | Biodiversity risk screening; nature exposure metrics including water consumption and land-use impacts; integration of WWF Biodiversity Risk Filter indicators |
| **MSCI GeoSpatial Asset Intelligence – On-the-Fly Real Estate Locations Process – Physical Risks** | 2024 | API and MSCI ONE workflow for calculating physical risk hazard exposure and financial impact for user-provided real estate asset locations |
| **MSCI Sovereign Bond Climate VaR Methodology** | March 2025 | Macroeconomic physical and transition risk modeling for sovereign bonds; NGFS scenario integration via the NiGEM model; yield curve shock derivation and bond P&L calculation |
| **MSCI Multi-Horizon Climate Value-at-Risk Methodology** | October 2023 | Corporate Climate VaR at custom time horizons (1, 3, 5, 10, 20, 30 years); equity and debt-level devaluation estimates under physical and transition risk scenarios |
| **Understanding MSCI's Climate Metrics** | January 2023 | Investor guide to the full suite of MSCI climate metrics; selection criteria by use case; coverage of Carbon Emissions, ITR, Fossil Fuel Revenue, Cleantech Revenue, LCT Score and Climate VaR |
| **How Can I Use Climate Scenarios? A Practical Guide** | December 2024 | Practical guidance on applying MSCI climate scenarios for portfolio analysis, stress testing and regulatory reporting; scenario selection and interpretation |

The documents listed above are available to clients on a subscription basis. Contact your MSCI client service representative for access.

# References

Wang, X., Towey, K., and Mammadov, E. (2025). "Is Physical Risk Financially Material? A Hurricane-Event Study." MSCI ESG Research LLC, September 2025.

Lee, L., Towey, K., and Ashfaq, U. (2025). "What the Market Thinks: A Corporate Resilience Survey." MSCI Institute, October 2025.

Kruttli, M.S., Tran, B.R., and Watugala, S.W. (2025). "Pricing Poseidon: Extreme Weather Uncertainty and Firm Return Dynamics." The Journal of Finance, Vol. LXXX, No. 2, April 2025.

Nguyen, D.D., Ongena, S., Qi, S., and Sila, V. (2022). "Climate Change Risk and the Cost of Mortgage Credit." Review of Finance, 26(6):1509-1549.

Swiss Re Institute (2025). "sigma No 1/2025 report: Natural catastrophes." April 2025.

NGFS Climate Scenarios

IPCC Sixth Assessment Report

"The Bill is Due: Physical Hazard Revenue Losses Mount, Plans Lag,"

"Compound Climate Hazards Pressure Beverage Giants," "Anticipating Hurricane Risk Before It Strikes,"

"Hidden in Plain Sight: Physical Risk in Asset Owners' Portfolios," "Temperature Check: The Long-Term Climate Risks Banks Can't Ignore," "When AI Meets Water Scarcity: Data Centers in a Thirsty World," "Does the Mortgage Market Price in Physical Risk?"

MSCI Sustainability Institute Climate Scenarios Guide (2024)

**Additional MSCI research and methodologies:**

MSCI ESG Research LLC. "MSCI GeoSpatial Asset Intelligence Methodology – Corporate Asset Locations (Module 1)." October 2025.

MSCI ESG Research LLC. "MSCI GeoSpatial Asset Intelligence Methodology – Physical Risk – Hazard Exposure (Module 2a)." October 2025.

MSCI ESG Research LLC. "MSCI GeoSpatial Asset Intelligence Methodology – Physical Risk – Financial Impact (Module 2b)." October 2025.

MSCI ESG Research LLC. "MSCI GeoSpatial Asset Intelligence Methodology – Nature Exposure and Impact (Module 3)." April 2025.

MSCI ESG Research LLC. "MSCI GeoSpatial Asset Intelligence – On-the-Fly Real Estate Locations Process – Physical Risks." 2024.

MSCI ESG Research LLC. "MSCI Sovereign Bond Climate Value-at-Risk Methodology." March 2025.

MSCI ESG Research LLC. "MSCI Multi-Horizon Climate Value-at-Risk Methodology." October 2023.

Shakdwipee, Manish, Guido Giese, and Zoltan Nagy. "Understanding MSCI's Climate Metrics." MSCI ESG Research LLC, January 2023.

MSCI Sustainability Institute. "How Can I Use Climate Scenarios? A Practical Guide." December 2024.

# Contact us

**About MSCI Inc.**

MSCI (NYSE: MSCI Inc.) strengthens global markets by connecting participants across the financial ecosystem with a common language. Our research-based data, analytics and indexes, supported by advanced technology, set standards for global investors and help our clients understand risks and opportunities so they can make better decisions and unlock innovation. We serve asset managers and owners, private-market sponsors and investors, hedge funds, wealth managers, banks, insurers and corporates.

To learn more, please visit www.msci.com
msci.com/contact-us

The process for submitting a formal index complaint can be found on the index regulation page of MSCI's website at: https://www.msci.com/index-regulation.

**About MSCI Sustainability and Climate Products and Services**

MSCI Sustainability and Climate products and services are provided by MSCI Solutions LLC and certain related entities, and are designed to provide in-depth research, ratings and analysis of environmental, social and governance related business practices to companies worldwide. ESG ratings, data and analysis from MSCI Sustainability and Climate are also used in the construction of MSCI Indexes.

| | |
|---|---|
| AMERICA | |
| United States | + 1 888 588 4567 * |
| Canada | + 1 416 687 6270 |
| Brazil | + 55 11 4040 7830 |
| Mexico | + 52 81 1253 4020 |
| EUROPE, MIDDLE EAST & AFRICA | |
| South Africa | + 27 21 673 0103 |
| Germany | + 49 69 133 859 00 |
| Switzerland | + 41 22 817 9777 |
| United Kingdom | + 44 20 7618 2222 |
| Italy | + 39 02 5849 0415 |
| France | + 33 17 6769 810 |
| ASIA PACIFIC | |
| China | + 86 21 61326611 |
| Hong Kong | + 852 2844 9333 |
| India | + 91 22 6784 9160 |
| Malaysia | 1800818185 * |
| South Korea | + 82 70 4769 4231 |
| Singapore | + 65 67011177 |
| Australia | + 612 9033 9333 |
| Taiwan | 008 0112 7513 * |
| Thailand | 0018 0015 6207 7181 * |
| Japan | + 81 3 4579 0333 |

* toll-free

# Notice and disclaimer

The data, data feeds, databases, reports, text, graphs, charts, images, videos, recordings, models, metrics, analytics, indexes, ratings, scores, cases, estimates, assessments, software, websites, products, services and other information and materials contained herein or delivered in connection with this notice (collectively, the "Information") are copyrighted, trade secrets (when not publicly available), trademarks and proprietary property of MSCI Inc. or its subsidiaries (collectively, "MSCI"), MSCI's licensors, direct or indirect suppliers and authorized sources, and/or any third party contributing to the Information (collectively, with MSCI, the "Information Providers"). All rights in the Information are reserved by MSCI and its Information Providers and user(s) shall not, nor assist others to, challenge or assert any rights in the Information.

Unless you contact MSCI and receive its prior written permission, you must NOT use the Information, directly or indirectly, in whole or in part (i) for commercial purposes, (ii) in a manner that competes with MSCI or impacts its ability to commercialize the Information or its services, (iii) to provide a service to a third party, (iv) to permit a third party to directly or indirectly access, use or resell the Information, (v) to redistribute or resell the Information in any form, (vi) to include the Information in any materials for public dissemination such as fund factsheets, market presentations, prospectuses, and investor information documents (e.g. KIIDs or KIDs), (vii) to create or as a component of any financial products, whether listed or traded over the counter or on a private placement basis or otherwise, (viii) to create any indexes, ratings or other data products, including in derivative works combined with other indexes or data or as a policy, product or performance benchmarks for active, passive or other financial products, (ix) to populate a database, or (x) to train, use as an input to, or otherwise in connection with any artificial intelligence, machine learning, large language models or similar technologies except as licensed and expressly authorized under MSCI's AI Contracting Supplement at https://www.msci.com/legal/supplemental-terms-for-client-use-of-artificial-intelligence.

The intellectual property rights of MSCI and its Information Providers may not be misappropriated or used in a competitive manner through the use of third-party data or financial products linked to the Information, including by using an MSCI index-linked future or option in a competing third-party index to provide an exposure to the underlying MSCI index or by using an MSCI index-linked ETF to create a financial product that provides an exposure to the underlying MSCI index without obtaining a license from MSCI.

The user or recipient of the Information assumes the entire risk of any use it may make, permit or cause to be made of the Information. NONE OF THE INFORMATION PROVIDERS MAKES ANY EXPRESS OR IMPLIED WARRANTIES OR REPRESENTATIONS WITH RESPECT TO THE INFORMATION (OR THE RESULTS TO BE OBTAINED BY THE USE THEREOF), AND TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, EACH INFORMATION PROVIDER EXPRESSLY DISCLAIMS ALL IMPLIED WARRANTIES (INCLUDING ANY IMPLIED WARRANTIES OF ORIGINALITY, ACCURACY, TIMELINESS, SUITABILITY, NON-INFRINGEMENT, COMPLETENESS, MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE) WITH RESPECT TO ANY OF THE INFORMATION. Without limiting any of the foregoing and to the maximum extent permitted by applicable law, in no event shall MSCI or any other Information Provider have any liability arising out of or relating to any of the Information, including for any direct, indirect, special, punitive, consequential (including lost profits) or any other damages, even if notified of the possibility of such damages. The foregoing shall not exclude or limit any liability that may not by applicable law be excluded or limited.

The Information, including index construction, ratings, historical data, or analysis, is not a prediction or guarantee of future performance, and must not be relied upon as such. Past performance is not indicative of future results. The Information may contain back tested data. Back-tested performance based on back-tested data is not actual performance but is hypothetical. There are frequently material differences between back tested performance results and actual results subsequently achieved by any investment strategy. The Information may include "Signals," defined as quantitative attributes or the product of methods or formulas that describe or are derived from calculations using historical data. Signals are inherently backward-looking because of their use of historical data, and they are inherently inaccurate, not intended to predict the future and must not be relied upon as such. The relevance, correlations and accuracy of Signals frequently change materially over time.

The Information may include data relating to indicative prices, evaluated pricing or other information based on estimates or evaluations (collectively, "Evaluations") that are not current and do not reflect real-time traded prices. No evaluation method, including those used by the Information Providers, may consistently generate evaluations or estimates that correspond to actual "traded" prices of any relevant securities or other assets. Evaluations are subject to change at any time without notice and without any duty to update or inform you, may not reflect prices at which actual transactions or collateral calls may occur or have occurred. The market price of securities, financial instruments, and other assets can be determined only if and when executed in the market. There may be no, or may not have been any, secondary trading market for the relevant securities, financial instruments or other assets. Private capital, equity, credit and other assets and their prices may be assessed infrequently, may not be priced on a secondary market, and shall not be relied upon as an explicit or implicit valuation of a particular instrument. Any reliance on fair value estimates and non-market inputs introduces potential biases and subjectivity. Internal Rate of Return metrics are not fully representative without full disclosure of fund cash flows, assumptions, and time horizons.

The Information does not constitute, and must not be relied upon as, investment advice, credit ratings, or proxy advisory or voting services. None of the Information Providers, their products or services, are fiduciaries or make any recommendation, endorsement, or approval of any investment decision or asset allocation. Likewise, the Information does not represent an offer to sell, a solicitation to buy, or an endorsement of any security, financial product, instrument, investment vehicle, or trading strategy, whether or not linked to or in any way based on any MSCI index, rating, subcomponent, or other Information (collectively, "Linked Investments").The Information should not be relied on and is not a substitute for the skill, judgment and experience of any user when making investment and other business decisions. MSCI is not responsible for any user's compliance with applicable laws and regulations. All Information is impersonal, not tailored to the needs of any person, entity or group of persons, not objectively verifiable in every respect, and may not be based on information that is important to any user.

It is not possible to invest in an index. Exposure to an asset class or trading strategy or other category represented by an index is only available through third party investable instruments (if any) based on that index. MSCI makes no assurance that any Linked Investments will accurately track index performance or provide positive investment returns. Index returns do not represent results of actual trading of investible assets/securities. MSCI maintains and calculates indexes but does not manage assets. The calculation of indexes and index returns may deviate from the stated methodology. Index returns do not reflect payment of any sales charges or fees an investor may pay to purchase securities underlying the index or Linked Investments. The imposition of these fees and charges would cause the performance of a Linked Investment to be different than the MSCI index performance.

Information provided by MSCI Solutions LLC and certain related entities ("MSCI Solutions"), including materials utilized in MSCI sustainability and climate products, have not been submitted to, nor received approval from any regulatory body. MSCI sustainability and climate offerings, research and data are produced by, and ratings are solely the opinion of MSCI Solutions. Other MSCI products and services may utilize information from MSCI Solutions, Barra LLC or other affiliates. More information can be found in the relevant methodologies on www.msci.com. MSCI Indexes are administered by MSCI Limited (UK) and MSCI Deutschland GmbH. No regulated use of any MSCI private real assets indexes in any jurisdiction is permitted without MSCI's express written authorization. The process for applying for MSCI's express written authorization can be found at: https://www.msci.com/index-regulation.

MSCI receives compensation in connection with licensing its indexes and other Information to third parties. MSCI Inc.'s revenue includes fees based on assets in Linked Investments. Information can be found in MSCI Inc.'s company filings on the Investor Relations section of msci.com. Issuers mentioned in MSCI Solutions materials or their affiliates may purchase research or other products or services from one or more MSCI affiliates, manage financial products such as mutual funds or ETFs rated by MSCI Solutions or its affiliates or are based on MSCI Indexes. Constituents of MSCI equity indexes are listed