Hidden in Plain Sight: Physical Risk in Asset Owners' Portfolios

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The location of companies' assets affects returns and volatility.

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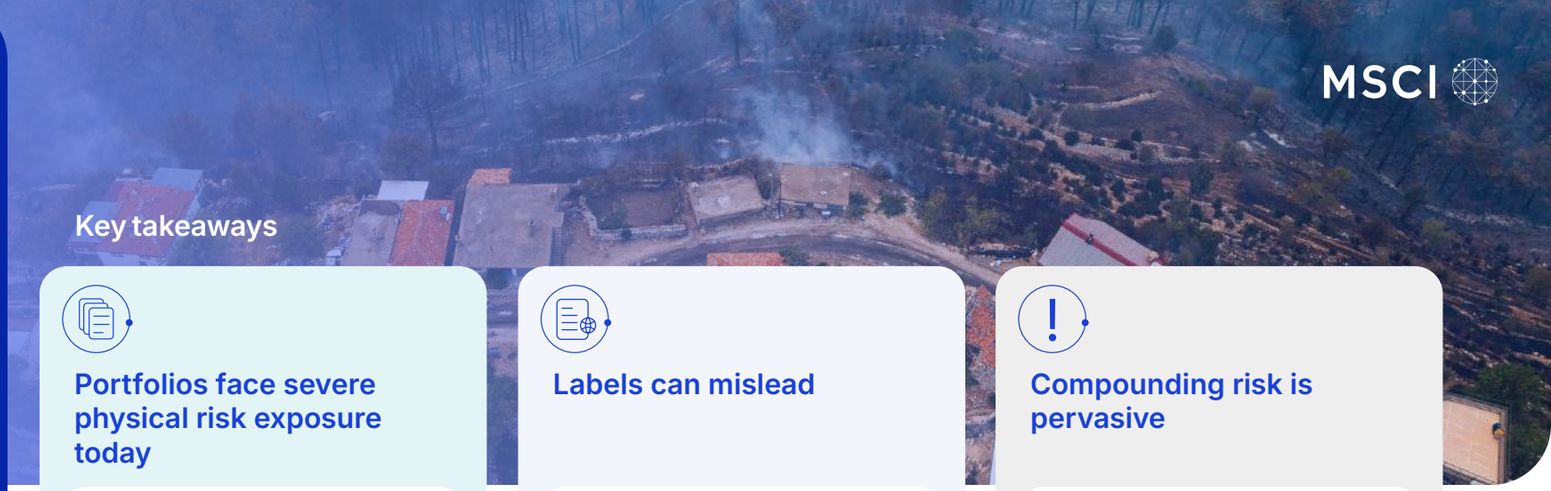
Hidden in Plain Sight: Physical Risk in Asset Owners' Portfolios

Location isn't just geography, it's financial risk exposed. The location of companies' assets affects returns and volatility. For investors, location can magnify portfolio drawdowns when hazards strike investee companies' facilities. Hazards striking key production sites, data centers or supply hubs can amplify risk through both direct asset damage and costly business interruptions. Yet these risk exposures are often invisible in traditional portfolio analyses.

Using MSCI GeoSpatial Asset Intelligence and MSCI Physical Risk Solutions, we analyzed 11,215 unique companies and around 500,000 physical assets underpinning the listed equity portfolios of 18 asset owners.[1] To better understand the physical risks financial markets face today, MSCI partnered with Swiss Re Risk Data Solutions to conduct this review, covering investors that together represent USD 4 trillion in total assets under management (AUM) and approximately USD 2 trillion in listed-equities exposure.

Our analysis found that 55% of the companies in their listed-equity portfolios already face severe physical hazards today. By value, this equals 25% of their total equity holdings, with small- and mid-cap companies particularly exposed. Where there are risks, there are also opportunities, however. Even within the same sector and region, companies can be impacted by physical risks in very different ways. As tools to assess and manage these risks continue to advance, investors are increasingly able to move from being merely exposed to being well-prepared, transforming hidden risks into opportunities for building stronger, more resilient portfolios.



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Key takeaways

Portfolios face severe physical risk exposure today

Physical risk isn't tomorrow's problem; it is already impacting portfolios. In the combined asset-owner portfolio, a quarter of portfolio value is already exposed to severe hazard levels today. But the range is stark: Some portfolios carry as little as 14% exposure, while others shoulder up to 61%. Heat waves (acute) and water scarcity (chronic) dominate current portfolio exposures and have clear economic costs.

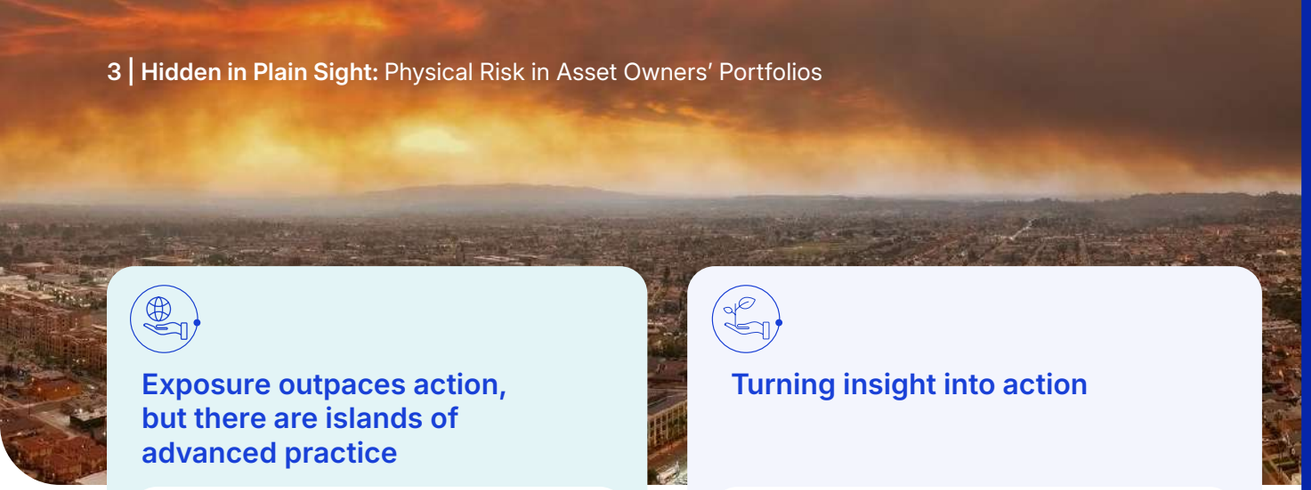
Labels can mislead

Where a company is domiciled and the sector it's classified into can mask exposures; two utilities companies may face very different risks, depending on where their facilities are located. We found that, on average, companies generated nearly 50% of their output from outside their home country,[2] and more than half the companies we analyzed operated across three or more countries.[3]

Compounding risk is pervasive

Physical hazards rarely fly solo: 89% of assets linked to 95% of companies analyzed face significant exposure to at least two hazards, and nearly two-thirds of companies are significantly exposed to three or more. In other words, almost every company in the assessed portfolios is navigating overlapping, high-intensity risk exposures, multiplying the potential for disruption and loss.

1. We constructed the combined asset-owner portfolio by combining all 18 equity portfolios, assigning each portfolio an equal weight. We then re-scaled the security weights in the portfolio so they sum to 100%.
2. Based on MSCI's exposure model from the GeoSpatial Asset Intelligence solution as of Sept. 29, 2025.
3. Based on MSCI's exposure model from the GeoSpatial Asset Intelligence solution as of Sept. 29, 2025. The modeled asset-level output reflects the inferred share of total company operations to each asset, derived from its productive capital and/or its employees.



Exposure outpaces action, but there are islands of advanced practice

Many of the most exposed firms do not formally disclose evidence of adapting or integrating physical risk into enterprise risk management, a gap that investors may choose to target through engagement and capital allocation to adaptation and resilience.

However, perhaps rapid change is at hand. The MSCI Institute publication "What the market thinks: Findings from our Corporate Resilience Survey," found that three quarters of the 550 companies surveyed across the nine most physical-risk exposed sectors stated they "have instituted a framework for managing physical risk, ranging from real-time monitoring systems that track hazards to climate scenario analysis. Adoption of such frameworks is highest (81%) among companies recently impacted by extreme weather events."

Turning insight into action

Asset owners can take steps to understand, manage and reduce physical risk in both their internally and externally managed portfolios. This starts with asset-level mapping, using geospatial intelligence to locate exposure and treating siting as a financial variable. For internally managed portfolios, this intelligence can inform allocation, risk limits and engagement priorities, as well as the repricing of exposures or the pursuit of new resilience-linked investment opportunities. For externally managed portfolios, the focus shifts to gauging exposure and vulnerability, assessing managers' treatment of physical risk and closing adaptation gaps through mandates, due diligence and stewardship dialogue. Across both types of portfolios, location-driven physical-risk intelligence helps asset owners set concentration thresholds, engage in site resilience and re-underwrite positions where risk remains high.

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So what does this mean?

Physical risks are no longer distant or hypothetical, they are eroding returns today. A recent MSCI research paper found that companies exposed to climate-related hazards such as hurricanes have already experienced statistically significant underperformance following extreme weather events. Asset owners who fail to integrate location-based risk intelligence may have to contend with mispriced assets, portfolio underperformance and missed opportunities in the growing adaptation economy. Those who act can not only reduce losses but position themselves at the forefront of resilience-driven investment.

MSCI gratefully acknowledges the following asset owners for providing the data that made this study possible. Their collaboration demonstrates a strong commitment to advancing best practices in understanding and managing physical climate risk.

- AFP Protección (Colombia)
- Australian Retirement Trust (Australia)
- California State Teachers' Retirement System (U.S.)
- New York State Common Retirement Fund (U.S.)
- Nordea Life and Pension (Nordics)
- Norges Bank Investment Management (Norway)
- Pension Protection Fund (U.K.)
- PensionDanmark (Denmark)
- Pensionskasse des Bundes PUBLICA (Switzerland)
- People's Partnership (U.K.)
- Railpen (U.K.)
- Stichting Pensioenfonds ABP (Netherlands)
- Universities Superannuation Scheme (U.K.)
- University Pension Plan Ontario (Canada)
- Washington State Investment Board (U.S.)

In addition, MSCI acknowledges the valuable contributions of three other asset owners based in Southeast Asia, Oceania and Western Europe, who chose not to be named.

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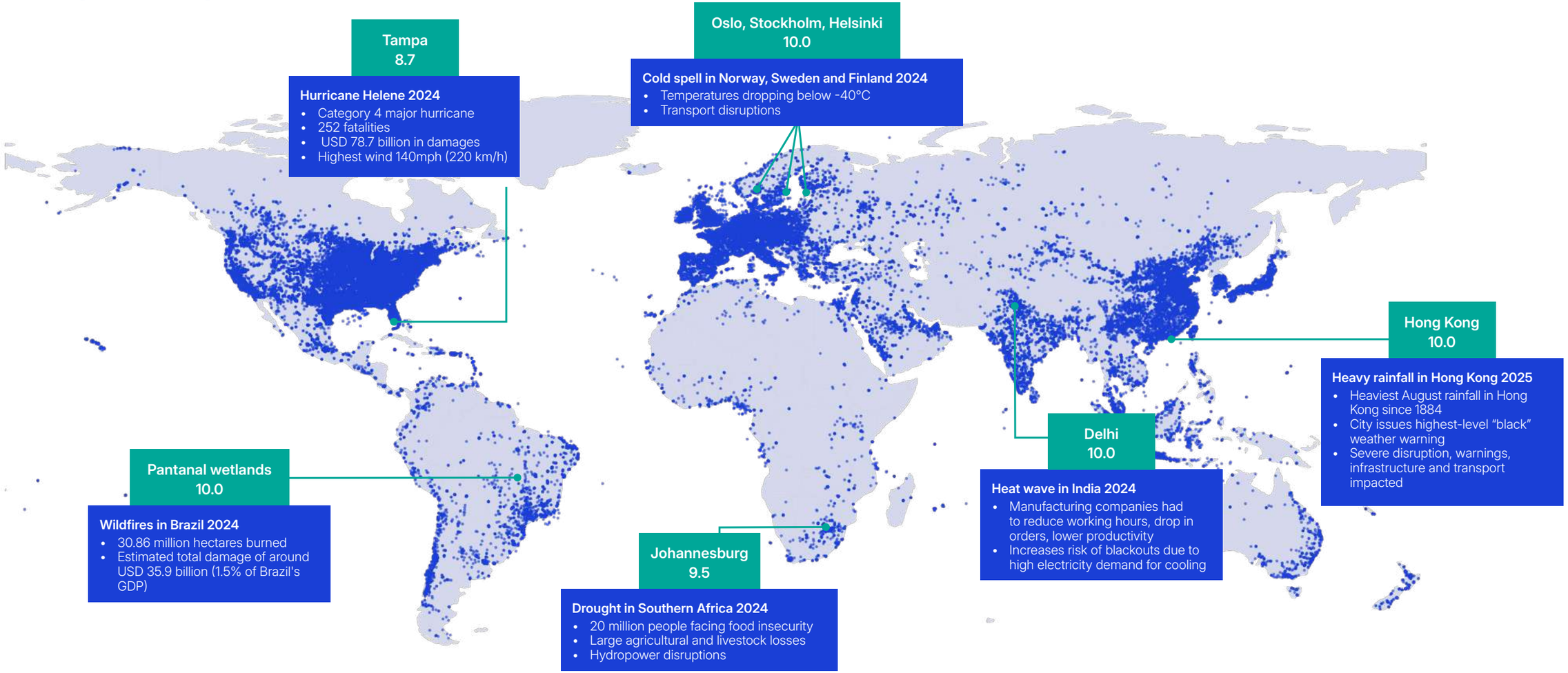
Executive summary

Investors with large equity portfolios have global physical risk exposure, regardless of regional investment focus



Data as of Sept. 29, 2025. The map shows the underlying assets (blue dots) of a European asset owner's portfolio. Recent extreme weather events are highlighted and align with areas showing high local hazard intensity (green boxes). For instance, our data indicates a high tropical-cyclone intensity value of 8.7 for Tampa, which was hit by Hurricane Helene in 2024. Source: MSCI Sustainability & Climate Research Services. MSCI Sustainability & Climate products and services are provided by MSCI Solutions LLC in the United States and MSCI Solutions (UK) Limited in the United Kingdom and certain other related entities.

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Location is a financial risk factor

Location determines exposure. Domicile is a weak proxy for physical-risk exposure because operations can be global. Nearly two-thirds of companies in the combined asset-owner portfolio operate in three or more countries, and almost half of company output is generated outside the home market, rising to 65% for European companies. The result: Investors face "faraway" hazards, such as tropical cyclones, through overseas assets of a European company, for example.

In other words, what looks safe on paper may mask real vulnerability on the ground.

Severe exposure, today

Physical risk isn't tomorrow's problem; it is already affecting portfolios. In the combined asset-owner portfolio, a quarter of the value is already exposed to severe hazard levels today. But the range is stark: Some portfolios carry as little as 14% exposure, while others shoulder up to 61%. We assessed portfolio holdings across a wide range of 28 hazards, including water-related (flooding, hail, water scarcity, saline intrusion, etc.), wind-related (tropical cyclone, tornado, etc.), temperature-related (heat wave, wildfires, extreme heat, permafrost thawing, etc.), and solid-mass-related (earthquakes, subsidence, landslides, etc.).

And these exposures are not theoretical. Market evidence suggests that physical risk is already impacting equity performance.

Market impact is observable

Companies with assets exposed to any of the observed 2022–2024 tropical cyclones underperformed, starting around five trading days before impact and for around 30 business days after.[4]

Investors themselves increasingly recognize this materiality, shifting the debate from "if" to "how fast?"

From exposure to financial materiality

For companies, the most concerning hit is often business interruption, not the headline asset damage to a facility. Lost output, delayed shipments, overtime, premium logistics and customer churn can outweigh repair bills.

Over the next year, our models estimate potential business interruption could lead to USD 1.07 trillion in lost revenue opportunities for companies in the combined portfolio.

4. Underperformance is measured by residual returns after controlling for country, industry and style factors. We use MSCI Global Equity Factor Model - Trading.
For further detail, please refer to: Xinxin Wang et al. "Anticipating Hurricane Risk Before It Strikes," MSCI Sustainability & Climate Research Services, September 2025.

Investor focus has shifted

The debate is no longer about whether physical risk matters but how quickly it will have a material influence on the valuation and volatility of portfolios. A 2024 MSCI Institute global survey of 350 institutional investors found that a majority (57%) believe weather-related physical risks are already driving economic losses and doing so sooner than expected.

The challenge is that physical risk rarely comes in isolation, it multiplies across hazards.

Compound extremes amplify risk

Physical hazards rarely come alone: We found that 89% of assets linked to 95% of the companies in our analysis face significant exposure to at least two hazards, and nearly two-thirds of companies are significantly exposed to three or more. In other words, almost every company in the assessed portfolios is navigating overlapping, high-intensity risk exposures, multiplying the potential for disruption and loss.

Despite rising recognition, translating this awareness into concrete action has been slow.

Awareness is rising, but action lags

Recognition of the financial relevance of physical risk is growing. For example, in the same 2024 MSCI Institute survey, most global institutional investors said they expect escalating losses from extreme weather, broadly consistent with a 2.8°C warming trajectory. Yet translating awareness into concrete action remains difficult. A recent study from Canada Pension Plan (CPP) Investments similarly found that industry practice is still in the early stages.[5] Investors face an overwhelming volume of data and a proliferation of methodologies, which often produce inconsistent results.[6] This complexity has slowed the integration of physical-risk analytics into decision-making.

Another MSCI Institute study found encouraging evidence of progress: three quarters of the 550 companies surveyed stated they "have instituted a framework for managing physical risk" in varying degrees of sophistication and integration into executive remuneration.

This leaves a clear adaptation gap and, for investors, a tangible engagement opportunity.

Adaptation gap. In 2024, natural catastrophes caused **USD 318 billion** in economic losses, with **USD 137 billion insured,** leaving a **USD 181 billion (uninsured) "protection gap"** — a reminder that **residual losses** persist unless exposure is reduced.[7]

In our combined asset-owner portfolio, only around **16%** of the most exposed firms (≥ 9/10 hazard-intensity score for any hazard) include physical risk in their overall risk-management disclosure. This points to actionable engagements, such as revised mandates, due diligence and stewardship dialogue, for externally managed portfolios. For internally managed portfolios, there are opportunities to reassess both public and private holdings and potentially engage with the management of investee companies for better information.

The age of unseen physical risk is over. Asset owners face risks of underestimating exposures, mispricing assets and avoidable drawdowns. By integrating geospatial intelligence, engaging with companies on resilience and closing the adaptation gap, investors can shift from being exposed to being prepared, turning unseen risks into opportunities for stronger, more resilient portfolios.

5. "Investing in a changing world: How public funds are addressing climate-related physical risks," CPP Investments, June 2025; "2023 Report on Sustainable Investing," CPP Investments, 2023.
6. "2024 Climate Risk Landscape Report," United Nations Environment Programme Finance Initiative, April 2024.
7. "sigma No 1/2025 report: Natural catastrophes: insured losses on trend to USD 145 billion in 2025," Swiss Re Institute, April 2025.

Hidden in plain sight:
Location as financial risk

Labels can mislead. Domicile and sector classification mask exposure because operations are global.

Considering only where a company is domiciled can obscure actual hazard exposure. Risk depends on the precise location of a company's assets, not just its headquarters. In the combined asset-owner portfolio, 62% of companies operate in three or more countries, and 47% of their output on average is linked to operations outside of their country of domicile, increasing to 65% of output for Europe-domiciled companies.

Asset owners often invest with a home-region bias or policy mandate. Yet portfolios that appear regionally concentrated are, in practice, exposed to physical risks around the world. Large multinationals run plants, warehouses, data centers and logistics hubs across continents, regardless of where they are headquartered. Because physical risk is local and tied to the exact elevation, latitude and longitude of operating sites, country of domicile is a weak proxy for physical risks. Adding supply chains to the mix would widen the geographic exposure even further.

In one illustrative case, the Europe-focused portfolio of an asset owner showed that although roughly 50% of its holdings were in Europe-domiciled companies, about 66% of the underlying output was generated through activities conducted outside Europe. This shifts the portfolio's hazard exposure to other regions. For example, Heidelberg Materials AG, a large manufacturing company headquartered in Germany, derives an estimated 92% of its output from operations outside the country. A similar pattern is observed for Japan's Bridgestone Corp., highlighting that this is not unique to Europe but rather a common feature of large multinational companies.

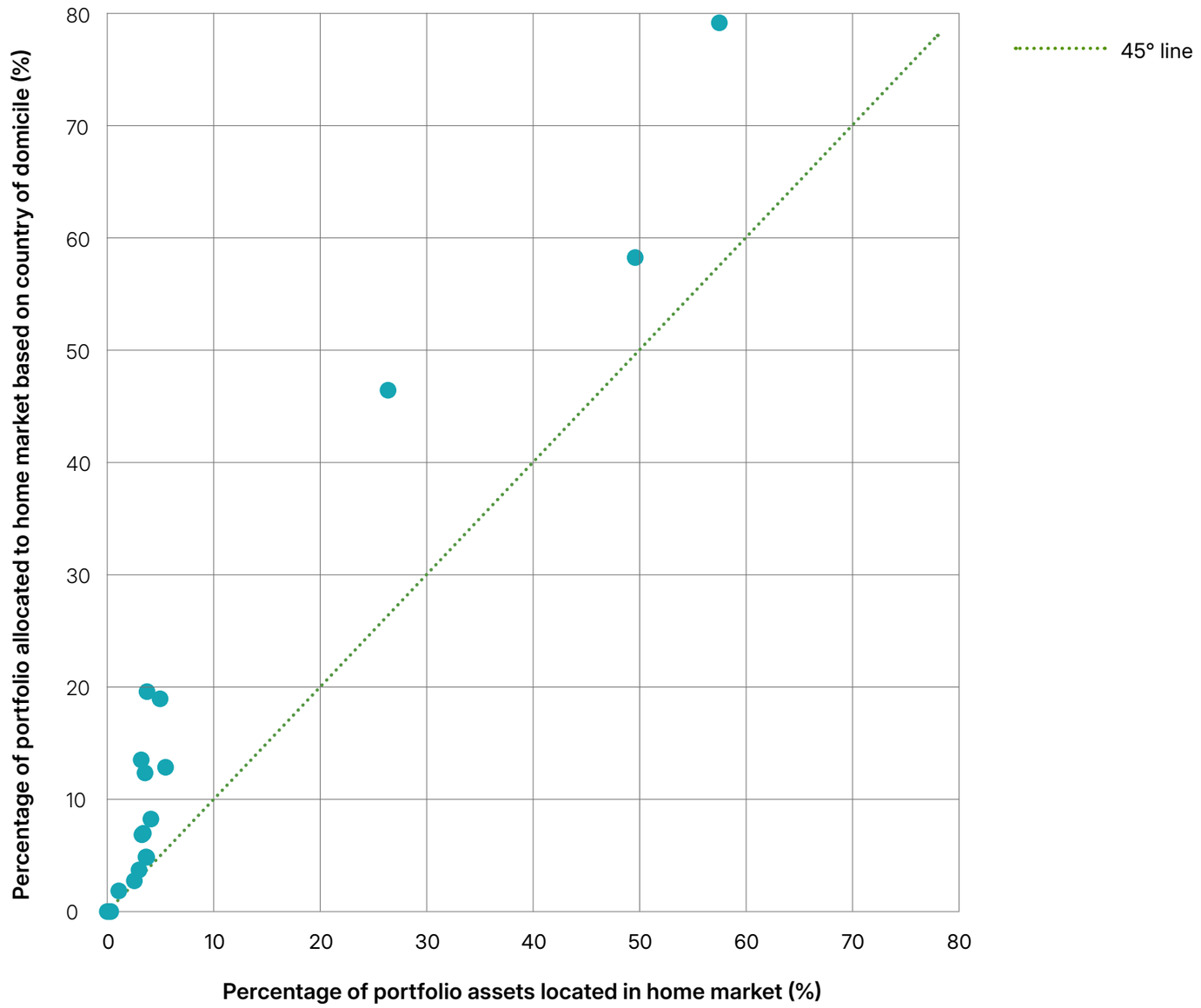
Even within the same sector and country, exposure to physical hazards can vary widely. For example, two U.S.-based electric-utilities companies from the combined portfolio show contrasting exposure profiles: One focused on the West Coast experiences moderate climate conditions, including exposure to earthquakes, while another operating in inland regions faces more volatile and extreme climate patterns with high exposure to heat waves, snowfall and convective events, such as hail, lightning and tornadoes (see chart on page 11 titled "Contrasting hazard exposures of two U.S.-based companies operating in the same electric utilities sector").

Asset owners often invest with home-region mandates, yet their holdings operate worldwide. A portfolio that looks European by domicile may include facilities in Asian floodplains and U.S. hurricane corridors.

The takeaway:

Exposures are often invisible in traditional portfolio risk analysis. Location-specific hazards can cluster far from headquarters. Asset-level views, joined to local hazard intensity, provide a more reliable basis for understanding where physical risk sits in today's portfolio. Without granular site-level data, these differences in risk of either direct asset damage or costly business interruptions remain hidden.

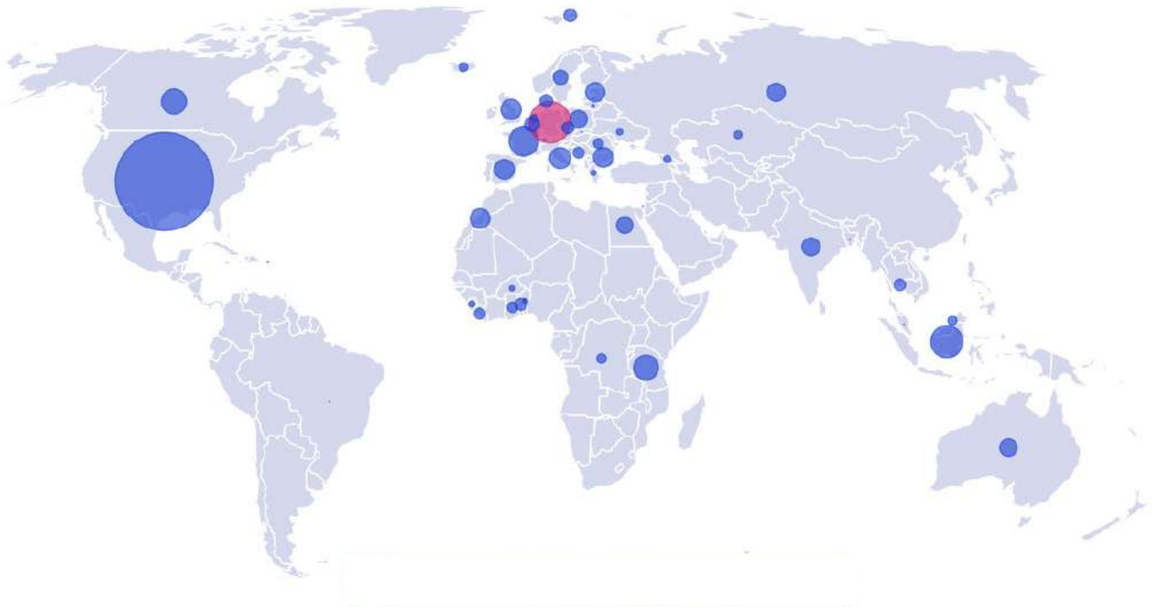
Home bias on paper, global exposure in reality



Data as of Sept. 29, 2025. Each dot represents one asset-owner portfolio. The x-axis shows the share of portfolio assets physically located in the investor's home market, while the y-axis shows the share of holdings domiciled in that market. Portfolios above the 45° line appear more "home-biased" based on company domicile than they actually are when asset locations are considered. In most cases, underlying physical assets are far more globally distributed than suggested by country-of-domicile classifications. Source: MSCI Sustainability & Climate Research Services

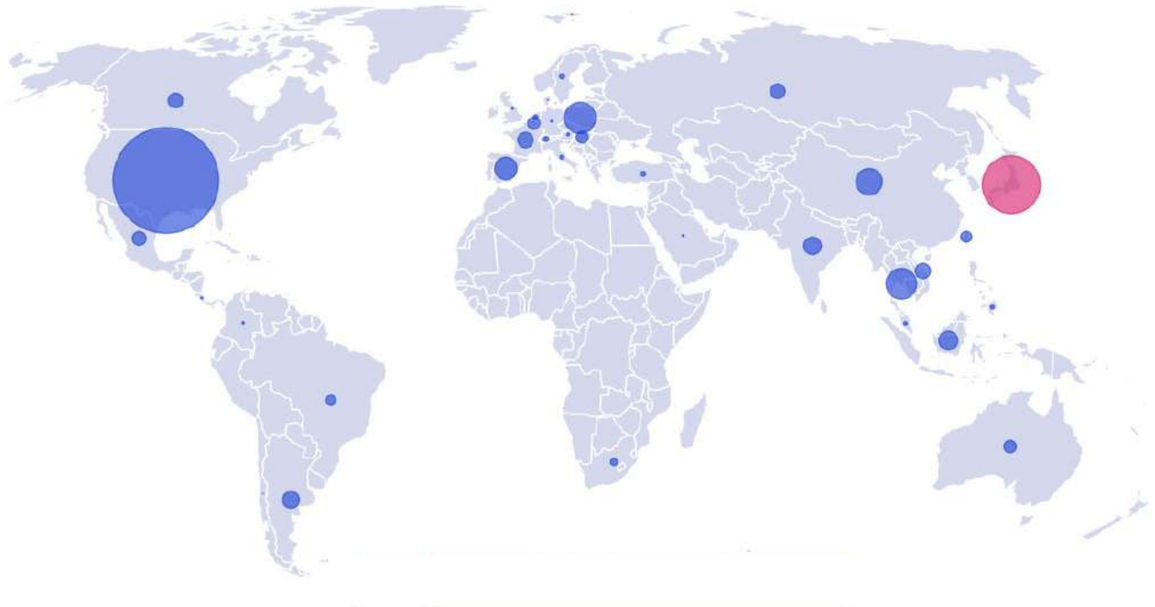
Large companies operate globally and are exposed to hazards worldwide

Heidelberg Materials AG



8.0% | 92% output outside Germany

Bridgestone Corporation



16.0% | 84.0% output outside Japan

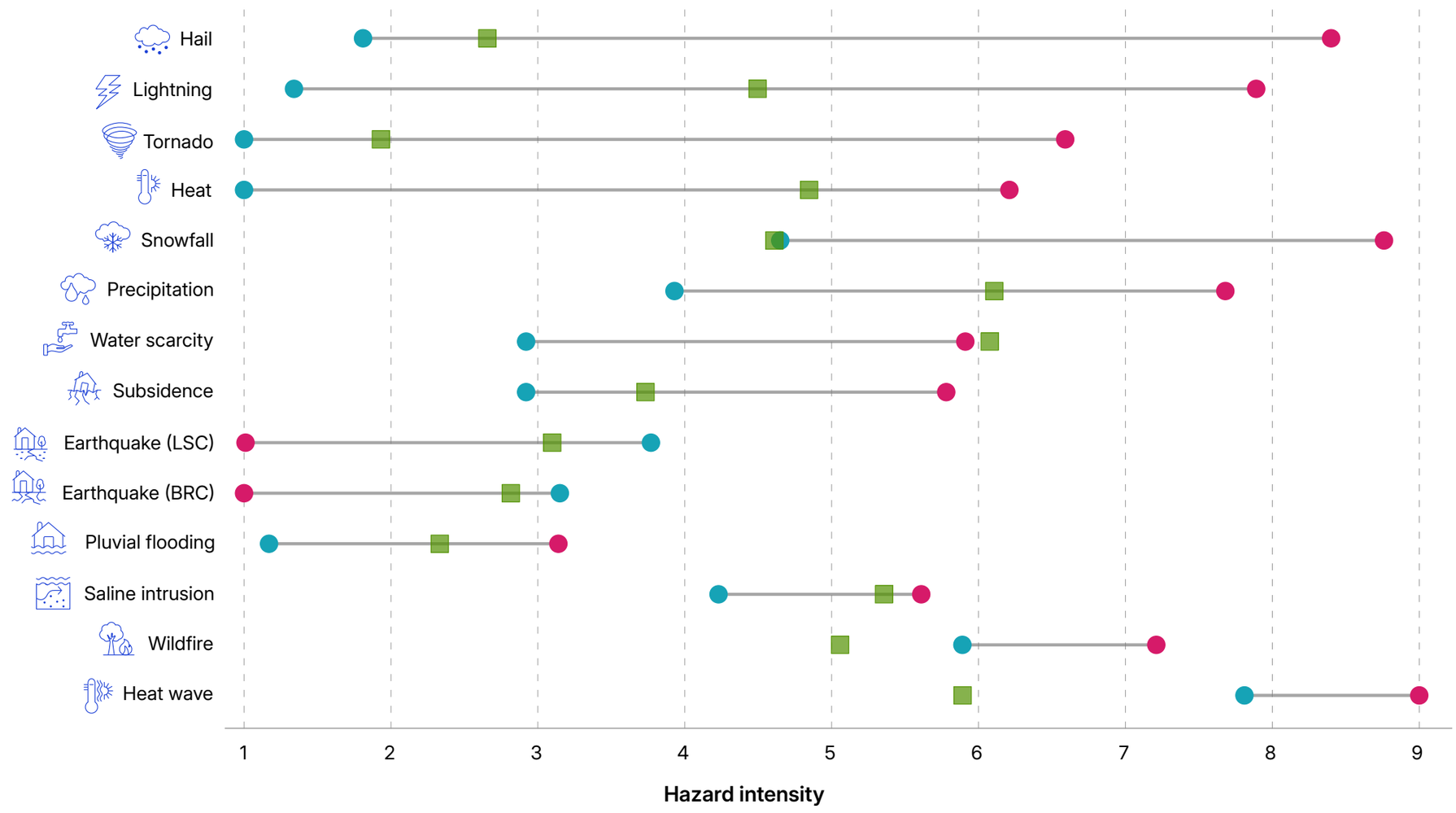
Higher output share Lower output share

Data as of Sept. 29, 2025. The estimated output by region is shown for Heidelberg Materials AG, based in Germany (left), and Bridgestone Corp., based in Japan (right). Source: MSCI Sustainability & Climate Research Services

Contrasting hazard exposures of two US-based companies operating in the utilities sector

Legend:

- Low hazard-exposed company
- Sector-country mean hazard intensity
- High hazard-exposed intensity



Data as of Sept. 29, 2025. The companies, represented by red and blue circles, exhibit notable variation in exposure levels. The gray horizontal line visualizes the difference between them, while the green box denotes the sector-country mean derived from all companies domiciled in the same country and sector within the combined asset-owner portfolio. Earthquakes are modeled using local soil conditions (LSC) or bedrock conditions (BRC). Source: MSCI Sustainability & Climate Research Services

To assess whether markets price in location risk, we analyzed trading patterns of storm-exposed companies before and after recent storm seasons. (See the following).

Market evidence: Location-specific hazards moved returns in 2022–2024.

Based on actual events, an MSCI study found that during peak tropical-cyclone season, more than half of the companies in the MSCI ACWI Index had at least one asset in a storm's path (approximately 75% of portfolio weight). **Impacted names underperformed** beginning **around five trading days pre-impact** and lasting for **around 30 business days after**.

Recent seasons showed that headline storms, such as Hurricane Ian and Typhoon Rai, disrupted supply chains and moved single-name and sector valuations.

What the data shows

Company impact

In MSCI's analysis of tropical cyclones, which focused on larger and medium-sized companies (in the MSCI ACWI Index), those with operating assets in storm paths significantly underperformed. The underperformance started about five trading days before landfall and continued for 30 business days after, the entire event study window, even after controlling for country, industry and style factors.[8]

Portfolio breadth

During peak tropical-cyclone season, more than half of MSCI ACWI companies had at least one exposed asset, representing about 75% of portfolio weight.

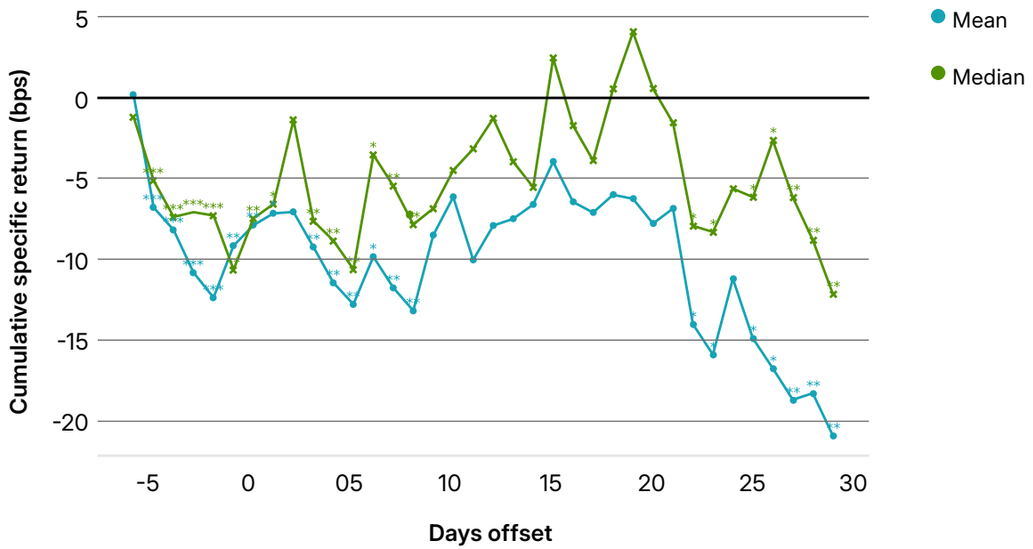
Impacted assets show high hazard-intensity values

More than 30,000 asset locations in the MSCI ACWI Index were impacted by real-world tropical cyclones in 2022–2024. Together, these assets have a mean tropical-cyclone intensity value of 7.5, with more than 60% having an intensity value higher than 8.

Why does this matter?

Based on historical storm tracks and stock-price action, facility location and characteristics are key puzzle pieces for determining financial impact. Joining site-level footprints to local hazard intensity reveals important concentrations. Two companies in the same country and sector can carry very different risks if one has critical facilities on higher ground while another has them in low-lying coastal areas. The asset-level view makes those contrasts visible and points directly to mitigation priorities.

MSCI ACWI companies impacted by tropical cyclones in 2022–2024 underperformed



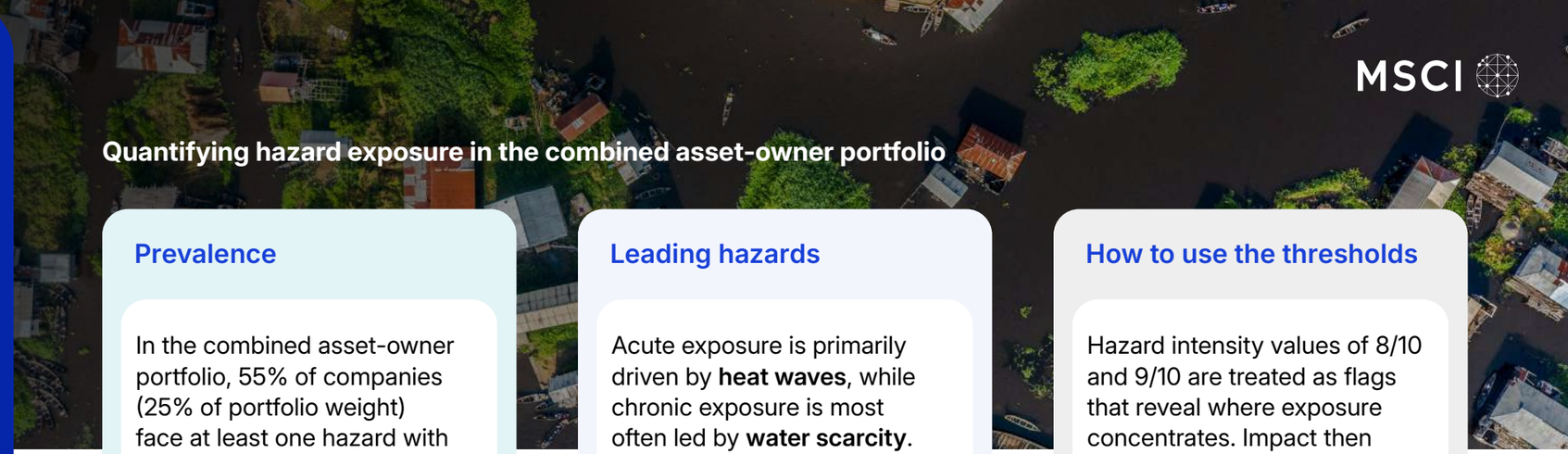
The question isn't whether location matters, but where to look first. So how widespread is this hidden risk across portfolios? The next section quantifies today's exposures found across the 18 assessed portfolios.

Data as of Sept. 29, 2025. We track cumulative abnormal excess equity returns for companies exposed to hurricanes, covering a period from five business days before impact to 30 business days after. The results show a consistent pattern: MSCI ACWI Index constituents impacted by hurricanes underperformed, with losses that deepen and remain statistically significant over time. Specifically: ***statistically significant at 99% confidence level that the mean is below 0; **statistically significant at 95% confidence level that the mean is below 0; *statistically significant at 90% confidence level that the mean is below 0. Source: MSCI Sustainability & Climate Research Services

8. Underperformance is measured by residual returns after controlling for country, industry and style factors. We use the MSCI Global Equity Factor Model - Trading.

Significant exposure, today

Physical risk isn't tomorrow's problem; it is already eroding portfolios. In the combined asset-owner portfolio, a quarter of portfolio value is already exposed to severe hazard levels today. But the range is stark: Some portfolios carry as little as 14% severely exposed portfolio value, while others shoulder up to 61% (see chart on page 14 titled "Exposure to severe hazard intensities across different portfolios"). We assessed portfolio holdings across 28 hazards, including water-related (flooding, hail, water scarcity, saline intrusion, etc.), wind-related (tropical cyclone, tornado, etc.), temperature-related (heat wave, wildfires, extreme heat, permafrost thawing, etc.), and solid-mass-related (earthquakes, subsidence, landslides, etc.).



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Quantifying hazard exposure in the combined asset-owner portfolio

Prevalence

In the combined asset-owner portfolio, 55% of companies (25% of portfolio weight) face at least one hazard with intensity value 9/10 or higher. Across individual portfolios, company exposure ranges from 30% to 55%, but portfolio weight swings more widely from 14% to 61%.

Leading hazards

Acute exposure is primarily driven by **heat waves**, while chronic exposure is most often led by **water scarcity**. This combination of hazards is particularly pronounced in portfolios with a stronger allocation to emerging markets. In contrast, portfolios tilted toward developed markets are more exposed to "wet/cold" hazards, including heavy snowfall, hail and extreme cold.

How to use the thresholds

Hazard intensity values of 8/10 and 9/10 are treated as flags that reveal where exposure concentrates. Impact then depends on vulnerability and readiness.

Interpreting hazard exposures across 28 hazards

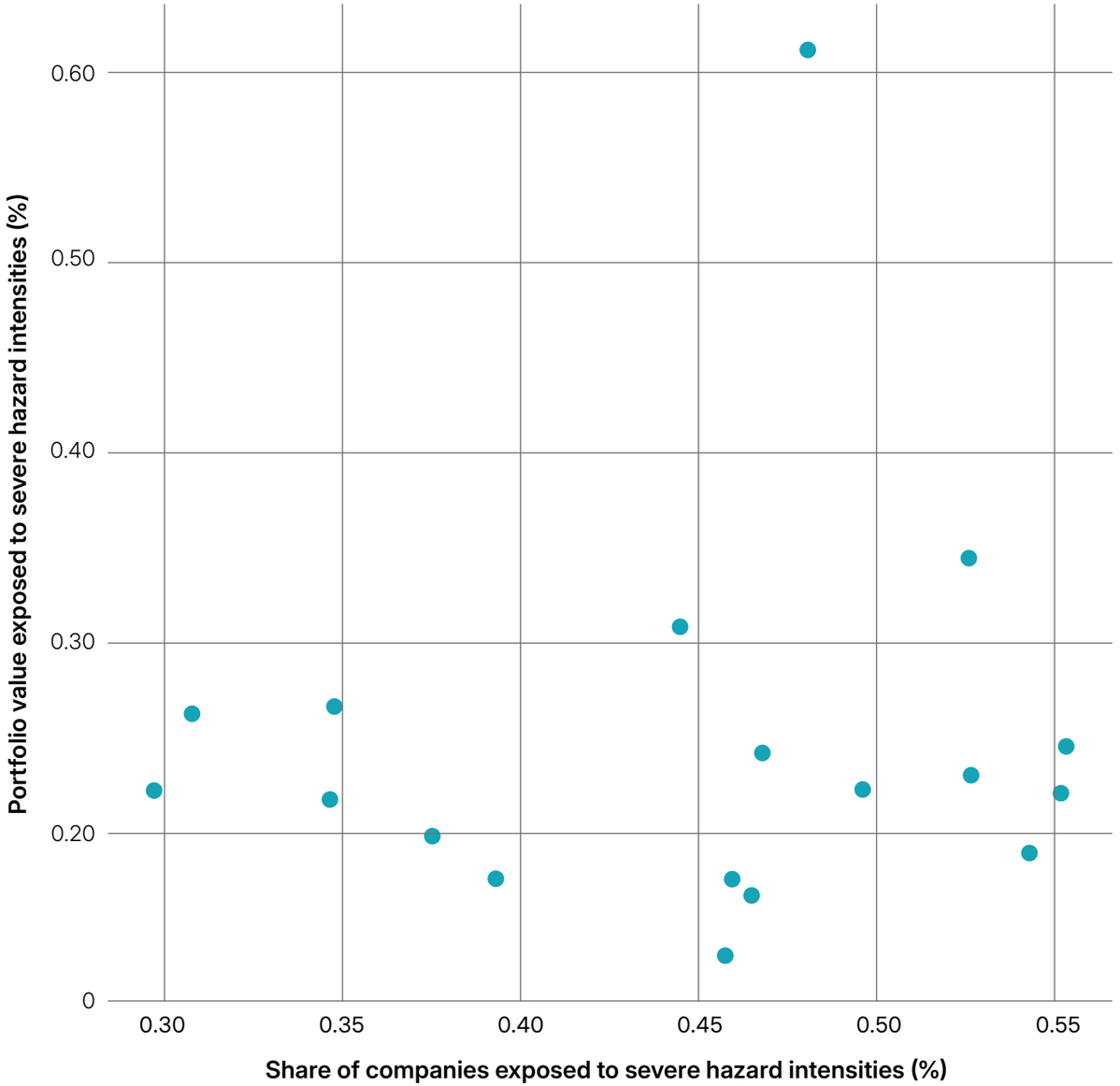
The hazard-intensity value (0–10) is based on current climate conditions. Significant exposure is defined as ≥8/10 (a company is counted if any hazard is ≥8/10) and severe exposure is ≥9/10.

Importantly, the intensity value relates to the relative intensity of occurrence within the same hazard type, so values are not comparable across different hazards per se.

For example, a tropical-cyclone intensity value of 9 corresponds to very high local sustained wind speeds above 55 meters/second, which refers to a "Category 3" event on the Saffir–Simpson Hurricane Wind Scale. A water-scarcity-intensity value of 9 corresponds to 59 days per year in which water demand relative to renewable water supply exceeds 60%, a ratio that is commonly referred to as a medium- to high-risk category.

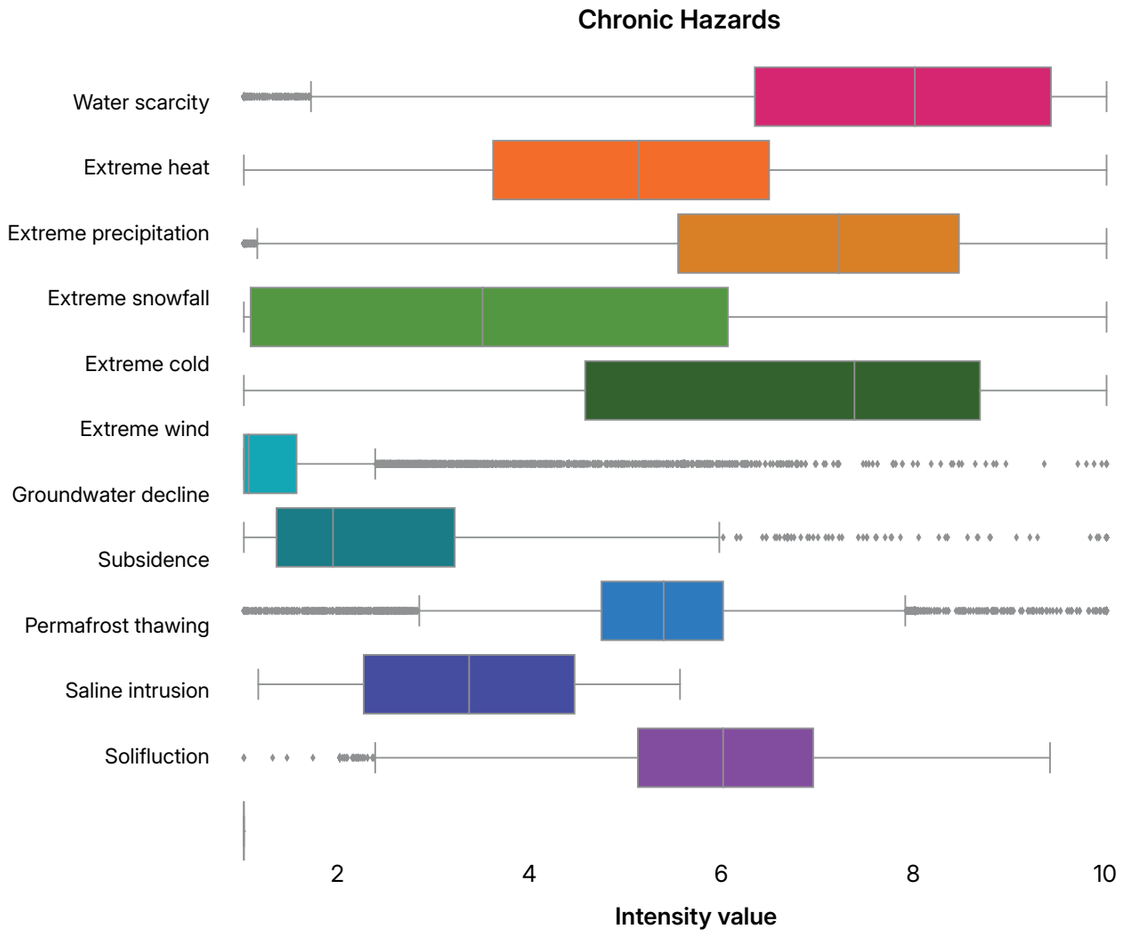
See Appendix for how we calculate hazard-intensity values.

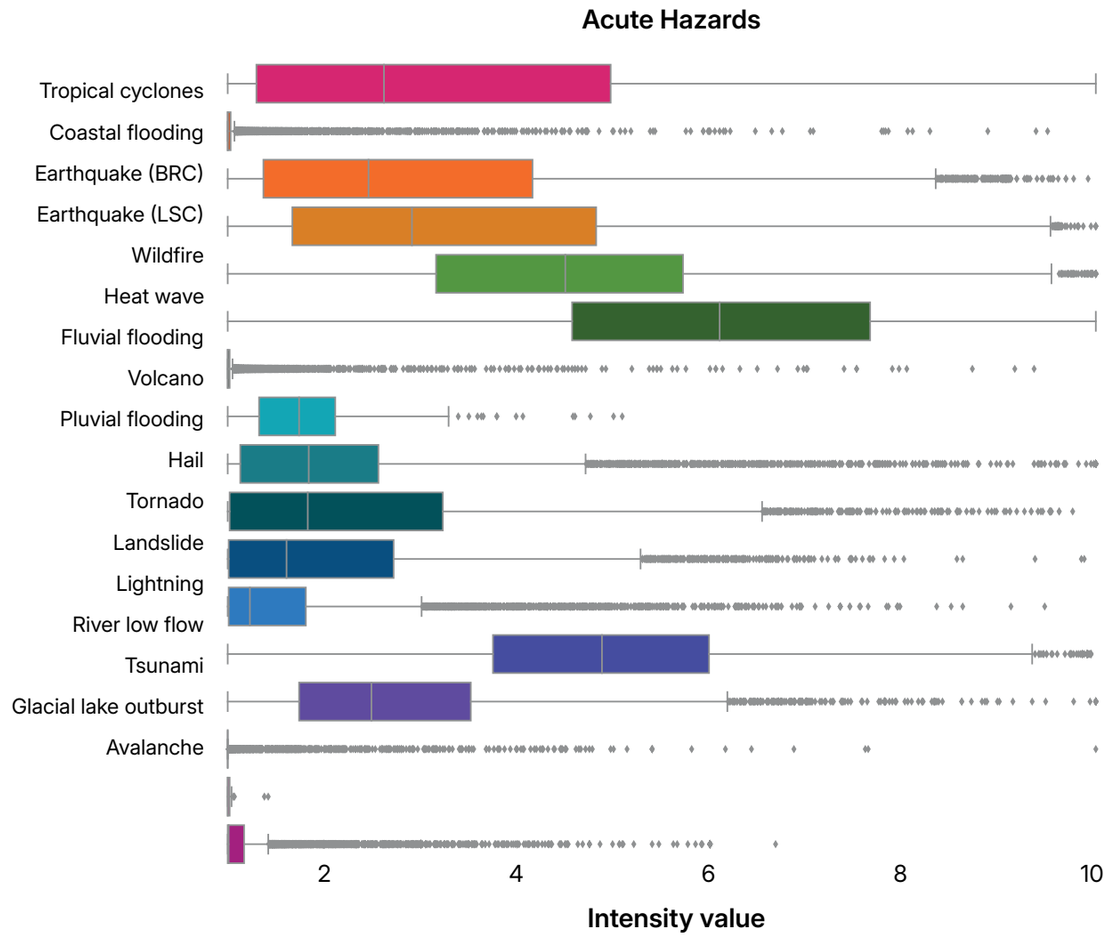
Exposure to severe hazard intensities across different portfolios



Data as of Sept. 29, 2025. Each portfolio in this study is represented by a blue dot. For most portfolios, the share of companies exposed to severe hazard intensities is larger than the respective portfolio weight, indicating that a large part of the exposure is carried by small-/mid-cap companies. Source: MSCI Sustainability & Climate Research Services

Distribution of hazard-intensity values across the combined asset-owner portfolio

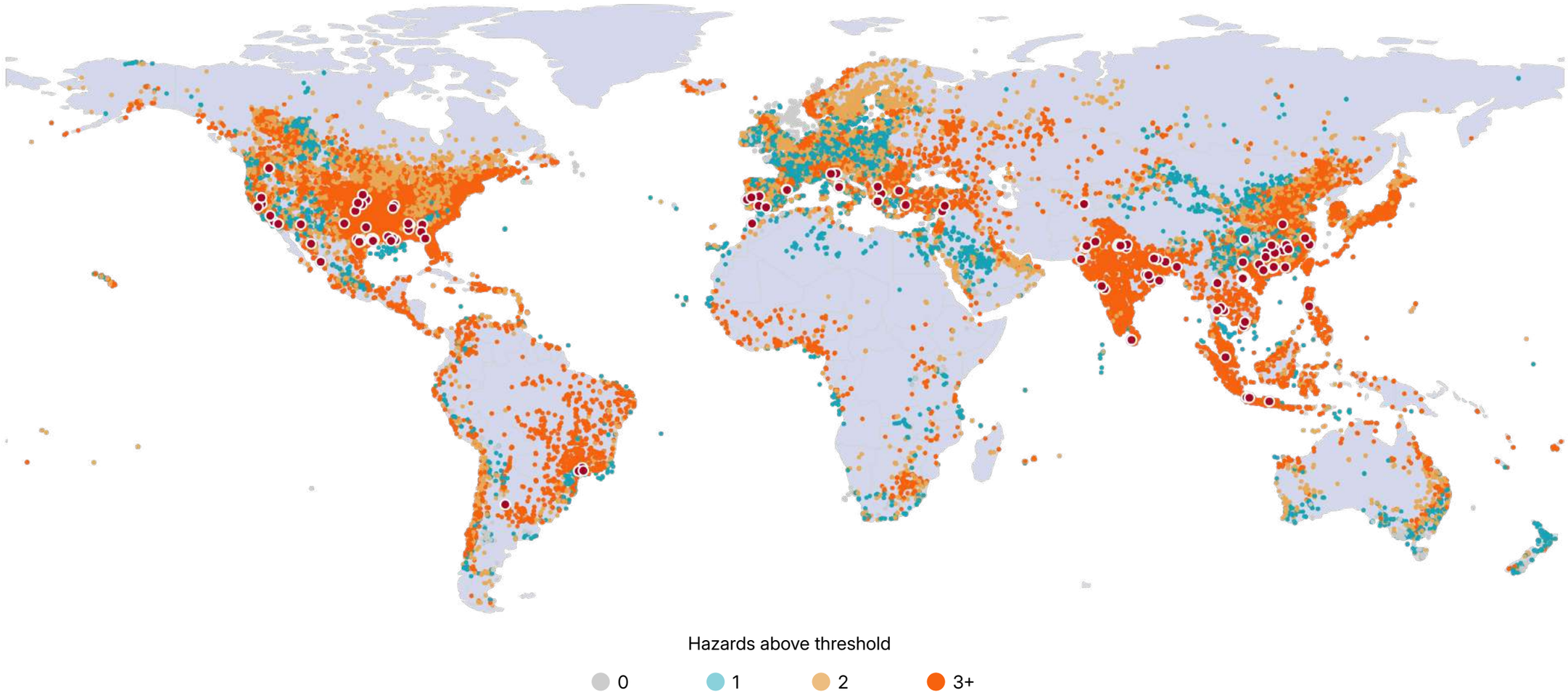




As highlighted above, hazard exposure must first be assessed at the level of individual locations. To form a company-level view, we aggregated asset-level exposures using weights based on each asset's fixed asset value and output value (see Appendix for details on the methodology).

Data as of Sept. 29, 2025. Box plots illustrate the range of hazard-intensity values across the combined asset-owner portfolio. Hazards are listed in approximate order of impact, with those higher on the chart generally considered more influential in determining losses than those lower down. This ordering is indicative only and does not represent a precise ranking of impact relevance for the portfolio. Source: MSCI Sustainability & Climate Research Services

Large share of companies face exposure to two or more hazards at same sites



Data as of Sept. 29, 2025. Asset locations can be significantly exposed to multiple hazards. The map shows all asset locations of the combined asset-owner portfolio. Asset locations are colored by the number of hazards with an intensity value of 8/10 or higher. Asset locations that have an intensity value of 8/10 or higher for water scarcity, heat waves and fluvial flood are highlighted as red dots. Source: MSCI Sustainability & Climate Research Services

Compounding hazards amplify exposure: Nearly all companies are exposed to multiple hazards

Recent seasons show more frequent **clustering of extreme weather** and more **compound events** (multiple hazards striking together or in sequence). Illustrative evidence of compounding from the Intergovernmental Panel on Climate Change Sixth Assessment Report and recent peer-reviewed studies points to rising co-occurrence rates and higher exposure where populations and assets are dense.[9]

The real world rarely delivers a single, isolated hazard. A **heat wave plus drought** can stress cooling systems and water supply at the same time.[10] A **tropical cyclone** arriving after **prolonged wet or dry spells** can worsen flooding or soil instability and lengthen downtime.[11]

Our portfolio finding:

Most companies face significant exposure to **combinations** of hazards.[12] Using local hazard intensities at the **asset level**, we observe that:

89% **of assets associated with 95% of the companies assessed** face two or more hazards at an intensity value of 8/10 or higher at their geolocations.

63% of assets associated with 86% of assessed companies sit in locations where **two or more hazards** even exceed **≥9/10** intensity.

Compound extremes can amplify disruption across power, water, transport and labor. The hazard-intensity thresholds can be treated as flags that show where potential risk concentrates. Impact then depends on vulnerability and readiness.

Hotspot regions

Certain regions function as hotspots where multiple hazards overlap (see chart on page 16 titled "Large share of companies face significant exposure to two or more hazards at same sites"). Compound extremes are especially concerning because their effects can interact nonlinearly. India, coastal China and the U.S. Gulf Coast are major centers for manufacturing, logistics or resource extraction. When these hubs are hit by multi-hazard events, disruption can propagate outward through supplier tiers and transport nodes.

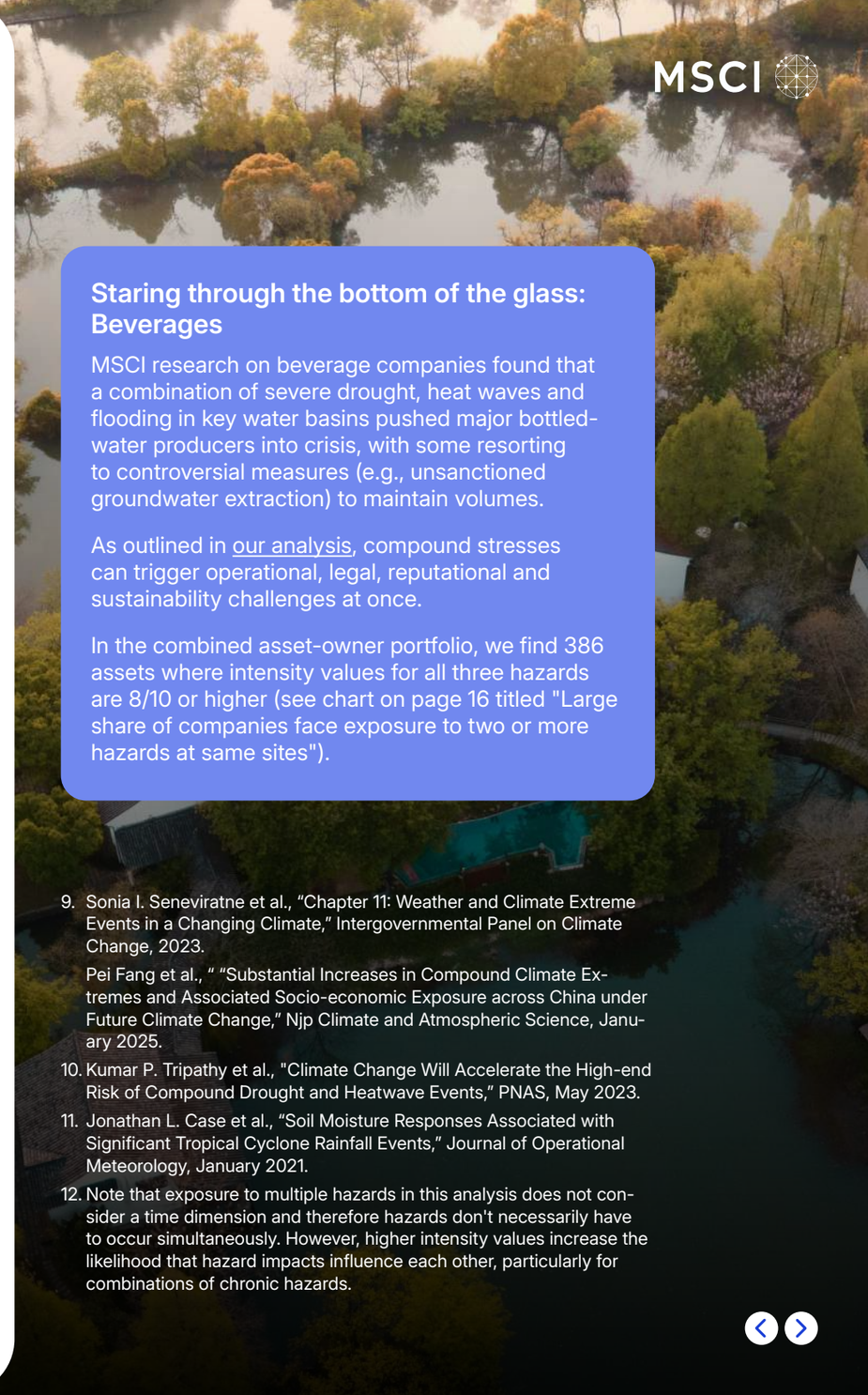
With exposure hotspots identified, the next section explores how exposures translate into financial impacts and insights about the materiality of physical risk today.

Real-world examples of recent compounding events:

2023: Canada wildfires
Persistent **heat** and widespread **drought** primed fuels, culminating in a record fire season and transboundary smoke episodes.

2023: Greece flooding
Record **rainfall** over Thessaly produced widespread **flooding** and cascading impacts in a landscape already stressed by a severe **wildfire** season.

2022: Pakistan flooding
Early-season extreme **heat** and **glacial melt** set preconditions that combined with an intensified **monsoon** to drive catastrophic flooding.



Staring through the bottom of the glass: Beverages

MSCI research on beverage companies found that a combination of severe drought, heat waves and flooding in key water basins pushed major bottled-water producers into crisis, with some resorting to controversial measures (e.g., unsanctioned groundwater extraction) to maintain volumes.

As outlined in our analysis, compound stresses can trigger operational, legal, reputational and sustainability challenges at once.

In the combined asset-owner portfolio, we find 386 assets where intensity values for all three hazards are 8/10 or higher (see chart on page 16 titled "Large share of companies face exposure to two or more hazards at same sites").

9. Sonia I. Seneviratne et al., "Chapter 11: Weather and Climate Extreme Events in a Changing Climate," Intergovernmental Panel on Climate Change, 2023.
   Pei Fang et al., " "Substantial Increases in Compound Climate Extremes and Associated Socio-economic Exposure across China under Future Climate Change," Njp Climate and Atmospheric Science, January 2025.
10. Kumar P. Tripathy et al., "Climate Change Will Accelerate the High-end Risk of Compound Drought and Heatwave Events," PNAS, May 2023.
11. Jonathan L. Case et al., "Soil Moisture Responses Associated with Significant Tropical Cyclone Rainfall Events," Journal of Operational Meteorology, January 2021.
12. Note that exposure to multiple hazards in this analysis does not consider a time dimension and therefore hazards don't necessarily have to occur simultaneously. However, higher intensity values increase the likelihood that hazard impacts influence each other, particularly for combinations of chronic hazards.

From exposure to loss

Exposure is not impact: From operational disruption to portfolio drawdowns

Hazard exposure is the starting point, not the end point. A high hazard-intensity value (e.g., ≥8/10) signals places where risks concentrate, but the same value for different hazards will not translate into the same financial outcome. A 9/10 for heat waves stresses workers, equipment and cooling capacity in very different ways than a 9/10 for coastal flooding. The realized loss depends not only on hazard intensity, but on vulnerability reflecting the types of assets, their criticality to operations and the resilience of supporting systems. Many investors limit their portfolio physical-risk assessment to measuring hazard exposure, using it mainly for reporting, screening or applying their own internal risk framework. Others go further to estimate financial impacts and assess the role of readiness and adaptation to reduce or manage these risks.

Exposure is not financial impact

A high-hazard exposure (e.g., expressed by a high intensity value) signals where a single hazard concentrates. Yet the same intensity value for different hazards will not equate to the same level of asset damage or business interruption because realized loss also depends on vulnerability and readiness.

MSCI's physical-risk framework

Vulnerability: What turns hazards into losses

Vulnerability magnifies or dampens the effect of exposure. A data center with redundant power and cooling may ride out a heat wave, while a single-sourced semiconductor plant may grind to a halt. Vulnerability is shaped by:

- **Asset type and design**. Older, undifferentiated facilities are more fragile.
- **Asset activity**. Labor-intensive activities are more vulnerable to heat stress, for example.
- **Operational concentration,** or reliance on a handful of mission-critical sites.
- **Supply-chain dependence**. Exposure cascades when logistics or suppliers are disrupted.
- **Readiness and maintenance.** Hardening, backup power and emergency planning reduce downtime.

In recent MSCI research, we proposed these six core components for a physical-risk framework, based on growing convergence across leading standards such as the EU taxonomy for sustainable activities, EU Corporate Sustainability Reporting Directive, International Sustainability Standards Board, Basel Committee on Banking Supervision, CDP (formerly the Carbon Disclosure Project) and Network for Greening the Financial System. Source: MSCI Sustainability & Climate Research Services

Drivers of impact: Business interruption vs. asset damage

Moving from hazard exposure to calculating financial impact requires differentiating between direct asset damage, the physical destruction or impairment of facilities and equipment and impacts related to business interruption, the indirect financial loss that arises when operations are temporarily halted or reduced, leading to lost production, rental income or service delivery.

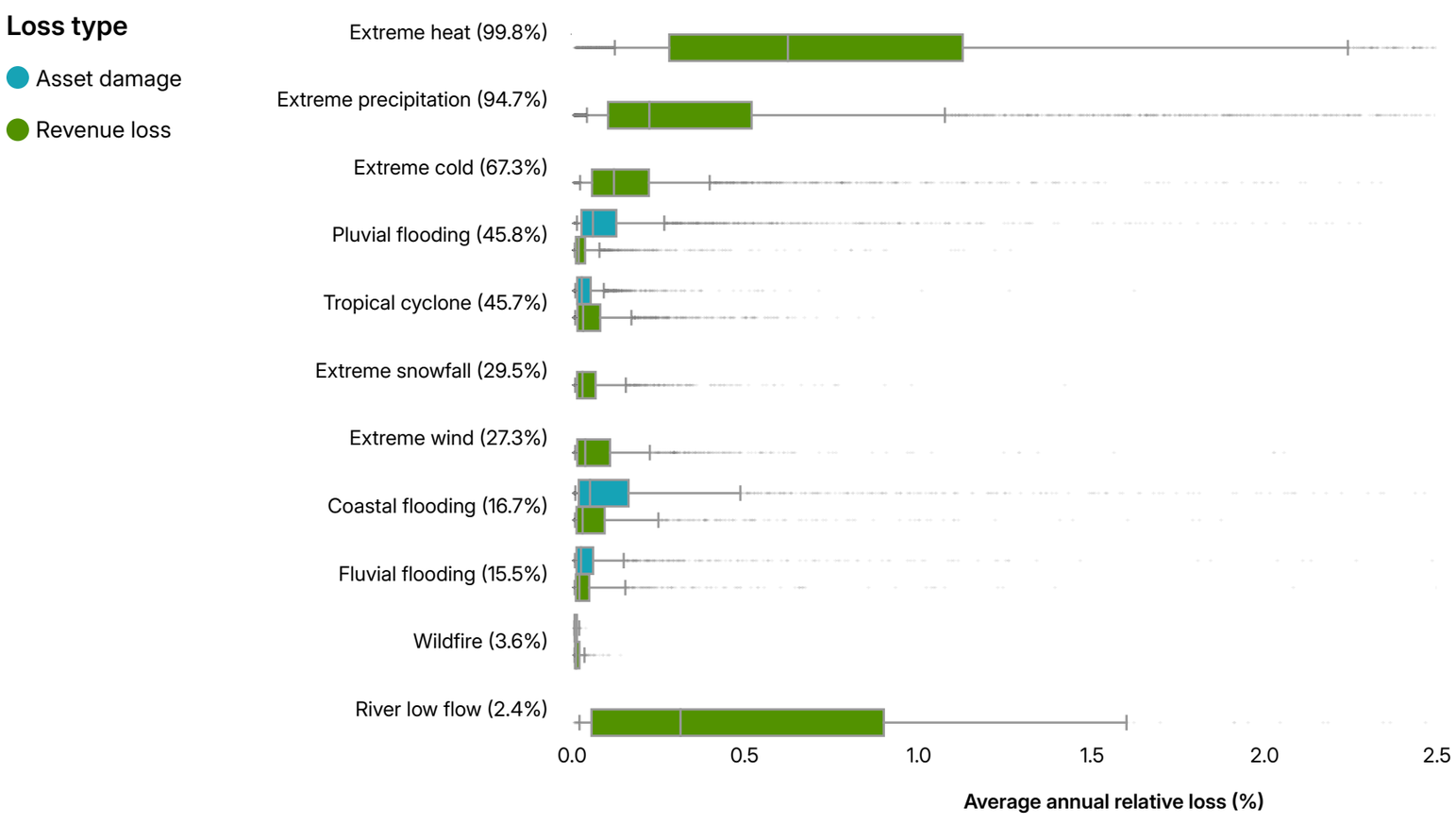
For many companies' management, the greater concern is that of day-to-day operations, so the impact of business interruption comes into focus. This is especially true for those with good insurance coverage or those who have not been impacted by acute physical risks in the recent past. While both are financially material, they differ in visibility and management attention. Asset damage from acute events such as hurricanes and floods often dominates headlines and boardroom discussions because the effects are immediate, tangible and easier to quantify. Business interruption, by contrast, unfolds more quietly through lost output, reduced labor productivity or prolonged recovery times. It may receive less focus from managers, especially in companies that have not recently faced a major event or assume insurance provides adequate protection.

Our results show that extreme heat and precipitation had the highest potential for impairment to revenue, resulting in average annual relative losses of at least 2.2% and 1.1%, respectively, for the 10% most impacted companies. River low flow is a noteworthy third and is particularly relevant for power-generation companies.

Compared with the cost of repairing physical asset damage from acute events, the revenue impact from lost output, delayed shipments and customer churn can be far greater. While coverage for business interruption is available from insurers, it is often bundled with other products and risks being poorly understood. The Swiss Re Institute's report on business interruption noted significant **protection gaps** where businesses underestimate their exposures or lack adequate coverage for complex supply-chain risks.[13]

13. Nikhilmon O U and Elena Pesce, "Quantifying Business Interruption: Risk Propagation in Complex Supply Chains," Swiss Re Institute, Oct. 29, 2024.

Relative average annual loss by hazard



Data as of Sept. 29, 2025. For most companies, business interruption often represents a larger dollar amount than asset damage. In this chart, we calculated impacts using MSCI's physical risk models applied to hazard exposure at the asset location. Relative business interruption losses are expressed as a share of annual revenue, while relative asset damage losses are expressed as a share of fixed asset value. Each boxplot displays the distribution of values: the interquartile range (IQR) from the 25th to 75th percentile, with the line inside representing the median, whiskers extending to the 1.5 x IQR, and dots indicating outliers. The percentage of companies in the combined asset-owner portfolio with relative losses greater than 0.01% is shown in brackets for each hazard. Source: MSCI Sustainability & Climate Research Services

Modeled portfolio results: Extreme heat leads business-interruption losses, while coastal and pluvial flooding drive asset damages

Extreme heat and heavy precipitation could impact over 94% of companies in the combined asset-owner portfolio, leading to substantial average annual losses from business interruptions today. Over the next year, across all hazards, our models estimate potential business-interruption losses could amount to roughly USD 1.07 trillion.

In contrast, coastal and pluvial flooding account for most of the modeled asset damage but affect a smaller portion of the portfolio of 17% and 46%, respectively. Combined across all hazards and companies, asset damage costs an estimated USD 76 billion.

Interruption risk scales with concentration at mission-critical sites and with supplier dependence, not just with facility replacement cost. The priority is to identify the assets that keep the business running and assess their readiness to recover.

With financial materiality identified, the question then moves to readiness. The next section shows where risk management and integration lag and why investment in resilience, not just insurance premiums, closes the protection gap.

MSCI

Rising awareness, lagging action

Awareness is rising

Recognition of the financial relevance of physical risk is growing. For example, a 2024 MSCI Institute survey found that most institutional investors expect escalating losses from extreme weather, broadly consistent with a 2.8°C warming trajectory. Yet translating awareness into concrete action remains difficult. A CPP Investments study similarly found that industry practice is still in early stages.[14] Investors face an overwhelming volume of data and a proliferation of methodologies, which often produce inconsistent results.[15] This complexity has slowed the integration of physical risk analytics into decision-making.

Exposure exceeds action

Across the combined asset-owner portfolio, exposure outpaces risk-management integration. In our combined asset-owner portfolio, **only about 16%** of the highest-exposed firms (intensity value of 9 or higher for any hazard) disclose integrating physical risk into enterprise risk management.[16] That is a small minority in the context of today's hazard levels. In other words, many of the most exposed companies lack the basic governance signal: assessment plus integration into risk-management processes.

Protection gap = adaptation investment opportunity

Why spend on resilience (not just insurance premiums)? Insurance transfers some loss. Resilience shrinks it. Evidence across studies shows strong benefit-to-cost ratios and faster recovery when preparedness is in place. For example, a global review paper found a 10-to-1 benefit over 10 years across 320 assessed adaptation investments.[17] Another study showed that pre-disaster spending in preparedness and adaptation reduces property losses nearly twice as effectively as post-disaster outlays.[18]

Insurance has been taken for granted in many developed nations, but recent experience has shown that this may not always be the case. Even when cover is available, it does not remove the loss. In 2024, natural catastrophes generated about USD 318 billion in economic losses. Insured losses from natural catastrophes were about USD 137 billion. The result was roughly USD 181 billion in uninsured loss, a "protection gap" of about 57%. That's the share of loss that ultimately falls on companies and investors unless it is reduced through adaptation.[19]

What does this mean for investors? Treat insurance as partial cushioning and part of the overall package, not a solution on its own. Corporates and investors may be wise to budget for residual loss unless companies can demonstrate credible site-level adaptation.

Putting it all together: **Location is a financial risk factor**. The concluding section recaps **what to do now** and why this is **investable, not theoretical**.

The protection gap: Insurance does not eliminate loss

"Total economic losses from natural catastrophes (high-impact acute hazards) amounted to USD 318 billion in 2024, of which 57% were uninsured. That left a still large global protection gap of USD 181 billion.

In recent years, the pattern has been that so-called 'secondary perils,' in particular severe convective storms (SCS), have contributed more to annual insured losses than 'primary perils.' However, primary perils (such as tropical cyclones and earthquakes) still hold the largest loss potential.

By a large margin, the U.S. continues to be where most loss events of USD 1 billion and above occur. The majority of these events are due to SCS, with the U.S. as the area where this risk is highest globally. Events like the floods in Europe, the United Arab Emirates and Brazil in 2024 and the Hawaii wildfires in 2023 show that loss severity is rising all over the world and across all perils, including in areas not traditionally thought of as natural catastrophe 'hotspots'."

Source: Swiss Re Institute, sigma No 1/2025 report

14. "Investing in a changing world: How public funds are addressing climate-related physical risks," CPP Investments, June 2025; "2023 Report on Sustainable Investing," CPP Investments, 2023.
15. "2024 Climate Risk Landscape Report," United Nations Environment Programme Finance Initiative, April 2024.
16. Data as of September 2025. MSCI Sustainability & Climate Research Services evaluates whether companies include climate-related risks (such as physical risks from climate change or transition risks from moving to a low-carbon economy) in its overall risk-management process.
17. Carter Brandon et al., "Strengthening the Investment Case for Climate Adaptation: A Triple Dividend Approach," World Resources Institute, May 2025.
18. Meri Davlasheridze et al., "The Effects of Adaptation Measures on Hurricane Induced Property Losses: Which FEMA Investments Have the Highest Return?" Journal of Environmental Economics and Management 81, 93-114, 2017.
19. "sigma No 1/2025 report: Natural catastrophes: insured losses on trend to USD 145 billion in 2025," Swiss Re Institute, April 29, 2025.

Turning risks into opportunities

From hidden to managed

Physical risk has always been embedded in portfolios. What has changed is our ability to measure and quantify it. Today, around a quarter of equity value sits in high-hazard zones (≥9/10). Nearly two-thirds of holdings face significant exposure to multiple hazards. Yet only 16% of the most exposed companies disclose integration of physical risk into risk management. Country and sector labels routinely understate exposures, while operations, outputs and supply chains span the globe.

What this means for asset owners

For asset owners, the losses that matter are business interruptions, not repair bills. Lost output, delayed shipments, premium logistics and churn can outweigh facility damage. Compounding hazards amplify those interruptions: Nearly every company assessed faces two or more severe hazards at the same locations.

Markets react when risk materializes. Our event analysis of recent hurricane seasons found that companies with assets in storm paths began to underperform about five trading days before landfall and continued to fall for about 30 business days after, as damage and disruption became evident. This suggests that markets reprice physical risk once it becomes visible, rather than fully embedding it in valuation ahead of time.

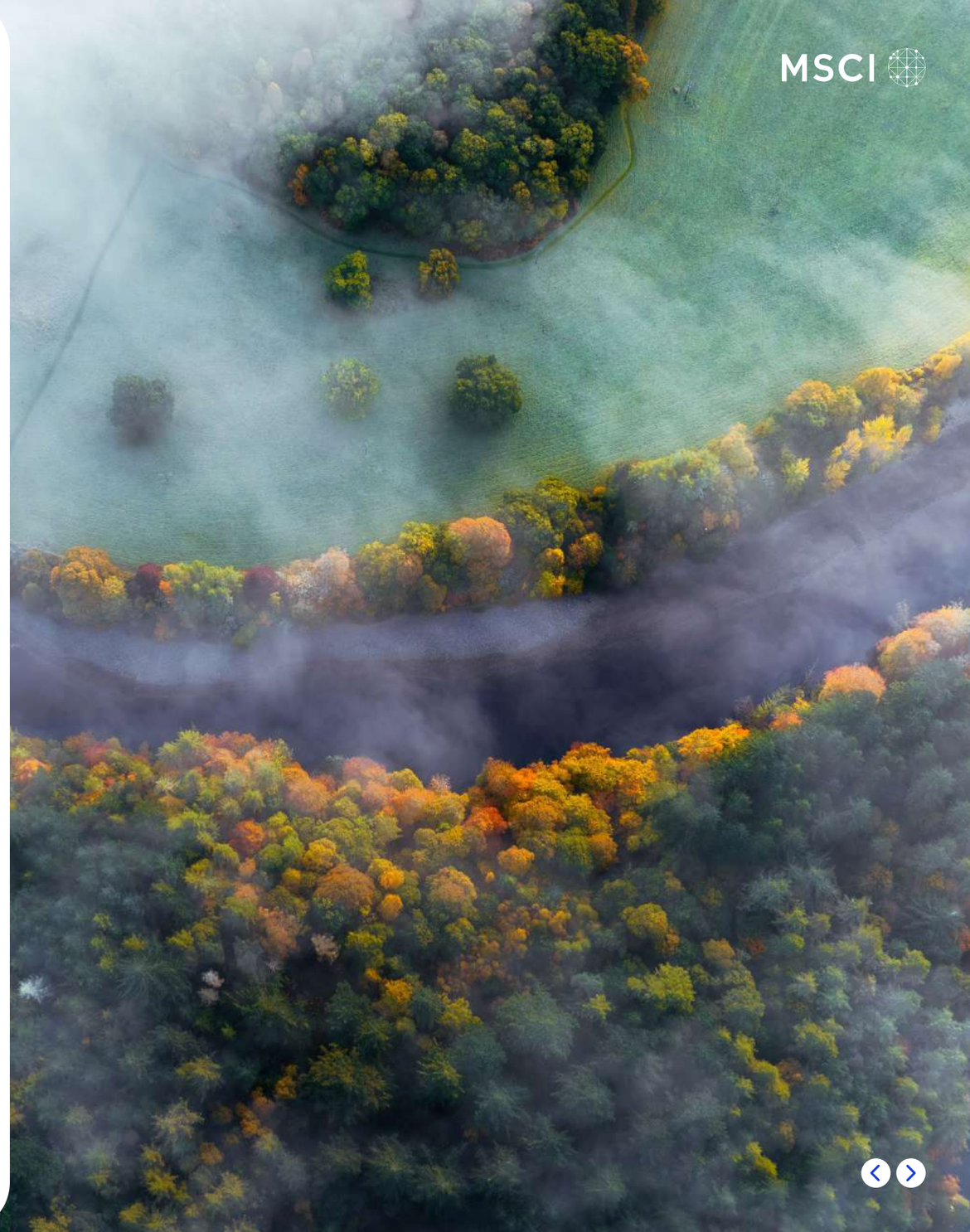
The implication is clear: Physical risk is financially material today. Portfolios that appear domestically focused are, in practice, globally exposed to overlapping hazards. Insurance provides only partial cushioning; tightening markets and sub-limits leave residual losses with asset owners unless issuers adapt.

Why it matters

Physical risk has moved from theoretical to tangible, affecting valuations, volatility and earnings across markets. For asset owners, understanding where risk concentrates, how vulnerable their holdings are, the potential financial impact and how well companies are prepared is essential. Integrating location intelligence and readiness assessments into investment decisions can uncover hidden exposures, close adaptation gaps and position investors to manage downside risk while capturing opportunities in resilience-driven growth.

What asset owners can do now

By integrating geospatial intelligence, engaging with companies on resilience and closing the adaptation gap, asset owners can shift from being exposed to being prepared, turning unseen risks into opportunities for stronger, more resilient portfolios.



Execution: Integrate location into decision-making and risk management

We have established the scale of physical risk, opportunities and limits of adaptation and reality that insurance cannot fully absorb losses.

Now, execution

Map and monitor exposure and financial materiality

Link holdings to site-level locations and track hazard exposures. By using detail-oriented physical-risk exposure and impact models, investors can identify the companies and locations to focus on first. Surface hotspots and track hazards at critical sites.

Assess business interruption, asset damage and readiness

Focus first on the parts of the portfolio with hotspots of high exposure on mission-critical sites where downtime drives output loss, not just replacement cost. Prioritize companies with compounding hazards and prepare a plan to act.

Act now

Incorporate exposure thresholds into portfolio risk-oversight frameworks to strengthen internal awareness of concentration risk. Reevaluate direct holdings where adaptation or disclosure materially lags exposure. Engage issuers and external managers on site-level resilience and risk transfer.

Why this is investable, not theoretical

The analysis of 18 global asset-owner portfolios shows that location drives volatility and loss. Exposure at today's hazard levels translates into financial materiality. But adaptation is a differentiator; issuers with stronger adaptation and risk-management practices tend to experience smaller drawdowns and faster stabilization after climate hazards, while less prepared peers suffer deeper and more persistent value impacts.[21] For asset owners, integrating physical-risk analytics into portfolio management, risk budgeting and engagement is both protection against drawdowns and an investment opportunity to lead on resilience. The age of hidden physical risk is over. Asset owners who act now can reduce losses, close adaptation gaps and capture opportunities in resilience-driven investment. Those who wait risk being left exposed.

21. Artio Grover and Matthew E. Kahn, "Firm Adaptation to Climate Change," National Bureau of Economic Research, August 2024; "Resilience or rebuild? The Costs and Benefits of Climate Adaptation Measures for Flood," Swiss Re Institute, November 2024.

Glossary of technical terms

Abnormal returns — The sum of differences between actual stock returns and expected returns over a period, calculated using factor models that control for market, industry and other influences to isolate the specific impact of an event like a hurricane.

Adaptation gap — The difference between current adaptation efforts and the level needed to adequately reduce climate-risk exposure.

Asset damage — Direct physical damage to facilities and equipment requiring repair or replacement, as distinct from business-interruption losses.

Business interruption — Financial impact from disrupted operations or loss of productivity, causing lost revenue opportunities. Often exceeds direct asset damage costs.

Combined ratio — An insurance metric showing profitability. Calculated as: (claims paid + operating expenses) ÷ premiums collected. A ratio above 100% means the insurer is losing money on underwriting. Example: 110% combined ratio = 10% loss.

Compound extremes/compound hazards — Multiple climate hazards occurring simultaneously or in close sequence at the same location (e.g., drought + heat wave + flooding).

Deductibles and sub-limits — Insurance-policy terms: Deductibles (or sometimes "excess" in retail contexts) are amounts paid before coverage begins; sub-limits cap payouts for specific types of losses within the overall policy limit.

Domicile/country of domicile — The country where a company is legally registered or headquartered, which may differ significantly from where it actually operates.

Engagement (investment context) — Active dialogue between investors and companies to influence corporate behavior regarding running the business, including the management of physical climate risks.

Enterprise risk management — Company-wide, holistic framework for identifying, assessing and managing all risks to business objectives.

Factor model — Statistical method isolating specific variables' impact on stock returns while controlling for other influences like market movements or industry trends.

Fair access to insurance requirements (FAIR) plan — U.S. state-sponsored insurance programs serving as insurers of last resort in high-risk areas.

Global Industry Classification Standard (GICS®)™ sectors — GICS is the global industry classification standard jointly developed by MSCI and S&P Dow Jones Indices. It organizes companies into 11 major sectors (energy, materials, industrials, etc.). Used for consistent industry comparisons across portfolios.

Hazard-intensity value (0–10) — MSCI's relative scaling of physical-hazard severity at specific locations, with 8+ indicating significant exposure and 9+ extreme exposure. See Appendix for more details.

Listed equity — Company shares publicly traded on stock exchanges, as opposed to private equity or other asset classes.

MSCI All Country World Index (ACWI) — A global equity benchmark covering large- and mid-cap stocks across developed and emerging markets.

Portfolio weight —The percentage of a total portfolio's value represented by a particular holding or group of holdings.

Principles for Responsible Investment — UN-supported network of investors committed to integrating sustainability factors into investment decisions.

Protection gap — The difference between total economic losses and insured losses from disasters. For example, a USD 100 billion disaster with USD 40 billion insured has a 60% protection gap.

Residual loss — Financial losses remaining after insurance payouts, representing the uninsured portion of total economic losses.

Secondary perils vs. primary perils — Insurance classifications: Primary perils include major hurricanes and earthquakes; secondary perils include severe convective storms, floods and wildfires, often more frequent but individually less severe. The classification is largely based on historic norms, and some secondary perils now cause more economic damage than primary perils.

Task Force on Climate-related Financial Disclosures — Framework for companies to disclose climate-related risks and opportunities.

Underwriting/re-underwriting — The process of evaluating and pricing investment or insurance risk; re-underwriting involves reassessing existing positions based on new information.

Weather-related terminology:

Coastal flooding — Inundation of land areas along the coast caused by storm surge, high tides or sea-level rise.

Convective storms — Localized storms producing damaging winds, large hail and tornadoes, formed by strong upward air movement. Includes thunderstorms and supercells.

Drought — Prolonged period of abnormally low rainfall leading to water shortage.

Extreme cold — Periods of unusually low temperatures that can damage infrastructure, disrupt operations and stress energy systems.

Fluvial flooding/river flooding — Flooding caused by rivers or streams overflowing their banks due to excessive rainfall, snowmelt or dam releases.

Heat wave — Extended period of abnormally high temperatures relative to the expected conditions for a region and time of year.

River low flow — Abnormally reduced water levels in rivers affecting hydropower generation and thermal power plants' cooling capacity.

Storm surge — Abnormal rise in seawater level during a storm, caused by wind pushing water onshore.

Tropical cyclone — Rotating storm system with organized thunderstorms, forming over tropical waters. Includes hurricanes (Atlantic/Eastern Pacific) and typhoons (Western Pacific).

Water scarcity — Chronic lack of sufficient available water resources to meet demand.

Wildfire — Uncontrolled fire in vegetation, including forest fires and bushfires.

Appendix:

How hazard-intensity values are calculated

Hazard-intensity values express the local severity or frequency of a hazard on a standardized, unitless scale from 0 to 10. Raw site-level metrics (for example, heat-wave duration or annual hail-day counts) are converted to this scale using methods suited to each hazard, such as logarithmic, percentile-based or composite approaches. A value of 0 means the hazard does not apply at that location. A value of 1 indicates no or very low exposure. A value near 10 indicates very high local intensity.

Company-level hazard-intensity values are computed as the weighted mean of asset-level hazard-intensity values (IV_{asset}) using the sum of the asset-level fixed asset value (A_{asset}) and output value (O_{asset}) as weight, to reflect the asset's relative importance to the company value and operations:

$$\textbf{Company Hazard Intensity Value} = \frac{\sum_{asset} IV_{asset} * (A_{asset} + O_{asset})}{\sum_{asset} (A_{asset} + O_{asset})}$$

Though not a direct measure of expected loss, these values offer a harmonized foundation for interpreting hazard levels, guiding exposure analysis and supporting consistent decision-making across a wide spectrum of natural hazards. Intensity values reflect present-day climate conditions and do not consider future climate scenarios.

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