WHITE PAPER

How Banks Can Transform Physical Climate Risk into an Opportunity

July 2024
By Andrea Castoldi, Giovanni Lucini, Bruno Micale, Amine Benayad, and Matteo Coppola

Acting Now on Physical Risk Is an Imperative for Banks

As climate-driven natural disasters increasingly become the new normal across regions, it is imperative for banks to understand their current and future portfolio exposures to climate-related physical risks. These risks should be quantified, integrated into clients' overall risk assessments, and considered in supporting clients' financing needs for adaptation and resilience measures.

Physical Climate Events Are Currently Causing Severe Damage

Companies are facing escalating climate risks because increasingly, climate perils are becoming actual events. For example, in 2022, 2.2 million hectares of farmland in China were severely impacted by drought.[1] In February 2024, the average temperature in the Southern Cone of Africa was 4°C to 5°C above the seasonal average, obliging some governmental administrations to temporarily shut schools and cease other productive activities.[2] These events join a series of recent climate disasters, including the wildfires in the US and Chile (the deadliest worldwide in 15 years),[3] historic floods in Afghanistan and Pakistan, typhoons in the Philippines, and heat waves in India and Japan. Companies' cost for such events is also escalating. In 2023, floods disrupted Italy's fruit harvest, resulting in losses of about $9.5 billion, of which roughly only $0.5 billion was covered by insurance.[4]

Physical Climate Risks Are Expected to Intensify

Current trends suggest that the world is increasingly unlikely to achieve the goal of limiting the global temperature rise to 1.5°C. In fact, according to the Intergovernmental Panel on Climate Change (IPCC), the likely temperature rise if current climate change mitigation policies are not amended to more compelling ones is an increase of 2.1°C to 3.6°C by 2050. Such a rise will cause more severe physical-risk events, which, in turn, are expected to trigger not only significant economic impacts on the most vulnerable regions and sectors but also dire social outcomes (for example, migrations and political instability) and environmental consequences (such as local ecosystems being destroyed or coming under heavy stress).

For instance, in the Southern Cone of Africa, if we continue along the current trajectory, the average temperature is likely to reach 4°C above the seasonal average by the year 2100 (compared with 2000). Such a change is expected to increase ocean levels by 100 centimeters, drought frequency by nine times in dry regions, and the intensity of extreme weather events by 30%. While these impacts would be less severe in an ideal 1.5°C scenario by 2100 (compared with 2000), we can still expect ocean levels to increase by more than 50 centimeters, droughts to be four times more frequent, and extreme weather events to intensify by more than 11%.[5]

1. Reuters, "China's Scorching Southwest Extends Power Curbs as Drought, Heatwave Continues," August 2022.
2. Economist, "Recent Heatwaves Are a Harbinger of Africa's Future," April 2024.
3. Teletrece, "Chile Records Wildfire with Highest Number of Deaths Worldwide in the Last 15 Years," February 2024.
4. Italian government estimates.
5. Earth System Dynamics, Carl-Friedrich Schleussner, et al., "Differential Climate Impacts for Policy-Relevant Limits to Global Warming: The Case of 1.5°C and 2°C."

Physical Climate Risks Are No Longer Isolated to a Few Regions

Climate change impacts disproportionately affect specific regions and nations. Geographical factors naturally render certain areas, such as coastal regions, more susceptible to particular climate hazards. For instance, North America faces heightened vulnerability to flooding and storms, resulting in increased risks for cities, settlements, and infrastructure.[6] Africa, Asia, and small islands are expected to suffer the most in general from climate hazards, with specific impacts on agriculture, fisheries, malnutrition, floods, and infrastructures, according to IPCC.

However, climate hazards are also increasingly affecting regions that were once considered less exposed, posing challenges to infrastructure that is ill-prepared for extreme events. In 2021, Germany faced the most expensive natural disaster on the country's record, with flash floods causing damages totaling $40 billion. This amount significantly surpassed the coverage provided by insurers, underscoring the unexpected magnitude of the event in a country typically perceived as having a low risk profile.

Additionally, excessive exposure to physical risk can also amplify preexisting regional vulnerabilities that are caused by a lack of financial resources to fund adaptation and resilience measures. This exposure implies that certain regions are more economically exposed to physical risk. For instance, in South Asia, approximately 12% of the combined GDP would be at risk under Representative Concentration Pathway (RCP) 4.5 in 2050.[7] Overall, lower-income countries face greater exposure than higher-income ones, with about 7% of combined GDP estimated to be at risk in 2050 for the former and only 2% for the latter. For example, the 2022 floods that submerged one-third of Pakistan caused $14.9 billion in damages and $15.2 billion in economic losses, equivalent to roughly 4% of Pakistan's GDP in 2022.

Banks Should Develop a Robust Science-Based Approach for Quantifying Physical Risk

Banks' portfolios are already highly exposed to physical climate risks. According to recent estimates, 80% of European bank loan portfolios are exposed to present and estimated physical-risk drivers (representing $2.9 trillion).[8] These risks include those anticipated up to 2040 from flood, water stress, heat stress, and wildfires.

Regulators are increasingly emphasizing the necessity of measuring the materiality of physical hazards and the consequent business implications. The European Central Bank, for example, is already requiring banks to measure the impact of physical hazards alongside that of transition hazards, following the concept of climate and environmental risks considered as a whole. It also requires that banks derive implications from such impact measurement, both regarding integration into risk management frameworks and into broader business strategy.[9] Inaction is expected to have severe consequences for banks, regardless of which climate scenario materializes in the future.

Banks assess physical risk by examining the impact of climate-related hazards on clients on the basis of exposure and vulnerability. This is critical to gain insights into the potential portfolio value at risk. For instance, BCG's evidence suggests that, on average, in higher-risk sectors (for example, agriculture, infrastructure, and power generation), up to about 10% of financed counterparties' EBITDA could be lost by 2025 as a result of the impacts of physical risk. Therefore, understanding climate change's influence on hazard frequency and intensity is crucial.

6. Intergovernmental Panel on Climate Change, *Climate Change 2022: Impacts, Adaptation and Vulnerability*, 2022.
7. S&P, *Weather Warning: Assessing Countries' Vulnerability to Economic Losses from Physical Climate Risks*, April 2022.
8. European Central Bank, *2022 Climate Risk Stress Test,* July 2022; ECB, *Financial Stability Review*, May 2021.
9. European Central Bank, *Guide on Climate-Related and Environmental Risks*, November 2020.

Banks have only recently begun to incorporate physical-risk considerations into their processes. This step has been driven by limited data availability and still-evolving methodologies that are critical to conduct physical-risk assessments and quantification exercises.

So far, banks have mainly deployed stress-testing frameworks in response to increasingly stringent regulations that require the consideration of physical risks in overall risk assessments. Currently, even leading banks on the topic are not yet fully mature in dealing with physical risks. They often use statistical approaches focused on sectors rather than on clients, resulting in limited granularity on exposure variability among sectors' players. However, a more granular approach is crucial because of the location- and asset-based nature of physical risks. Without this type of assessment, it is challenging to produce tangible client-specific results that could support overall risk and business assessments.

Nevertheless, risks are often assessed at the portfolio level using commonly observed practices, including:

- Different methodological approaches for corporate lending and mortgages
- An occasional assessment of companies' vulnerability through questionnaires
- An initial assessment perimeter consisting of a sample of locations that is later expanded to include more assets
- The exploration of multiple IPCC scenarios, with the RPC 8.5 (most pessimistic) often included
- A quantification of financial impact achieved through an evolving-risk score view that's still under development

Despite the challenges, given the materiality of potential physical-risk impacts, banks should begin to quantify the effects on clients' financials and credit worthiness, particularly for the most exposed regions and sectors within their portfolios. Moreover, the expected increasing relevance of physical risks will trigger the need to finance and support companies in their adaptation and resilience measures, thus generating a business opportunity in the short and medium terms.

The Four Building Blocks of Robust Physical-Risk Quantification

There are multiple and progressive methodological approaches to quantifying physical risk. However, regardless of the approach chosen, there are four key building blocks that banks should always consider: exposure, hazards, vulnerability, and economic impact. (See Exhibit 1.)

Exposure

Exposure is the degree to which a portfolio, an asset, or an operation is potentially affected by significant climate variations. To determine the level of a portfolio's exposure to climate risks, banks must first identify clients' asset locations and geographic coordinates for which climate hazard data needs to be collected.

Generally, there are five key steps to determine exposure:

1. Segment the selected portfolio across categories (for example, client sectors).

2. Map clients' assets within each of these categories using geographic coordinates.

3. Select clients' locations to be analyzed during the assessment.

4. Acquire hazard data for input.

5. Translate hazard data into comparable scores.

Exhibit 1 - A physical-risk assessment measures the impact of climate hazards on clients by evaluating their exposure and vulnerability to climate events

Sensitivity

Hazards × **Exposure** × **Vulnerability** > **Economic impact**

Hazards

Probabilistic modeling of climate-related hazards, including **extreme** events (such as heat waves and floods) **and chronic** changes (such as the sea level rising) based on temperature scenarios and time horizons

Exposure

Exposure of client operations (through **physical assets, people, suppliers, infrastructure,** and other economic assets) at a specific location **that is affected** by climate hazards

Vulnerability

Predisposition of client business and assets **to be adversely affected** by the hazard to which they are exposed (for example, on the basis of input dependency and structural features)

Economic impact

- Risk **of impact on asset value and financial resilience** of financed clients
- **Materializes for banks via credit risk,** impacting both **client cash flows,** for debt repayment, **and collateral values**
- Generates **opportunities for** adaptation and resilience **financing**

Sensitivity can be quantified by analyzing the transmission channels that make the risk tangible for the client in terms of economic impact, including the value of assets and guarantees, impact on revenues, and capex needed for mitigation

Sources: Intergovernmental Panel on Climate Change; BCG analysis.

While the first three steps may be accomplished with relatively little effort, the acquisition of hazard data for input into the assessment remains a significant challenge for most banks looking to quantify climate risk. This is largely because the availability and comparability of data sources is limited in a still-fragmented provider landscape. As such, when acquiring hazard data for input, banks should leverage multiple internal and external data sources, including public and private databases specific to each sector being considered during the assessment. They may also consider reaching out to their clients for further insights on the specific climate exposure of their assets and operations.

In general, when determining exposure, banks should leverage a progressive data-augmentation strategy to ensure the implementation of a flexible approach to climate risk quantification that may expand in scope and precision if and when additional hazard data becomes available.

Hazards

Hazards, or risk drivers, indicate the potential for climate-related physical risks or trends to occur—ones that may cause not only damage to an asset or operation but also their loss. Physical risks may be categorized as acute (for example, event driven) or chronic (for example, longer-term shifts in climate patterns). (See Exhibit 2.)

Hazard metrics must be an appropriate proxy for the risk considered (such as water depth for a flood risk) and the need to be comparable across risks.

As previously mentioned, hazard data provisioning is the cornerstone of any physical-risk quantification exercise. It is necessary to identify what risk drivers should be included in the physical-risk quantification exercise to be undertaken. This is because sector-specific data sets will typically include information on relevant hazards only, thus supporting banks in the prioritization of climate hazards to be analyzed.

Banks will also need to decide on three critical parameters that define the perimeter for hazard analysis:

1. **Time Range.** How far into the future should the physical-risk impacts be modeled and quantified? What year should be considered as the assessment baseline?

2. **Climate Scenarios.** Which potential future scenarios should be modeled? Which climate scenario provider should be used to source scenario data?

3. **Hazard Magnitude.** What return period (for example, probability of occurrence) should be selected for acute hazards? What level of magnitude for a chronic hazard should be modeled? (For example, how far from the median should the impact model be?)

Exhibit 2 - Physical climate risks will be acute and chronic

ACUTE	How will it impact us?	CHRONIC
Flooding	Asset damage	Sea level rising
Heat waves	Employee health and safety	Increasing temperatures
Water stress	Water availability	Long-term drought
Drought and disease	Crop yield and price	Land infertility

Source: BCG analysis.

Time Range. The time range selected for the assessment will shape the level of potential impact considered by the quantification exercise. Multiple time horizons may be chosen to test the impact of physical risks in the short, medium, and long terms. Generally, this selection will be impacted by the use case of the assessment output. For example, from a risk perspective, the longest financing a bank will offer its clients will not exceed 15 to 20 years, and as such, the most relevant time horizons for the assessment would be 2030 and 2040. However, from a disclosure perspective, banks may want to align with common market disclosure practices. Therefore, they may choose to use 2030 and 2050 as time horizons for the quantification exercise.

Climate Scenarios. Climate scenarios enable users to compare different possible versions of the future and the levers and actions that produce them. Differences among scenarios are particularly driven by assumptions about the overall level of climate policy action and technological and socioeconomic development (for example, energy demand). These assumptions then determine the level of temperature rise and, therefore, of the frequency and magnitude of climate events that could be expected by 2100. Thus, the choice of climate scenario will also shape the potential impact profile of physical risks on banks' portfolios and counterparties.

Market players typically leverage two externally recognized providers to lend credibility to their physical-risk assessments: IPCC and NGFS (Network for Greening the Financial System). (See Exhibit 3.) However, the choice between the two will ultimately depend on the type of hazard data, regional coverage, and time horizons required for the physical-risk quantification exercise.

Hazard Magnitude. The probability of occurrence for acute physical risks generally determines the expected magnitude of the acute physical event modeled. For example, the impact of a flood event with a return period of 100 years will be expected to have more-severe consequences than the same event with a 50-year return period, but the event will be expected to have less-severe impacts than a flood with a 200-year return period.

Exhibit 3 - The mainstream climate scenarios of IPCC and NGFS fall into four categories across the temperature spectrum

Category	Temperature	IPCC AR6[1]	NGFS
Net zero 2050 (Paris goal)	–1.5°C	SSP 1–1.9	NZ 2050 Low demand
Net zero 2070	–2°C	SSP 1–2.6	Delayed transition[2] Below 2°C
Current trend	<3°C	SSP 2–4.5	NDCs
Business as usual	+3°C	SSP 3–7.0 SSP 5–8.5	Current policies
Too little too late	2.3°C		Fragmented world

Sources: IPCC AR6, Working Group I, Chapter 1; International Energy Agency; NGFS; Bank of England; BCG analysis.

Note: SSP = shared socioeconomic pathways; NZ = net zero; NDC = nationally determined contribution.

[1]Intergovernmental Panel on Climate Change (IPCC), *Sixth Assessment Report* (AR6): Working Group I prioritized these scenarios since they are the focus of climate research (e.g., Coupled Model Intercomparison Project 6, or CMIP6), but the group also considered four more scenarios to fill gaps (e.g., SSP 4–3.4 at <2.5°C and SSP 4–6.0 at <3.5°C).

[2]Delayed scenarios (e.g., policy action delayed to 2030).

However, the magnitude of chronic physical risks will need to be proxied differently given the longer-term nature of their effects. For example, banks may choose to model chronic hazards with an expected impact above a certain level of the median effects of similar climate events to prepare for a less optimistic future. However, regardless of how it is determined, the choice of hazard magnitude to be considered in the physical-risk assessment will also shape the results of the quantification exercise.

When the time range, climate scenarios, and hazard magnitude are defined, banks will need to select a representative hazard metric for each hazard identified. (See Exhibit 4.) Robust hazard metrics will be characterized by the following:

- Degree of market adoption of the metric as a proxy for the selected hazard
- Relevance to the regional perimeter of the assessment under expert criteria (for example, it is unlikely for temperatures to reach more than 50°C in Europe; hence, metrics such as the number of days above 50°C may not be relevant as proxies for extreme heat)
- Relevance to the specific hazard selected (for example, marine flood depth may not be a relevant proxy metric for riverine flooding)

Vulnerability

Vulnerability refers to the propensity of assets, operations, or clients to be adversely affected by the physical hazards to which they are exposed. As previously discussed, the vulnerability to physical risks can vary greatly depending on locations, though it can also be impacted by the physical and financial mitigations in place at the asset level.

Exhibit 4 - Examples of hazard metrics and selection criteria

Hazard metrics

		Storms						
Hazard	Flood	Wind speed	Precipitation	Heat	Frost	Water scarcity (including droughts)	Wildfire	Sea level rise
Hazard metric	Mean depth of the water (meters) at the 100-year return period	★ Mean maximum is one minute of wind speed (km/h) in 100-year return period Annual number of days with favorable conditions for severe thunderstorm formation	★ Mean maximum is daily total precipitation (mm) at 100-year return period	★ Mean annual number of days with temperature >35°C Mean annual number of days with WBGT[1] >32°C	★ Mean annual number of days with temperature <–10°C	★ Mean annual local water stress[2] Mean annual number of months with three-month SPEI[3] <–2	★ Mean number of wildfires expected per grid cell in 1,000 years	★ Annual mean flooding depth (meters) in coastal areas due to high tides

Selection criteria

Globally recognized KPIs
Most widely recognized and used hazard metrics to be selected to represent each hazard

KPIs representative of the hazard
Depending on the type of hazard, banks need to select the KPI that can best represent the specific hazard

★ Selected for hazard assessment (illustrative)

Sources: Jupiter; BCG analysis.

[1]Wet bulb global temperature.

[2]Ratio of human water demand to water supply from the local watershed.

[3]Standardized Precipitation Evapotranspiration Index.

Assessing vulnerability involves a three-step process:

1. Define key sectoral archetypes.

2. Group physical hazards to be assessed.

3. Identify archetype vulnerabilities by physical hazard.

The first step toward assessing vulnerability is to define key sectoral asset archetypes. An asset archetype represents a group of assets that share key characteristics prone to be affected similarly by climate hazards. Therefore, banks will first need to list all types of assets to be covered by the assessment, taking into account their location and the area's topography. Then, for each type of asset, they will need to identify the key attributes and characteristics most likely to be affected by the hazards considered in the assessment. Finally, banks will need to categorize assets into archetypes by identifying common vulnerability attributes. Given our experience, a minimum level of different asset archetypes to be considered is 50 to 60.

The number of asset archetypes identified will depend on the sectors and subsectors, as well as the desired level of analytical granularity and precision required by the banks. For instance, the asset archetypes of a counterparty operating in the power generation market may be first grouped by the type of energy generated (such as gas, hydro, or solar). (See Exhibit 5.) Then, once the key characteristics of each type of energy generation asset are identified, assets may be further aggregated into new categories for the purposes of the physical-risk quantification exercise. For example, gas and coal plants both harness heat to generate steam, and they present similar vulnerabilities as large industrial buildings. Therefore, they could be grouped under a thermal archetype.

Exhibit 5 - The definition of asset archetypes for the power generation sector—five for power plants and one for headquarters

Generation technology	**Gas**	**Coal**	**Oil**	**Geo-thermal**	**Biomass**	**Nuclear**	**Hydro**	**Wind**	**Solar photovoltaic**	**Head-quarters**
Key characteristics	**Generation technique implies** harnessing heat energy from various sources to generate steam, which then needs to be cooled **Cooling systems** are dependent on **water availability** and **air and water temperature** Power plants have the **same vulnerabilities** (for example, flooding, storms, and wildfires) **as large industrial buildings**					Similar to geothermal **Cooling system for reactors cannot be shut down**	Highly dependent on **water supply**	Highly dependent on wind Blade, rotor, and structure are affected by **wind, storms, and icing**	Highly affected by **rain, snow, and dust** blocking sun rays Surface vulnerable to **hailstorms**	Same vulnerability as office buildings
Asset archetypes	**Thermal**					**Nuclear**	**Hydraulic**	**Wind**	**Solar**	**Headquarters**

The difference between onshore and offshore will come from the severity of the hazard derived from the location of the turbine

Sources: Desktop research; expert interviews; BCG analysis.

By leveraging key asset archetypes at the sector level, banks can extend the scope of the quantification assessment to a larger portion of their portfolio and, subsequently, further narrow down their analysis to the hazards, asset types, and counterparties most at risk from physical climate risk.

The second step toward assessing vulnerability is to group the physical hazards to be assessed into larger hazard categories that display similar potential impacts. Banks should first begin by listing all hazards that they have identified as relevant to the quantification exercise, accounting for topography, project scope, and counterparty priorities. They will then have to group hazards whenever similar potential impacts on a counterparty's asset are expected (for example, pluvial, coastal, and fluvial floods). Finally, banks will need to prioritize hazards on the basis of their own analytical priorities and the priorities of the counterparties in scope. (See Exhibit 6.) This prioritization will further narrow down the focus of the physical-risk assessment to the most material hazards with the potential of significantly impacting their portfolios.

The third and final step in a vulnerability assessment is the identification of archetype vulnerabilities by physical hazard. (See Exhibit 7.) This includes the consideration of both counterparties' assets and operational vulnerabilities and can be accomplished using one of three approaches:

1. **A semiquantitative approach** that leverages desktop research and sectorial expert insights to qualitatively assess asset and operational vulnerabilities by assigning a score to each

2. **A quantitative approach** that uses more-generic damage functions for each asset archetype to estimate potential impact

3. **A more tailored, quantitative approach** that uses custom-built damage functions that consider physical-risk mitigation measures in place to estimate potential impact specific to the asset being assessed

Exhibit 6 - Hazards should be grouped together to ensure a practical and exhaustive assessment

Hazard category	Flood	Precipitation	Wind	Heat	Cold	Wildfire	Hail	Drought
Acute	Coastal	Extreme precipitation	Extreme wind	Heat waves	Frost	Wildfire	Extreme hail	Water scarcity
	Fluvial				Snow			
	Pluvial	*Flooding events can result in permanent submersion*						
Chronic	Sea level rise	Chronic rain	Chronic wind	Chronic heat	Chronic cold			Chronic drought

All hazards falling under the same category differ only in terms of:

- **Origin** (for example, different types of flooding depending on location)
- **Severity** and frequency (for example, an acute heat wave vs. a chronic temperature increase)

These dimensions will be accounted for and distinguished on a case-by-case basis depending on archetype specificities and asset location[1]

Sources: Desktop research; BCG analysis.

[1]E.g., an offshore wind turbine (identified based on location) will be more likely to face sea level rise vs. an onshore wind turbine, which will face pluvial or fluvial flooding.

Exhibit 7 - A vulnerability study of a manufacturing center that assesses each asset archetype

Manufacturing center example

Impact \ Hazard	Flood (A)	Storm (wind)	Storm (precipitation)	Wildfire	Frost	Water scarcity	Heat (B)	Sea level rise
Physical assets (building, equipment, and inventory)	5	5	5	5	1	1	1	5
Operations (disruption to logistics, productivity, and infrastructure)	5	2	5	5	2	3	5	5
Qualitative vulnerability (average)	5	4	5	5	2	2	3	5

A *__Physical assets:__ floods can cause irreparable damages to assets (depending on the location)*

__Operations:__ floods can also impact business operations, such as by interrupting daily work because a building is inaccessible

B *__Physical assets:__ low impact on physical assets since heat waves and higher temperatures do not lead to infrastructure damage*

__Operations:__ high temperatures impact productivity and increase cooling (for computer servers, for example) and workforce costs

Vulnerability to hazards should be mapped on a quantitative scale from five to zero

- **5** Critical: the hazard could have a very significant effect, potentially causing months of interruption
- **4** High: the hazard could have a material effect, causing significant disruptions for more than a week
- **3** Moderate: the hazard could have a sizable effect, disrupting operations for weeks
- **2** Low: the hazard could have a limited effect, causing mild disruptions to operations or little damage to physical assets
- **1** Negligible: the hazard could cause insignificant changes, within the expected variability of climatic events
- **0** Not applicable: the hazard will have no effect; there is no vulnerability to the risk

Source: BCG analysis.

The degree of data granularity required by each approach is progressively more significant, with little-to-no client-specific information needed for the semiquantitative approach, but with significant details required about the asset and counterparty's specificities for the more-tailored quantitative approach.

Economic Impact

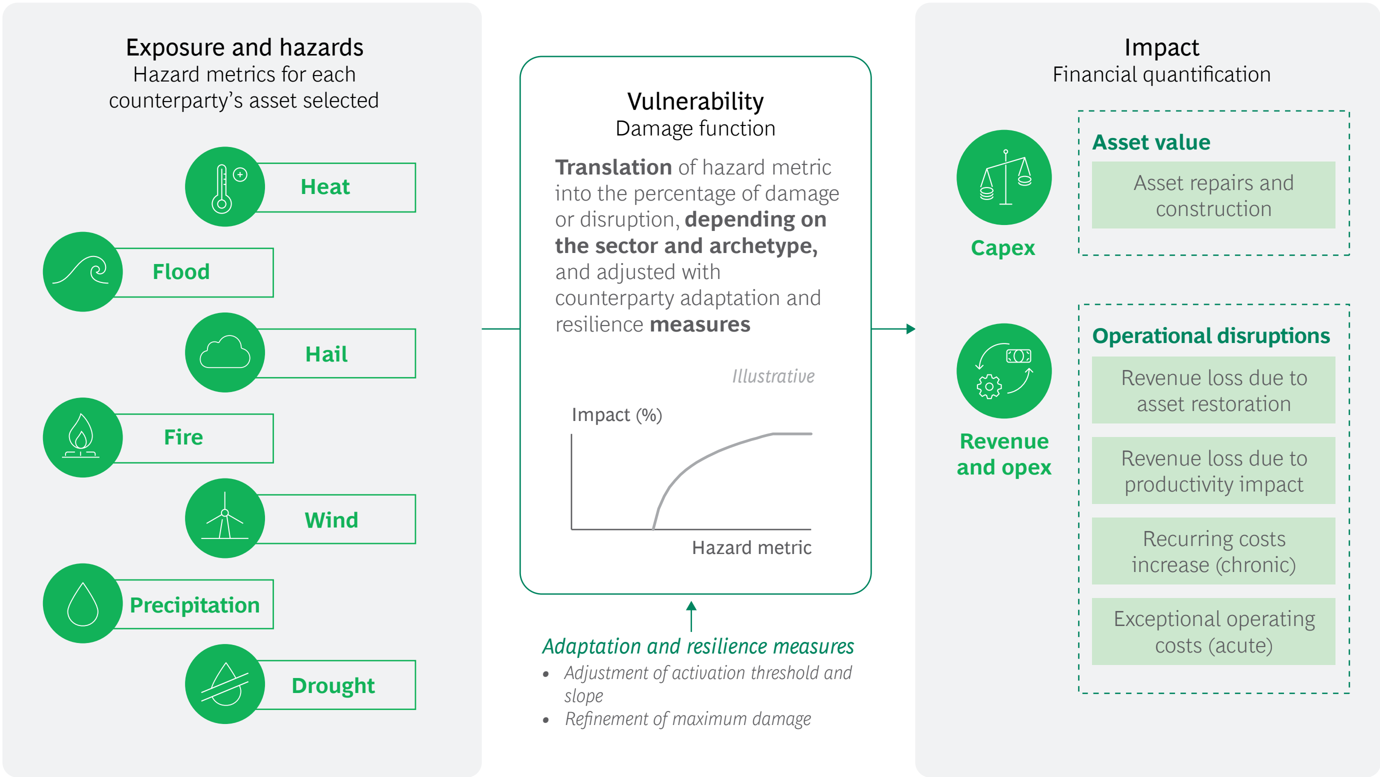
Economic impact refers to the calculated economic impact on assets, operations, and supply chains resulting from the manifestation of physical climate risks. Economic impact is generally quantified through the use of damage functions and more or less tailored to the asset or asset archetype being assessed. (See Exhibit 8.)

The economic effects of physical climate risks are directly related to clients' financial statements and can be categorized under capex, revenue, and opex impacts.

Capex. Physical risks can result in capex impacts by directly damaging assets, including building and infrastructure, machinery, and inventory. As such, capex impacts are primarily related to asset reconstruction costs and can significantly affect a client's cash flow.

Revenues. Physical risks can also negatively impact a client's revenues. This is because, depending on the sector and asset archetype being considered, damaged assets could lead to operational downtime. Some hazards, especially temperature-driven ones, could also directly affect a client's working environment by decreasing daily productivity. In addition, physical risks could indirectly impact a client's revenues by affecting its buyers, suppliers, and distribution channels.

Exhibit 8 - The damage function is the key junction, linking hazards and concrete financial impacts, adjusted per counterparty through A&R measures



Source: BCG analysis.

Note: A&R = adaptation and resilience.

Opex. Finally, physical risks can lead to opex-related impacts through exceptional operating costs, through an increase in recurring operational costs, or through a price increase due to key suppliers also being impacted by physical climate hazards, or all three. Acute climate risks, such as heat waves, could lead to a rise in operational costs (for example, an increase in cooling costs due to summer heat waves) for a given period of time. Additionally, depending on the sector and archetype being assessed, an increase in certain hazard metrics could lead to a permanent opex increase (such as an increase in maintenance costs for routes due to increased precipitation).

In order to quantify economic impact, banks need to translate the identified hazard metrics into an expected percentage of asset damage or operational destruction through a damage function. Damage functions should be specific to a sector or asset archetype and can be adjusted with counterparty adaptation and resilience measures if the information is available.

Damage functions are generally comprised of four key elements:

1. **Shape.** The overall shape of the damage function (for example, log, exponential, or linear).

2. **Slope.** The expected speed of the damage, which is dependent on asset archetypes.

3. **Activation Threshold.** The value above which damage starts (for example, the percentile or absolute value of a key variable).

4. **Maximum Damage Threshold.** The maximum percentage of damage caused by a given hazard.

BCG's Perspective on Next-Generation Physical-Risk Quantification

There are two primary approaches that banks may adopt to assess the impact of physical risks at the portfolio or counterparty level: outside in or inside out. (See Exhibit 9.) The choice behind which one to leverage will depend on the desired output format (semiquantitative or quantitative), the level of data available for the assessment, and the degree of precision required from the quantification exercise. Banks that choose the outside-in approach sometimes follow up with the inside-out approach.

Outside-In Approach

An outside-in approach can offer banks a dynamic result that can be updated with changing hypotheses or that can be enhanced by adding granularity. This approach allows banks to identify the sectors and clients with the greatest potential of vulnerability to physical risks and, therefore, with the highest likelihood of seeing their probability of default increase. An outside-in assessment can deliver a semiquantitative or a quantitative output.

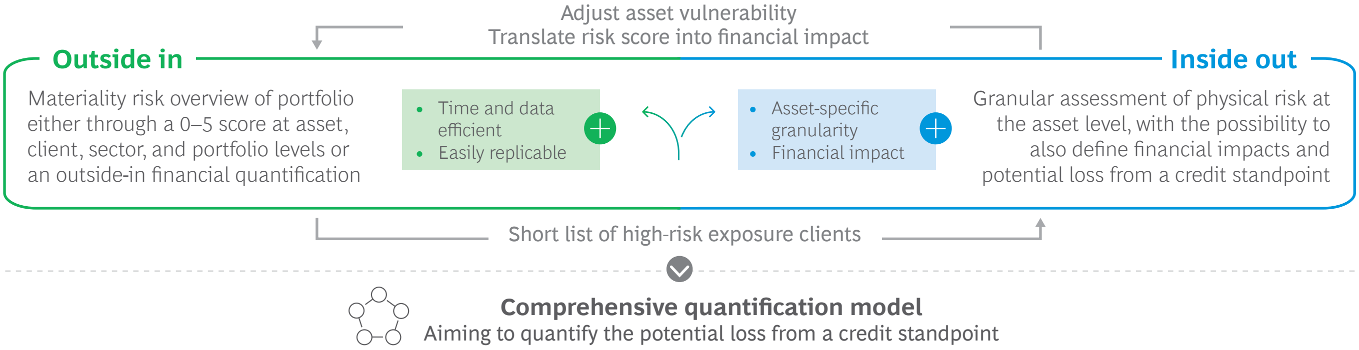
Semiquantitative Methodology. The semiquantitative methodology uses geospatial, climate, and other data to quantify physical risks and assigns a qualitative score that reflects changes in quantification results. By leveraging this method, banks can generate a synthetic score heat map at the asset and client levels for each selected sector. They can further narrow down future analysis to the sectors and counterparties most at risk.

A semiquantitative method requires limited external and counterparty-specific information and can be accomplished by leveraging multiple sources, including expert input, literature, desktop research, and peer benchmarking. As such, this method allows banks to easily and more quickly gain insights over their portfolio and counterparties' exposures without investing significant resources. (See the sidebar "Case Study: A Semiquantitative Outside-In Assessment of Power Sector Counterparties.")

Quantitative Methodology. A quantitative outside-in approach will leverage general damage functions to quantify the economic impact of physical climate risks on selected asset archetypes and counterparties.

While this method offers a more granular view of potential portfolio and counterparties' vulnerabilities, compared with the semiquantitative method, it still does not take into account asset or counterparties' specificities, including any adaptation and resilience measures in place. (See the sidebar "Case Study: A Quantitative Outside-In Assessment of a Power Counterparty.")

Exhibit 9 - A physical-risk assessment can be done at different levels of granularity that feed each other in a comprehensive quantification approach



Source: BCG analysis.

Case Study: A Semiquantitative Outside-In Assessment of Power Sector Counterparties

BCG supported a bank in its initial semiquantitative assessment of its exposure to physical climate risks.

The bank identified power generation as a key priority sector given its high vulnerability to physical hazards and the availability of public asset data. BCG ran the assessment for a sample of clients that represented a significant share of the bank's loan exposure within the power sector portfolio and that covered the five asset archetypes mentioned earlier.

Key hazards and vulnerabilities were identified and scored on a scale of zero to five, leveraging BCG's experts' input, academic literature, and publicly available asset and hazard data. (See the exhibit below.)

The output of this outside-in semiquantitative assessment was a synthetic score heat map for the power sector that not only yielded useful insights at the sector, archetype, client, and asset levels but also allowed the bank to narrow down the focus of future analyses.

Wildfire, flood, drought, and hail have scores of four or higher for at least one archetype

		Flood	Precipitation	Wind *Acute*	Wind *Chronic*	Heat	Cold	Wildfire	Hail	Drought
Solar	Assets	4	0	3	0	1	1	5	4	0
	Operations	4	3	2	0	1	1	5	3	1
Wind	Assets	2	2	3	0	0	1	5	3	0
	Operations	2	2	3	0	0	2	5	2	0
Thermal	Assets	4	1	2	0	0	2	5	2	3
	Operations	4	1	1	0	3	2	5	1	3
Nuclear	Assets	3	1	2	0	0	1	4	2	4
	Operations	5	1	1	0	3	2	4	1	4
Hydraulic	Assets	3	2	0	0	0	2	3	1	2
	Operations	2	2	0	0	1	3	4	1	4
Head-quarters	Assets	4	1	3	0	1	1	4	2	2
	Operations	3	1	1	0	2	1	3	1	1

No vulnerability 0 1 2 3 4 5 Critical vulnerability

Sources: Desktop research; expert interviews; BCG analysis.

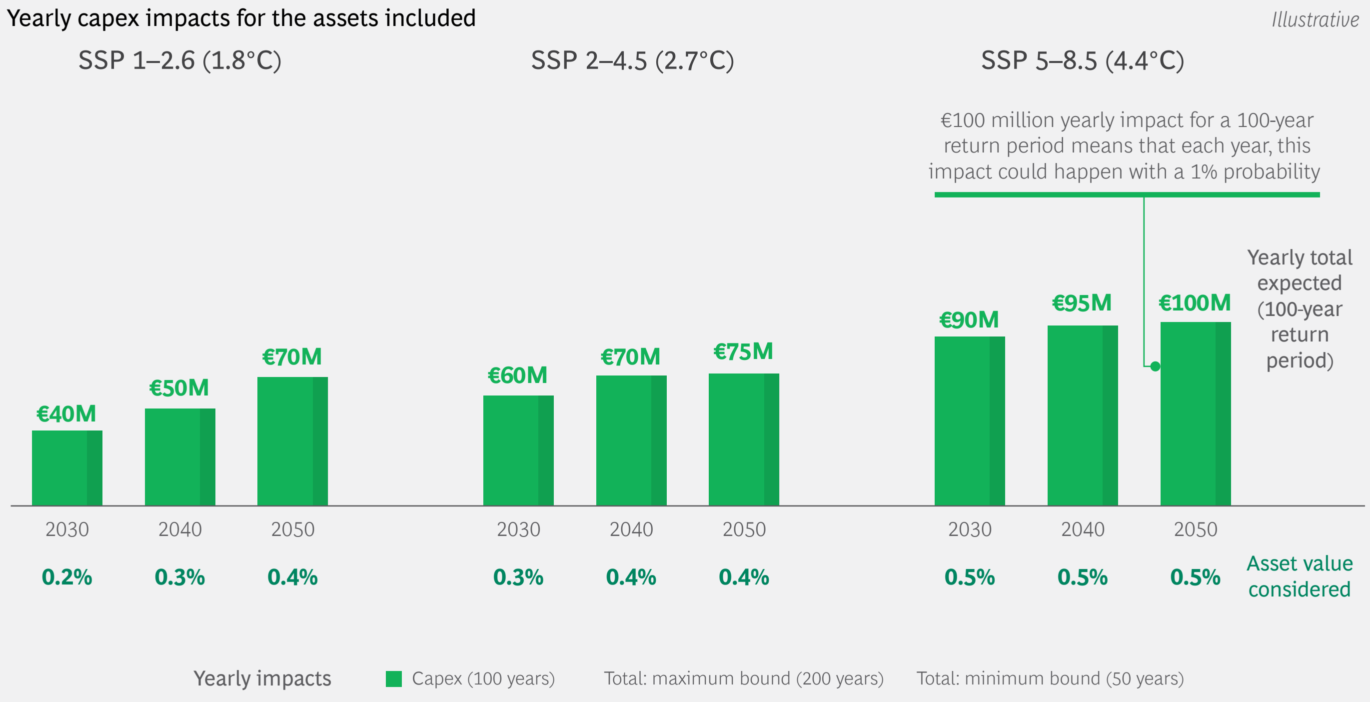
Case Study: A Quantitative Outside-In Assessment of a Power Counterparty

The bank that BCG supported for the semiquantitative assessment selected a company for a more granular climate-risk assessment. This evaluation leveraged general damage functions identified and defined by BCG to quantify the potential economic impact of physical risks on the company.

BCG's initial assessment focused on more than 60 assets prioritized on the basis of a synthetic risk score and annual power generation. However, following the first engagement with the company, four assets were selected to quantify the potential economic impact of physical risks across time horizons and climate scenarios.

The assessment considered the potential capex impact across six climate hazards, as the company confirmed it expected limited impacts on revenues and opex. The mitigation measures in place (such as asset specificities and insurance) were not considered at this stage. However, adjustments to damage functions for specific asset archetypes covered by increased regulations (for example, flood protection requirements) were put in place. (See the exhibit "The potential yearly capex impact across scenarios and years, reaching €100 million in 2050 for SSP 5 through SSP 8.5.")

The potential yearly capex impact across scenarios and years, reaching €100 million in 2050 for SSP 5 through SSP 8.5



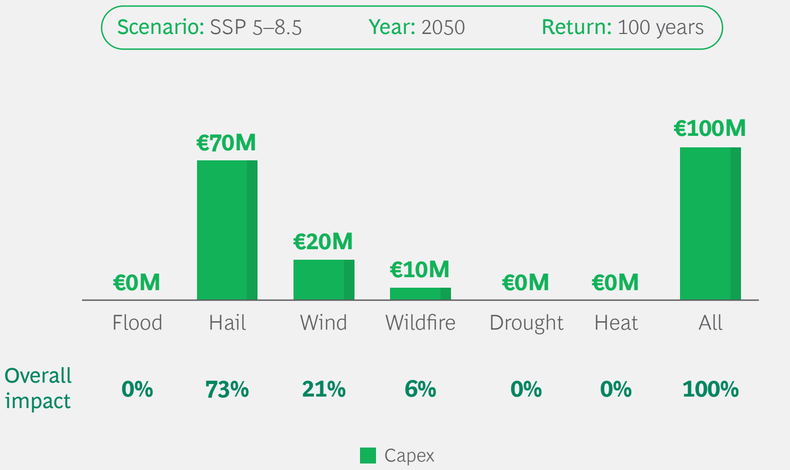
Sources: Jupiter; Global Energy Monitor; International Energy Agency; company reports; BCG analysis.

The analysis was then further broken down by potential hazard impact for each prioritized asset to highlight the most material hazards for the company. (See the exhibit “Hail would potentially represent the most material risk and could be responsible for 73% of the €100 million theoretical capex impact by 2050.”)

Hail would potentially represent the most material risk and could be responsible for 73% of the €100 million theoretical capex impact by 2050

Illustrative

Yearly impact per hazard for the four assets included (€billions)



Key takeaways

Adaptation and resilience measures that are already in place or planned may change quantification results

- Capex potential impact of **€100 million in 2050**

Hail — Impacts mainly plants manufacturing solar panels

Wind — Affects mainly power stations converting wind to thermal energy

Sources: Jupiter; Global Energy Monitor; International Energy Agency; company reports; BCG analysis.

Inside-Out Approach

As previously discussed, the variability of exposure to physical risks across regions and business sectors only further highlights the importance of understanding the specificities of each. An inside-out quantification approach enhances the outside-in approach and allows banks to further focus their analysis on three crucial parameters:

1. **Client’s Sector.** Physical impacts can differ depending on the business sector. According to MSCI, for example, the downside potential in energy companies’ market value due to the impacts of physical risks is up to four times that of health care companies. Utilities, consumer staples, and industrials are other heavily impacted sectors. Therefore, the assessment should begin by evaluating the most exposed sectors in the portfolio from a top-down perspective. For example, in an orderly scenario (2°C), energy, utilities, and consumer staples are estimated to be the most at risk, with the potential downside (as a percentage of companies’ market value) at roughly –17%, –16%, and –11%, respectively.[10] Among physical risks, the most material is coastal flooding, primarily due to infrastructure location.

2. **Client’s Activities.** The focus of the assessment needs to be narrowed down to a specific client and its assets in the portfolio’s most exposed sectors. Indeed, a client is often confronted with highly specific challenges owing to its particular operating model and the physical characteristics of the assets it owns or operates. A bank needs to identify its clients’ critical assets and their interrelationships to better understand the magnitude of the bank’s economic exposure to a given physical hazard.

10. MSCI, “Which Sectors Are Most Affected by Climate Risks?,” May 2023.

3. **Client's Suppliers.** The assessment should also be extended to a client's tier one suppliers and to its proximate support infrastructure (such as roads, power, and gas supplies). Suppliers' exposure and vulnerability to physical risks could strongly affect a client's business. For instance, in 2021, raw materials needed for automobile production were deeply affected by semiconductor shortages that were partially due to water scarcity in Taiwan.[11] As such, a client's activities could be critically impacted by physical risks, especially in industries with a concentrated supplier base, custom raw material requirements, or limited opportunities to build inventory buffers. This is because the natural hedging provided by supplier diversification becomes more complex to achieve in these situations. Therefore, prioritized suppliers should be identified and included in the overall physical-risk assessment, with particular consideration of supply routes in case of low redundancy and few alternatives.

An inside-out approach can further integrate a client's specificities into outside-in risk assessments, providing banks with a more granular, counterparty-specific view of physical-risk vulnerability.

Unlike the outside-in approach, the inside-out approach requires a close collaboration between a bank and each client to obtain detailed data for a more accurate quantification of potential physical-risk impacts. This quantification can be accomplished by tailoring general damage functions that were leveraged during the outside-in assessment and will generally require information on the asset specificities and mitigation measures in place. For example:

- **Asset-Specific Physical Features.** Are there specific features that make an asset (for example, building materials) more resilient or vulnerable for each hazard?

- **Physical Mitigation Measures.** What mitigation measures (for example, a sea wall surrounding the asset) are implemented for each asset to gain resilience?

- **Financial Mitigation Measures.** Are the assets insured against climate hazards? (See the sidebar "Case Study: Integrating Financial Mitigation Measures into the Assessment of a Commercial Real Estate Counterparty.")

In addition to a more tailored estimate of potential economic impact, an inside-out approach may also include the assessment and quantification of a counterparty's supplier and infrastructure impacts. To do so, banks should first map the relevant counterparty's supply chain and then identify the key elements they wish to consider. These could include:

- **Key suppliers,** when the counterparty has a concentrated supplier base or limited opportunities to build inventory buffers, when the supply of raw materials is essential for production, or both

- **Key customers,** when the counterparty's revenues are particularly dependent on the sale of highly customized products or services that cannot be sold elsewhere, when revenues are concentrated across a few key customers, or both

- **Key shipping routes,** where the counterparty relies on nonredundant routes to receive production inputs or deliver finished products

11. Wall Street Journal, "The Chip Shortage Is Bad. Taiwan's Drought Threatens to Make It Worse," April 2021.

Case Study: Integrating Financial Mitigation Measures into the Assessment of a Commercial Real Estate Counterparty

Given the quantitative results from its initial outside-in assessment, a bank sought to gain a deeper understanding of the mitigation measures in place at a commercial real estate player. The bank was looking to validate whether the company's insurance policy could reduce the estimated potential capex impact from various physical hazards.

BCG supported the bank in the engagement of the company to obtain the information required for tailoring the damage functions previously leveraged. This was achieved through a series of workshops, where BCG and the bank shared and validated the insights gained from the company and gathered additional data on the prioritized assets chosen for the more granular assessment. (See the exhibit "Key assumptions are made to account for asset specificities and to refine the assessment for each building.")

Key assumptions are made to account for asset specificities and to refine the assessment for each building

	Net physical impact Asset characteristics	Net financial impact Adaptation and resilience assumptions
Hail	• Type of roof (material) • Value of roof (absolute and percentage of building value)	• Amount of insurance coverage with the minimum and maximum deductible
Wind	• Value of buildings • Value of vulnerable components as a percentage of total value • Presence of trees (potential flying debris)	• Amount of insurance coverage with the minimum and maximum deductible
Flood	• Building value • Number of floors and total height • Number of underground floors	• Amount of insurance coverage without a deductible
Fire	• Building value	• Amount of insurance coverage without a deductible
Drought	• Value of vulnerable vegetation • Minimum drought event duration beyond which plants and trees start dying	• Not applicable

Notes about the analysis

- Public coverage was not modeled because of a lack of clarity (reliance on ministerial decree)
- Insurance was assumed to be consistent across all assets, including abroad
- Insurance coverage may increase over the next few years, but that is not accounted for in the analysis

Source: BCG analysis.

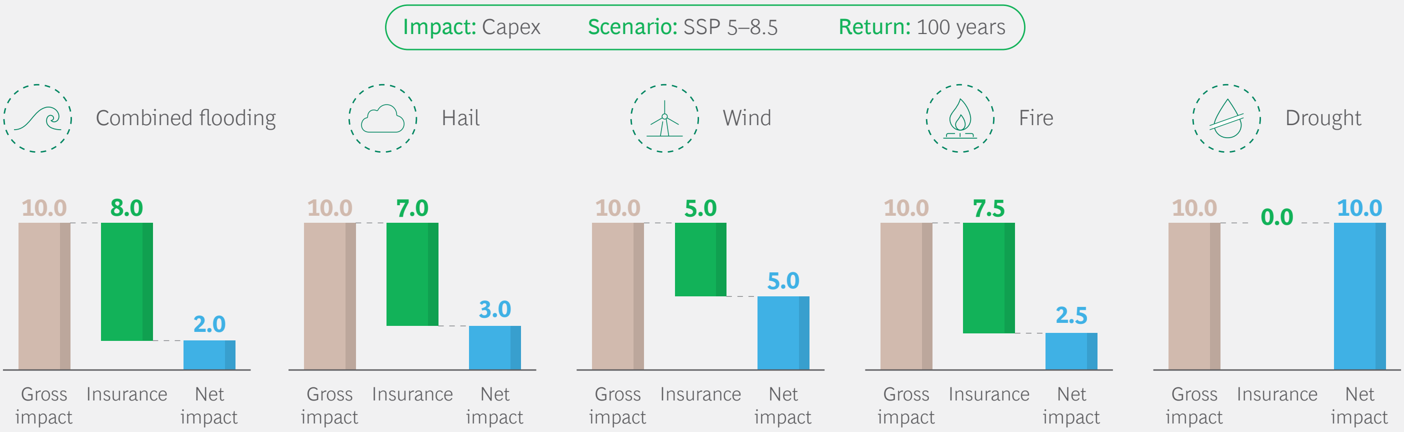
When the information was collected, the analysis was focused on better understanding the impact that insurance may have on mitigating physical-risk vulnerabilities.

BCG tailored the existing damage functions and modeled the adjusted results, taking into consideration the specifics of the company's insurance policy (for example, the deductible and maximum coverage). This analysis resulted in a significant adjustment of the potential capex impact, fully mitigating the effect of all previously identified material hazards with the exception of drought. (See the exhibit "By adding the insurance layer to the simulations, hail and flood impacts are the risks most covered, while coverage for drought is lacking.")

By adding the insurance layer to the simulations, hail and flood impacts are the risks most covered, while coverage for drought is lacking

Illustrative

100-year return period capex impacts for each hazard before and after insurance layer included, for the assets prioritized (€millions)



Combined flooding	Hail	Wind	Fire	Drought
Assumptions	*Assumptions*	*Assumptions*	*Assumptions*	*Assumptions*
Strong insurance coverage	Strong insurance coverage	Strong insurance coverage	Strong insurance coverage	No insurance coverage › **Priority hazard** for an insurance policy but insurance premium will need to be considered

Insurance premium and its potential increase[1] were not taken into account in the analysis; companies should compare cost with impact before making any decision on an insurance contract

Sources: Jupiter; company reports; BCG analysis.

[1]Because of the increase in intensity and frequency of climate hazards (chronic effect).

How to Leverage Physical-Risk Assessment to Create Value for Clients

Banks should build a clear understanding of the evolution of physical risk in their portfolio, starting with a comprehensive outside-in assessment (using semiquantitative scoring, for example) that allows them to spot the most impacted sectors, clients, and regions. Then banks should conduct a more in-depth analysis of those sectors and clients using a more quantitative approach. It is also crucial to start engaging clients to verify and fine-tune the results on the basis of additional data and information (that is, inside-out quantification). The adopted approach, input data, and assumptions should be fully transparent within the organization to generate confidence about the reliability and insightfulness of the results. Leveraging less transparent solutions from external providers proved to fall short when such information started to be used for decision making and client engagement.

The results of physical-risk assessments fuel at least two use cases:

- **Strengthening the bank's risk management** by integrating the results of physical-risk assessments into the risk management framework. Banks should focus on credit risk, which is where the bulk of physical risk's impacts fall, and should include the results of physical-risk assessments not only in their risk appetite framework (RAF) but also in their credit policies as a parameter to define portfolio steering. To inform portfolio management, for example, banks can include one or two metrics—such as a percentage of the portfolio at high risk or a percentage of assets at high risk—that cover physical risk.

  When banks integrate such risk considerations into their broader risk management framework, they have a more solid view of their own credit risk. For example, it has been observed that a bank could see the probability of defaults on some of its exposures rise by up to 4% to 5% for counterparties located in high-risk flooding areas.[12] Some banks leverage dedicated teams to assess more in-depth high-risk counterparties and assets. Going forward, a full integration into risk models will be required; however, this level of maturity has not been reached yet.

- **Creating new channels to engage with clients** by exploring adaptation and resilience financing opportunities. The evolution of physical risks requires that companies take actions to mitigate risks so that they avoid incurring significant losses in asset value and avoid experiencing business interruptions.

  Mitigation measures include both extended (and peril specific) insurance coverage and physical measures (for example, building walls to safeguard key plants from flooding, having oversized plant components to accommodate higher average temperatures or reduced water availability, strengthening of materials used for construction, and constructing hail barriers to prevent crop damage in agriculture). In particular, physical mitigation requires financing and represents an opportunity for banks. Leading banks are starting to systematically explore this opportunity, differentiating approaches for large, medium, and small clients.

12. Focus Censis Confcooperative, "Environmental Disasters Burn 210 Billion Euros," 2024.

Larger clients that are in sectors most exposed to physical perils have a medium to high level of awareness regarding their risks and the required mitigation actions. Thus, the role of banks is to prioritize those clients, formulate an outside-in perspective on where the risk is concentrated (for example, on which assets), and start engaging clients in a dialogue to both fine-tune the outside-in view (for example, to gather additional data on the physical features of the client's assets) and explore financing needs. This approach requires a solid quantification methodology, verified results, and a well-defined go-to-market process.

Medium and smaller clients (for example, clients in agriculture and retail) typically have a very limited or no capability to quantify physical-risk impacts in the short and medium terms. Thus, banks could play a fundamental role by providing easy-to-use tools to perform a first assessment (using client-provided data) and link to that an offering that includes not only financing but also partnerships with insurance companies (for example, to mitigate specific perils) and with solution providers (such as companies that implement adaptation and resilience measures) in a wider ecosystem to serve the emerging needs of their client base.

BCG will continue to partner with banks worldwide to further develop and advance physical-risk assessment methodologies and advise on how to best collaborate with their clients to avoid risks, protect the environment, and generate additional opportunities.

About the Authors

Andrea Castoldi is a managing director and partner in BCG's London office and global co-lead for climate risk in financial institutions. You may contact him by email at castoldi.andrea@bcg.com.

Giovanni Lucini is a partner and director in BCG's Milan office and the firm's global expert on climate risk. You may contact him by email at lucini.giovanni@bcg.com.

Bruno Micale is a project leader in BCG's Milan office and a core member of the firm's task force on climate risk in financial institutions. You may contact him by email at micale.bruno@bcg.com.

Amine Benayad is a managing director and partner in BCG's Paris office and the firm's global lead for climate and sustainability in financial institutions. You may contact him by email at benayad.amine@bcg.com.

Matteo Coppola is a managing director and senior partner in BCG's Milan office and the global leader of the firm's risk and compliance practice. You may contact him by email at matteo.coppola@bcg.com.

For Further Contact

If you would like to discuss this white paper, please contact one of the authors.

Boston Consulting Group partners with leaders in business and society to tackle their most important challenges and capture their greatest opportunities. BCG was the pioneer in business strategy when it was founded in 1963. Today, we work closely with clients to embrace a transformational approach aimed at benefiting all stakeholders—empowering organizations to grow, build sustainable competitive advantage, and drive positive societal impact.

Our diverse, global teams bring deep industry and functional expertise and a range of perspectives that question the status quo and spark change. BCG delivers solutions through leading-edge management consulting, technology and design, and corporate and digital ventures. We work in a uniquely collaborative model across the firm and throughout all levels of the client organization, fueled by the goal of helping our clients thrive and enabling them to make the world a better place.

For information or permission to reprint, please contact BCG at permissions@bcg.com. To find the latest BCG content and register to receive e-alerts on this topic or others, please visit bcg.com. Follow Boston Consulting Group on Facebook and X (formerly known as Twitter).


bcg.com