

METHODOLOGY ABSTRACT

Physical Climate Risk Metrics

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Methodology Abstract: Physical Climate Risk Metrics

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This document is a condensed version of the Physical Climate Risk Metrics methodology document. It explains key elements but does not have all details contained in the full methodology, which includes additional details on calculation formulae, data sources, timelines for updates and definitions. The comprehensive methodology document is available for all Physical Climate Risk clients and can be obtained through Global Access and/or your client advisor.

Highlights

- Sustainability Physical Climate Risk Metrics provide quantitative data to support multiple investment use-cases for understanding and managing risks related to physical climate exposure, reporting, portfolio construction, and company engagement.
- For each company, the direct and indirect risks, and associated losses are calculated as separate signals to align with the recommendations of the Task Force on Climate-Related Financial Disclosures (TCFD).
- Both direct and indirect losses are combined to give an overall financial exposure signal.
- The product offers a timeseries of both discounted and non-discounted cumulative damages and loss ratios up to 2050 and beyond.
- Two climate change scenarios are addressed in the product: Representative Concentration Pathways (RCP) 2.6 and RCP 8.5.
- The hazards and metrics are categorized to give insights into the distribution of exposure according to:
 - » The contribution of each hazard to a company's exposure.
 - » The countries where the hazard exposure and financial exposures are generated.
 - » The relative ranking for each type of hazards exposure metric of a company compared to its industry peers and the entire universe of companies.
 - » The relative ranking of the financial exposure metrics of a company compared to its industry peers and the entire universe of companies.

Our changing climate calls for the assessment of exposure to physical climate hazards

Introduction

To assess the financial implications posed by the impacts of climate change on businesses, the Task Force on Climate-related Financial Disclosure (TCFD) has recommended the disclosure of climate-related physical hazards of **Acute Events** and **Chronic Changes** and how they are expected to affect a company's operations.² In response to evolving reporting needs and investor interest, Morningstar Sustainalytics has developed **Physical Climate Risk Metrics** that assess the physical climate exposure faced by companies. These metrics are underpinned by data from XDI³, a global leader in assessing physical climate risk. The metrics provide quantitative data to support different investment and client use-cases, including (1) understanding and managing risks related to physical climate exposure, (2) reporting, (3) portfolio construction, and (4) company engagement.

Methodology Description

Overview

The key metrics to the methodology

There are three key inputs used in the methodology of the Physical Climate Risk Metrics:

1. Data on the likelihood and magnitude of **Climate Hazards** impacting a company's physical assets and operations, and how they will change with time under different climate change scenarios.
2. Data on the **Direct Risk** and **Indirect Risk** these climate hazards pose on the company and how they change with time under different climate change scenarios.
3. Financial data that translates these physical climate exposures into financial exposures.

These all create various metrics used to assess a company's exposure to climate hazards and risks and the associated financial losses.

Physical Climate Hazard Data

Climate change models determine the expected change of hazards under different climate change scenarios

Climate Hazards can result in significant physical damage to infrastructure and productivity losses, and these include forest fire, flooding (pluvial and fluvial), coastal inundation (sea level rise), extreme wind, extreme heat, soil subsidence, and freeze-thaw, and cyclone wind (see Exhibit 1 below). **Global Climate Model** data is used to determine how the probability and intensity of these hazards will change in the future under different climate change scenarios. Morningstar Sustainalytics provides two climate change scenarios from the Coupled Model Intercomparison Project 5 (CMIP5)⁴ for this assessment:

- Representative Concentration Pathway, **RCP 2.6** that models a world transitioning to a future warming of ~2 °C by the end of the century; and
- **RCP 8.5** that models the future under a worst-case scenario resulting in global warming ranging from 3.2 °C to 5.4 °C by 2100.

Exhibit 1: Climate-Related Hazards and their Descriptions

Hazard	Description	Weather Parameter	Ancillary Data	Business Impact
 Forest Fire	An unplanned, uncontrolled and unpredictable fire occurring in an area of combustible vegetation of shrubs and trees.	Daily temperature, humidity (vapour pressure deficit), and wind speed.	Forest-fire prone land which entail forest and urban cover data or maps.	Forest fires can damage assets and infrastructure that are in proximity to trees and other vegetation. This is an acute event.
 Flooding	This is an overflowing of water, that is caused by excess rainfall (pluvial) or by a river overflowing its banks (fluvial), that submerges land which is normally dry. Excess rainfall can cause flash floods, surface water to pool and/or flow downhill. Rivers overflowing their banks are caused by excess rainfall upstream or upstream snow melt. These types of flooding are non-coastal flooding.	Annual maximum 24-hour precipitation.	Flood maps with severity and return frequency statistics.	Floods can directly damage infrastructure and equipment as well as cause loss in productivity by its impact on employees. This is an acute event.
 Coastal Inundation	This is an overflowing of sea water that submerges dry coastal land. Coastal inundation is caused by rising sea levels, high tides in combination with storm surges, and coastal lands sinking.	Sea level rise projections due to climate change.	Digital elevation models, storm surge and wave models, land movement / subsidence data, and tide gauge data.	Coastal flooding can directly damage infrastructure and equipment and cause loss in productivity by its impact on employees. This is both an acute event and chronic change.
 Extreme Wind	Gusts and/or sustained winds that exceed the design threshold of a given infrastructure and are a threat to life. Climate change can alter weather systems producing high winds including convective storms that produce severe down drafts.	Daily maximum near-surface wind gusts.		High winds can damage infrastructure, cause disruption by downing power lines, and put life and property at risk by causing loose material to become projectiles. This is an acute event.
 Extreme Heat	A period of high temperature and humidity that compromises human health and productivity based on the wet bulb globe temperature effect.	Daily temperature and humidity.		Extreme temperatures can cause various operational systems to fail causing operational disruption, and extreme heat can cause human productivity loss. This is both an acute event and chronic change.
 Soil Subsidence	The downward vertical movement of the earth’s surface caused by the climate induced drying of soil that in turn causes contraction and cracking.	Annual cumulative precipitation that falls within the 10 th percentile.	Soil type maps.	This soil movement can damage the foundation and walls of infrastructure. This is a chronic change.
 Freeze-Thaw	The cycle of freezing then thawing in regions that experience winter. Porous material (e.g., concrete, brick, stone) can be damaged when liquid water freezes and expands. Non-porous material will not be affected.	Days where both the maximum daily temperature is above 0°C and the daily minimum temperature is below 0°C.		Freeze-thaw can damage the foundation and walls of infrastructure that are built with porous material. This is both an acute event and chronic change.
 Cyclone Wind	Catastrophic gusts and sustained winds greater than 208 km/h that are associated with Category 4 and 5 tropical cyclones.	Historical sea surface temperatures and their projections due to climate change.		Tropical cyclones cause catastrophic damage to infrastructure from the extreme winds. This also causes loss in productivity and are a threat to life. This is an acute event.

Source: XDI Systems and Morningstar Sustainabilitytics

Physical Climate Risk Data

Direct Risk metrics that determine direct damages and losses

Climate Hazards result in both Direct Risk and Indirect Risk to a company. Direct risk is due to climate hazards that cause direct damage and loss to its physical assets. Direct damage can be estimated by the metrics **Asset Damage Risk** and **High Risk Assets**. Asset Damage Risk estimates the vulnerability of direct infrastructure damage. The High Risk Asset metric determines the percentage of a company’s infrastructure or asset that have damages exceeding 1% of its replacement cost.

The direct losses which estimate non-damage related disruption is estimated by the **Productive Capacity Loss** metric. This is the degree of productivity disruption due to component failure and non-physical impairment such as heat stress on workers.

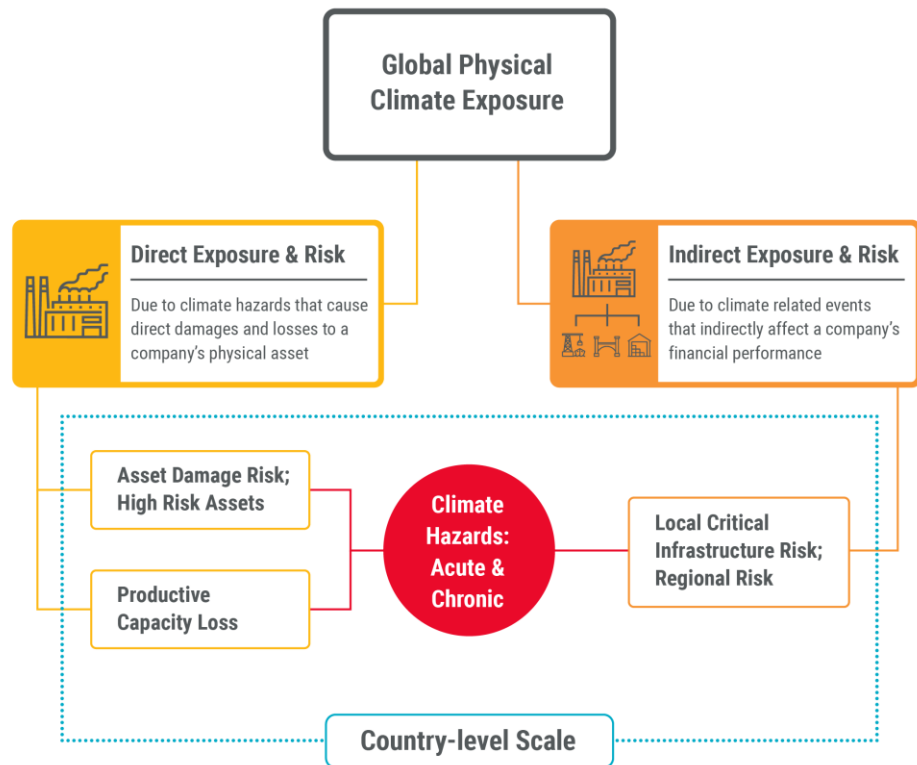
Indirect Risk metrics that determine the indirect loss

Indirect risk is due to climate hazards that do not directly impact a company’s physical asset but can affect a company’s financial performance through lost productivity. For example, if a hurricane causes a power outage that results in an indirect interruption of a company’s production through the inability to operate the equipment in the factory but does not damage the company’s factory directly.

The most immediate and measurable indirect risks is captured by the **Local Critical Infrastructure Risk** metric. The **Regional Risk** metric estimates the average risk of damage to the built environment in the region where the company operates.

How these data and associated risks contribute to the company’s global physical climate exposure are schematically represented in Exhibit 2.

Exhibit 2: Direct and Indirect Exposure and Risk



Source: Morningstar Sustainability

Financial Data

Morningstar financial metrics are used to translate climate hazards into financial exposures

Financial metrics including revenue, asset value and cash flow from Morningstar’s databases of standardized company financial reports are then used to translate the above-described climate risk metrics into financial losses. For all financial metrics, the inflation adjusted values are used.

Financial Exposure Metrics

A conservative estimate of the physical climate risks

The Physical Climate Risk Metrics also estimates the unmanaged physical impacts of climate extremes in financial terms. Unmanaged means that no adaptation or resiliency measures have been included in the climate risk assessment conducted by XDI. This gives a conservative estimate of the physical climate risks companies can experience under the two climate change scenarios of RCP 2.6 and 8.5 to year 2050.

Exposures are unique to each company due to geographic location and time horizon

The physical hazard exposure is translated into a financial signal to approximate the financial exposure faced by companies over the next decades up to 2050. The Physical Climate Risk Metrics and Financial Exposure Metrics are exclusive to each company as they are determined by the hazards and subsequent direct and indirect risks unique to each company's geolocated infrastructure or physical asset.

These financial exposure metrics should serve as an approximation of physical risk in a financial context. They are not intended to be used as strict predictions of future damages.

Financial exposure to climate hazards is defined as a loss ratio

Financial exposure to climate hazards is defined as a loss ratio and is calculated as the ratio of the cumulative expected damage loss due to these hazards to the company's cumulative global financial position up to 2050.

The overall financial exposure Total Loss Ratio is determined by the direct and indirect exposures

The direct and indirect exposures are calculated as separate signals to align with the TCFD recommendations. These give the **Direct Loss Ratio** and **Indirect Loss Ratio**, respectively. Both are combined to give a single overall financial exposure signal of **Total Loss Ratio**.

Benchmarking

Allowing for comparisons between different data points

Categories of the various hazards and metrics are defined so that their respective relative contribution to the company's climate hazards, and financial exposures can be determined.

Comparisons can also be made between geographies, peers, and industry averages, and between different time horizons and climate change scenarios.

For these comparisons there are three key comparison metrics:

- **Contribution Percent:** The percentage contribution and ranking of the hazards and countries to the company's global direct and indirect risks.
- **Relative Ranking:** The percentile ranking based on the full universe for each direct and indirect risk metric.
- **Total Loss Ratio:** The total loss ratio for each company is ranked universally and among its industry peers.

Each hazard's relative contribution on a global scale is determined

For each company, the direct risk metrics of Asset Damage Risk and Productive Capacity Loss are broken out into their **Global Hazard Contributions** as percent contribution and associated category.

Additional geographical detail of exposure and vulnerability

The relative contribution to the company's total global risk is calculated for each hazard, scenario and year or time horizon. The percent contribution is then grouped into one of four categories: Negligible, Moderate, Significant and Leading.

The purpose of the **Country Contribution** categories is to give additional geographical detail: Where the exposure and vulnerability is arising and contributing to a company's overall assessment across the direct and indirect climate risk metrics.

The Country Contribution details the respective contribution from every location a company has owned physical assets exposed to any of the physical hazards within the assessment, for each scenario and time horizon.

Country Contribution categories are grouped into the four categories that are similar to the Global Hazard Contributions given above.

Relative Ranking Category

For each of the direct and indirect risk metrics based on the distribution of the full universe of companies, each company is ranked universally and by industry to give its **Relative Rank**.

- Ranking across the full Ratings Plus Universe signals a company's risk relative to the full distribution of companies.
- Ranking across the company's industry signals a company's risk relative to companies with similar types of physical assets and activities.

The Relative Rank of a company is grouped into categories of: Significantly Below Average, Below Average, Average, Above Average, and Significantly Above Average.

Company Total Loss Ratio Ranking and Category per Time Horizon, Scenario, and Loss Ratio Metric

Companies' Total Loss Ratios (both Discounted and Undiscounted), are ranked universally based on the distribution of the full universe of companies to arrive at the **Total Loss Ratio Rank**:

- Ranking signals that a company's physical climate financial exposure relative to the full distribution of companies.
- Ranking across the company's industry signals a company's financial exposure relative to companies with similar types of physical assets.

The magnitude of the Total Loss Ratio is further categorized to signal the level of a company's financial exposure to physical climate hazards. This categorization scheme is consistent for both the RCP 8.5 and RCP 2.6 scenarios and is given as: Negligible, Low, Medium, High, and Severe.

Glossary of Terms

Acute events	Phenomena that are a result of or caused by extreme weather.
Asset Damage Risk	This is the likelihood of climate hazard occurrence combined with the vulnerability of the asset and its components.
Chronic Changes	These are the longer-term shifts in the climate.
Climate Hazard	A physical event or process that is weather, ecosystem and/or ocean related that can harm human health, livelihood or natural systems society depends on.
Country Contribution	The percentage contribution by each of the company's direct and indirect risk metrics per country for each climate change scenario and year.
Direct Loss Ratio	The ratio of the annually accumulated expected direct losses calculated from the direct risk metrics to the annually accumulated operating cash flow of the company.
Direct Risk	This is the likelihood that climate hazards negatively impact the physical assets that the company owns and/or which the company has some level of control.
Global Hazard Contribution	The percentage contribution to the company's total global risk per hazard for each climate change scenario and year, and for each direct risk metrics of Asset Damage Risk and Productive Capacity Loss.
Global Climate Model	A numerical model that simulates the global atmosphere and its chemistry, ocean, land and land use change.
High Risk Asset	This is the company's owned infrastructure or asset that is expected to have annual average loss due to damage that exceed 1% of the infrastructure or asset replacement cost.
Indirect Loss Ratio	The ratio of the annually accumulated expected losses calculated from the indirect risk metrics to the annually accumulated operating cash flow of the company.
Indirect Risk	This is the likelihood that climate hazards negatively affect services and resources the company utilizes but does not own or control.
Local Critical Infrastructure Risk	This is the failure likelihood, caused by acute events, of local government infrastructure in proximity to the company's physical assets, that disrupt the flow of goods and services to the company.
Physical Climate Risk Metrics	This is a suite of loss metrics that gauge a company's exposure to the physical impacts of climate change.
Productive Capacity Loss	This is the percentage of annual productivity disruption due to component failure, damage, repairs, and non-physical damage loss to the operations of a company.
RCP 2.6	Representative Concentration Pathway of greenhouse gas concentration trajectory adopted by the Intergovernmental Panel on Climate Change that results in a climate warming equivalent to 2.6 Watts per square metre by 2100. This is a climate change scenario.
RCP 8.5	Representative Concentration Pathway of greenhouse gas concentration trajectory adopted by the Intergovernmental Panel on Climate Change that results in a climate warming equivalent to 8.5 Watts per square metre by 2100. This is a climate change scenario.
Regional Risk	This is the average damage likelihood, caused by acute and chronic events, of the built environment in the local government region where the company's physical assets are located. It provides an indication of the relative risk of operating in the region.
Relative Rank	The percentile rank of each of the company's direct and indirect risk metrics for each climate change scenario and year. The percentile rank is relative to the full universe of companies as well as its industry peers.
Total Loss Ratio	This is the arithmetic sum of the Direct Loss Ratio and Indirect Loss Ratio.

Endnotes

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- ² TCFD 2017: "Recommendations of the Task Force on Climate-related Financial Disclosures" Final Report; accessed (07.09.2022) at: <https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf>
- ³ XDI; accessed (17.10.2022) at: <https://xdi.systems/>
- ⁴ Box SPM.1: Representative Concentration Pathways (RCPs) in IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of the Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.
- ⁵ US Congress: "Discount Rates in the Economic Evaluation of U.S. Army Corps of Engineers Projects"; accessed (16.09.2022) at: [Discount Rates in the Economic Evaluation of U.S. Army Corps of Engineers Projects \(congress.gov\)](#)

Change Log

Version	Date	Initiator	Main items that changed	Comment / Rational
1.0	02.05.2023	Climate Solutions, Methodology & Product Architecture	N/A	N/A

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² TCFD 2017: Recommendations of the Task Force on Climate-related Financial Disclosures, Final Report, <https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf> accessed 2022-09-07.

³ XDI, <https://xdi.systems/> accessed 2022-10-17.

⁴ Box SPM.1: Representative Concentration Pathways (RCPs) in IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of the Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.