

CRIS

Climate Risk Impact Screening

*A unique method to assess the impacts of
physical risks from climate change on
financial assets*

The methodological guidebook

A method developed by  **carbone4**
Version 1 – November 2017

With support from





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About Carbone 4

Carbone 4 is an independent consulting firm specialized in issues related to the energy and climate transition. Carbone 4 carries out studies to assess risks related to the energy transition and climate change for actors in both the public and private sectors.

Sponsors

Carbone 4 launched the development of a stakeholder-driven method to identify the physical risks that potentially weigh on asset portfolios. The development of this method, called CRIS - Climate Risk Impact Screening - is supported by several financial institutions: main sponsors are Agence Française de Développement (AFD), Caisse des Dépôts et Consignations (CDC), Fond de Réserve pour les Retraites (FRR), Natixis-Mirova, Caisse Centrale de Réassurance (CCR) and CDG Capital, and supporters are Établissement de Retraite Additionnelle de la Fonction Publique (ERAFF), Electricité de France (EDF) and BNP Paribas. This methodological guidebook was produced within the scope of this project.

Acknowledgments

The CRIS team is thankful to all sponsors for their advice and support. The CRIS team would like to thank the experts of the scientific council that provided useful input into the methodological development of CRIS (in alphabetical order): Ben Caldecott (Oxford Sustainable Finance Programme at the University of Oxford), Thierry Cohignac (CCR), Gael Giraud (AFD), Hervé Guez (Mirova), Céline Guivarch (CIRED), Stéphane Hallegatte (World Bank), Hervé Le Treut (IPSL), Morgane Nicol (I4CE), Nathalie de Noblet (LSCE IPSL), Antonin Pottier (CERNA), Nick Robins (UNEP Inquiry), Philippe Roudier (AFD). The CRIS team would also like to thank all Carbone 4 members that provided useful feedback on the project.

The views and opinions presented here are those of the authors based on work carried out by Carbone 4. All partners are not liable under any circumstances for the content of this publication.

Citation

Violaine Lepousez, Claire Gassiat, Clément Ory, Jane Stewart, Julien Huau, Hughes-Marie Aulanier, Jean-Marc Jancovici. Climate Risk Impact Screening: the methodological guidebook. Carbone 4, Paris. October 2017.

CRIS website

<http://www.crisforfinance.com>

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More detailed information can be provided upon request (for instance equations, data sources, tools and analysis). Potential users but also research institutions are welcomed to contact us.

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EXECUTIVE SUMMARY

To tackle the issue of how the financial sector can address climate challenges through better disclosure, the Financial Stability Board, upon request of the G20 countries, established the Task Force on Climate-Related Financial Disclosures (TCFD) in December 2015. One year later, the Task Force issued a set of recommendations. In laying out the framework for disclosure, the Task Force outlines **two major categories of climate-related risk: transition risks (related to carbon and mitigation issues) and physical risks (related to impacts and adaptation issues).**

Faced with the absence of adequate tools to analyze the exposure of multi-asset investment portfolios to the physical consequences of climate change, Carbone 4 launched the development of an innovative methodology called Climate Risk Impact Screening, or CRIS. **CRIS is a methodology to provide comprehensive information on the potential risks due to future climate change impacts on a financial asset. CRIS can be applied to corporate, infrastructure, and sovereign assets.**

CRIS has been designed to accompany financial institutions and provides ratings (i) to mainstream climate issues into investment decisions, (ii) to report on the impacts of climate change under three IPCC scenarios, and (iii) to enhance dialogue with portfolio constituents.

Based on a multi-hazard scenario-based assessment, a value-chain analysis, and a pragmatic bottom-up approach, CRIS enables the broad assessment of different climate-related physical risks facing financial assets (that can be a company, an infrastructure or a country) and their underlying business units in the future. It generates ratings easily comparable by market indices, peers, markets, and sectors for different physical risks and allows users to see which business segments in different markets are more or less at risk.

Each climate risk rating is a function of location-specific climate hazards and sector-specific vulnerability. It is a combination of climate projections for specific areas (i.e. risks related to sea-level rise, increase in temperature, heat waves, floods, etc.) and an issuer's sector-specific vulnerability. Concretely, mapping a company's activities is based on its financial reports (sectoral and geographical breakdowns of fixed assets or revenues depending on the sectoral capital intensity). Climate information captures the change of intensity (or frequency) of climate-related hazard in the future due to climate change, based on scientific projections and location-specific aggravation factors. Sectoral vulnerability profiles integrate the potential impacts on assets, expenses and sales based on an exhaustive review of sectoral and past events reports.

CRIS method cover 7 direct hazards, 9 risk-aggravating context indicators, 210 countries, and all business sectors organized in 60 different sectoral vulnerability profiles, for 3 IPCC scenarios (low, medium and high-emission scenario) and 2 time horizons (2050 and 2100).

The CRIS methodology was developed with support from the French Development Agency (AFD), Caisse des Dépôts et Consignations (CDC), Fond de Réserve pour les Retraites (FRR), Natixis-Mirova, Caisse Centrale de Réassurance (CCR), CDG Capital, Etablissement de retraite additionnelle de la Fonction Publique (ERAFP), Electricité de France (EDF) and BNP Paribas, and with input from a high-level scientific advisory board.

Carbone 4 developed a unique service based on this method. Corporate risk ratings will be available for the **MSCI World universe** in early 2018. The CRIS service will also propose a statistical bottom-up approach that covers **10,000 listed issuers. For infrastructure, real-estate, and private equity, CRIS services are ready-to-use** for every sector and country. **Sovereign risk ratings are available at the country level for 210 countries.**

With this new method, **Carbone 4 is the first to offer the financial sector a complete climate risk analysis package**, addressing both transition risks (with our carbon-related CIA method) and physical risks (with this CRIS method).

I. A BRIEF INTRODUCTION TO PHYSICAL RISKS

Climate-related financial risk issues made major gains in visibility when Mark Carney, Chair of the Financial Stability Board and Governor of the Bank of England, delivered a speech at Lloyd's of London on September 29, 2015. Drawing notably on examples from the insurance sector, Carney emphasized the potential misalignment between financial time horizons (shorter term) and climate change time horizons (longer term) that might threaten financial stability on a massive scale. Reflecting a growing sentiment among financial stakeholders, he concluded that in order to avoid abrupt changes in the valuation of assets, **information disclosure is key**: *"With better information as a foundation, we can build a virtuous circle of better understanding of tomorrow's risks, better pricing for investors, better decisions by policymakers, and a smoother transition to a lower-carbon economy."*

Climate change brings two families of risks that are relevant for the financial sector: physical risks that expose assets to the consequences of climate change (e.g. rising sea levels, drought, flooding, etc.), and transition risks related to the impacts of policies to reduce greenhouse gas (GHG) emissions.

Climate projections extracted from the latest IPCC report

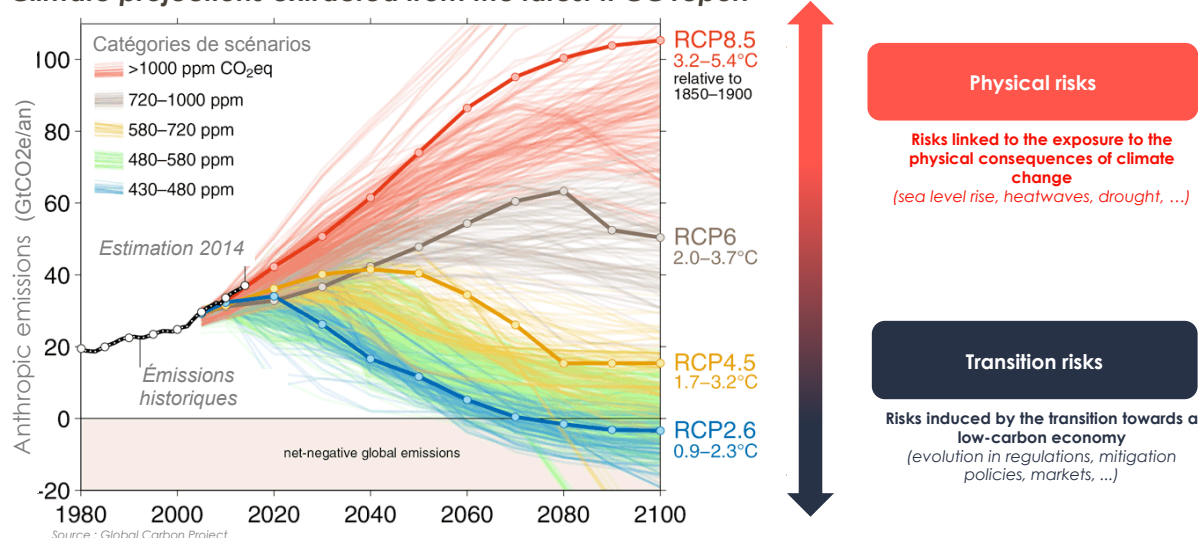


Figure 1 - Climate-related risks posed by climate change

More concretely, physical risks stem from the **potential impacts of climate change that will materially and financially** affect companies and economies in general. A great many corporate subsystems may be affected: infrastructure first of all, but also operational processes, employees and the entire chain of logistics and subcontractors. These physical impacts may lead to direct physical or operational risks, financial, regulatory or legal risks, market risks, damage to reputation and image, or political consequences. **The consequences of climate change will have an impact on the value of investment portfolios and on the repayment capacity of companies, via the impacts on their operating cash flows.**

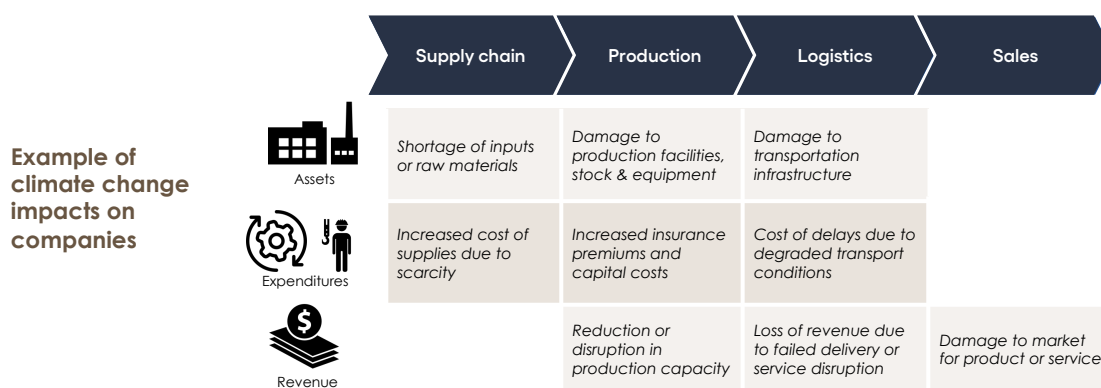


Figure 2 - Climate change exposes companies to several types of risks leading to drops in revenues and impairment losses
(Source: Carbone 4)

Investors are more and more inclined to push companies to address climate change issues (see the Task Force on Climate-related Financial Disclosures), and legislators require investors to report on both types of risk (see the French Energy Transition Act, article 173). **It is absolutely necessary to anticipate the physical risks of climate change**, and this will call for a better understanding of the phenomena involved and a close analysis of all the portfolio assets exposed to these risks.

CRIS meets this need, with a method that assesses exposure of financial assets to physical risks linked to climate change. This service is based on an innovative methodology developed with support from the French Development Agency (AFD), Caisse des Dépôts et Consignations (CDC), the French Fond de Réserve pour les Retraites (FRR), Natixis-Mirova, Caisse Centrale de Réassurance (CCR), CDG Capital, French public-sector pension manager ERAFP, Electricité de France (EDF) and BNP Paribas, and with input from a high-level scientific advisory board.

Some key facts

- **Number of events causing economic losses has tripled between 1980 and 2014.**
- In 2016, **1900 loss events occurred** representing USD 175 bn. **93% of these events were climate-related** (hydrological, meteorological, and climatological events).
- **Only 30% of 2016 weather-related loss events were insured.**
- **Floods in Thailand in 2011 with losses of 45 USD bn showed how a local impact can alter global supply chains:** 9,859 factories closed, 1,700 roads destroyed or paralysed, 6000 cars not produced each day, hard disk prices doubled, etc. **Only 22% were insured.**



Wildfire in Canada in May 2016: USD 4bn overall losses, 28% uninsured



Floods in Europe in May-June 2016: USD 6bn overall losses, 47% uninsured



Hurricane in Caribbean in Sept 2016: USD 10bn overall losses, 63% uninsured



Floods in China in July 2016: USD 20bn overall losses, 98% uninsured

Figure 3 - Some key figures on recent climate-related loss events
(Source: Pictures from Munich Re 2016 & Figures from Munich Re 2016 and Riverside 2012)

II. CORE PRINCIPLES AND RESULTS OF CRIS

1. Objectives and coverage

Carbone 4 introduces its new Climate Risk Impact Screening (CRIS) method to **assess physical climate-change risks that affect corporate, infrastructure, and sovereign investment portfolios**. It is designed to accompany financial institutions in the context of a changing global climate.

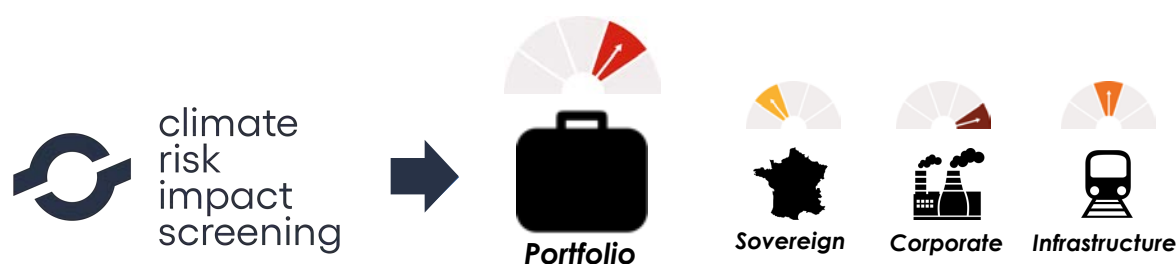


Figure 4 - CRIS provides ratings for corporate, infrastructure and sovereign investment portfolios

In concrete terms, **the CRIS method enables the provision of risk ratings for securities and for portfolios**, which **capture exposures to several physical risks under three scenarios from the Intergovernmental Panel on Climate Change (IPCC) and two future time horizons**. Ratings for issuers are built by assessing the sectoral and geographic distribution of the issuer's activity, and correlating them with scientific databases processed by Carbone 4. The final rating includes a climate component and a sectoral and contextual vulnerability rating, considering different projected climate trends and future climate scenarios, for various time frames.

CRIS ratings on physical risks at the portfolio level allow users to **understand how much of their portfolio is at high risk due to climate change**, for three IPCC scenarios. **CRIS ratings can be incorporated into risk management systems to enhance long-term return at the portfolio and asset level**. Best-in-class and benchmark analysis makes it possible to **identify the riskiest assets across a portfolio**. More detailed information enhances **dialogue with the underlying assets' owners**.

CRIS ratings are available for all countries and sectors. Sovereign risk ratings are already available at the country level for 210 countries. Carbone 4 will propose a new service to make corporate risk ratings available for the MSCI World universe in early 2018. The CRIS service will also provide a statistical bottom-up approach that covers 10,000 listed issuers. For infrastructure, real-estate and private equity, CRIS services are ready-to-use for every sector and country.

2. Main features

1. A comprehensive assessment of physical risks

The climate change risk of an asset, such as a corporate stock or bond, infrastructure project, or sovereign bond, can be studied with varying degrees of detail and at various scales. An extensive literature and market review reveals a lack of comprehensive methodology to assess the physical risk exposure of large, multi-asset portfolios spanning the entire globe. Most studies carried out by asset owners and managers have centered on a few individual assets at the project evaluation or pre-investment stages (i.e. for project finance), or have focused on a specific sector, specific geographic region, or on a handful of extreme climate events. However, there is a clear need to measure the risk level of entire portfolios, both to guide investment strategy and to meet reporting requirements. **The high number of assets requires an efficient and comprehensive approach to risk analysis**, all while maintaining a high level of accuracy regarding asset-specific characteristics and location.

CRIS responds to the need for global coverage, all with a bottom-up, asset-by-asset approach. Its main objective is to enable users to assess the exposure of multi-asset portfolios to all main physical climate change hazards in all geographical regions. **CRIS offers a multi-hazard risk screening, based on a multi-scenario climate projections analysis and a value-chain sectoral vulnerability assessment.**



Figure 5 - CRIS deals with the impact of climate-related hazards on multi-asset investments

CRIS covers 7 direct climate hazards, acute and chronic; 9 risk-aggravating contexts that lead to indirect climate hazards (such as floods); all countries are covered (210), for 3 climate scenarios and 2 future time horizons. An exhaustive list of potential impacts on the assets, expenses, sales and value chain of business activities have been carried out for all sectors, based on a 60-sector classification. **CRIS method enables a comprehensive analysis of physical risks rising from climate change.**

The CRIS method covers risks only and not opportunities that could arise from climate change.

2. A rigorous approach based on transparent databases

CRIS method is based on a robust methodological framework. Risk is expressed as a combination of a climate hazard and a vulnerability to this hazard. For one particular asset, risk depends mostly on its location and on its sectoral activity.

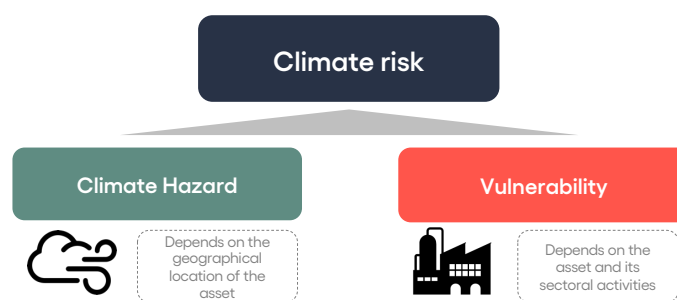


Figure 6 - The methodological framework for CRIS risk analysis

Therefore, CRIS combines:

1. **Descriptive financial data on the company's activity that are company-specific**, to capture the geographic and sectoral breakdown of its activities (fixed assets or revenues depending on the sectoral capital intensity);
2. **And scientific data on climate hazards and sectoral and sovereign vulnerability, that are respectively location-specific and sectoral specific**, to assess the climate evolutions and the gross vulnerability of each sector to each hazard.

These scientific databases have been built upon a rigorous and transparent approach. For instance climate data was extracted and statistically processed from multi-model ensemble and scenarios used by IPCC for each hazard. Median signal and uncertainties coming from the models are captured, for each scenario et time horizon. Original data are sourced and all processing steps are described.

3. A pragmatic bottom-up approach

CRIS carries out risk analysis for each portfolio constituent before aggregating individual risk ratings at the portfolio level, based on the relative weight of each constituent. Similarly, **for a company with various sectoral activities in various countries, the risk analysis is run for each of the underlying business segments** before aggregating risk ratings at the company level. This bottom-up approach is ideal for several reasons. It is well suited to the analysis of physical climate change risks, as the impacts of these risks are highly dependent on the geographic location of an asset. The bottom-up method facilitates integration of asset-specific characteristics, such as resiliency measures undertaken by a company, thus enhancing dialogue and shareholder engagement. This characteristic also makes it possible to compare different assets present in the same sector or the same location. Lastly, a bottom-up method allows detailed information on the underlying assets. **Final indicators are rich, founded on various layers of aggregated data which can be revealed according to the user's desired level of information.**

To offer the most comprehensive coverage, all CRIS analyses rely on publicly available data. Anticipating data availability constraints, **CRIS applies a pragmatic tier-based approach** in conducting individual analyses: the most precise and relevant data are used where available, with progressively less precise data, even averages, being used if necessary. In this way, CRIS is operational even in the absence of the most precise data, and easily accommodates updated and higher quality data as they are published. Therefore, CRIS analysis can currently be run for MSCI companies and sovereign assets (since financial information is readily available). For specific infrastructure or real estate assets, CRIS analysis is ready-to-use but contingent on the availability of financial information. In this first version, the CRIS service used country-level climate information, except for 6 countries that have infra-national averages (Canada, USA, Brazil, Russia, India and China).

While the CRIS methodology takes an asset-by-asset approach, it remains a preliminary screening tool to identify the most exposed securities. Following CRIS analysis, more detailed asset-specific studies can be carried out, and that process should inspire companies to disclose more data over time.

4. Multidimensional indicators for diverse user-oriented applications

Physical risk issues can be managed in three different ways; hence CRIS ratings were designed to answer three potential different uses.



Figure 7 - CRIS provides useful information for three applications

First, CRIS indicators are ideal for reporting. Regulatory and international standards, such as Article 173 of the French Energy Transition Law and the recommendations of the Task Force on Climate-Related Financial Disclosures (TCFD), distinguish physical risks and transition risks in reporting frameworks. In the TCFD recommendations, insurance companies are encouraged to describe the potential impacts of physical risks from changing frequencies and intensities of weather-related perils, and provide quantitative information at the business division, sector, or geography levels. The TCFD also recommends that organizations describe how resilient their strategies are to climate-related risks, taking into consideration scenarios consistent with increased physical climate-related risks. Accordingly, CRIS provides risk ratings for different scenarios and time horizons, to understand and improve the resilience of investment strategy under different plausible future states of the world. The IPCC scenarios used in CRIS, which describe GHG emissions trajectories and their respective global warming levels, are universally recognized and provide a consistent foundation for scenario testing.

Second, results are designed to inform investment strategy. CRIS indicators can be easily integrated into internal management systems such as Environment, Social and Governance (ESG) systems. The overall rating, attributed to an entire portfolio, facilitates comparison with a benchmark portfolio and guides asset allocation. Risk ratings attributed to each portfolio constituent allow for comparison with the best-in-class in a sector. At both the asset and portfolio levels, risk ratings are broken down by climate hazard in order to understand the risks. Multi-level indicators provide an array of options for target-setting and portfolio optimization.

Last but certainly not least, **CRIS results should be used to enhance dialogue with portfolio constituents.** CRIS allows financial organizations to optimize dialogue by identifying which securities require improved resiliency measures, but also which ones require improvements in data availability and disclosure. The richness of the asset-level information offered by CRIS, detailed later in this guide, adds structure and consistency to the dialogue. As a result, engagement and risk management efforts are more focused and productive.

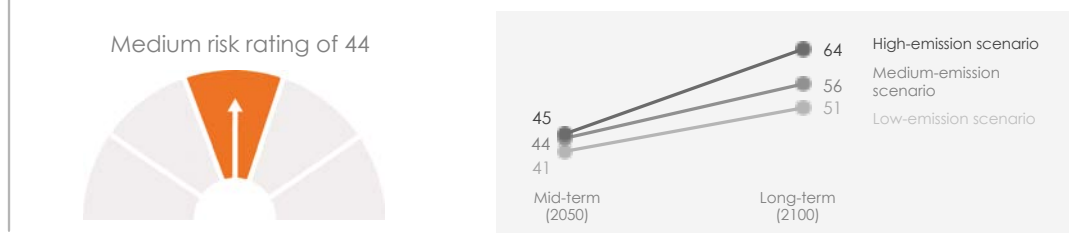
3. Core indicators

CRIS provides a set of comprehensive information on different climate change related physical risks facing financial assets and their business units in the future. It generates ratings that are easily comparable with market indices, peers, markets, and sectors for different physical risks and allows users to see which business segments are more or less at risk in different markets. Risk ratings are attributed on a scale of 0 to 99: the higher the rating, the higher the risk for a given asset. A 5-class system has also been designed.

The following core ratings are provided at the asset and portfolio levels: an overall aggregated risk rating run under three different IPCC climate scenarios and two time periods (2050 and 2100) and risk ratings for 7 direct climate hazards.

Aggregated risk rating for mid-term and medium-emission scenario, and sensitivity analysis for various scenarios and time horizons

Ratings are expressed on a scale from 0 to 99 across all scenarios, time horizons, and countries.



Risk ratings by climate hazard for the asset for mid-term horizon and medium-emission scenario

Ratings for each hazard are expressed on a scale from 0 to 99 across all scenarios, time horizons, and countries.

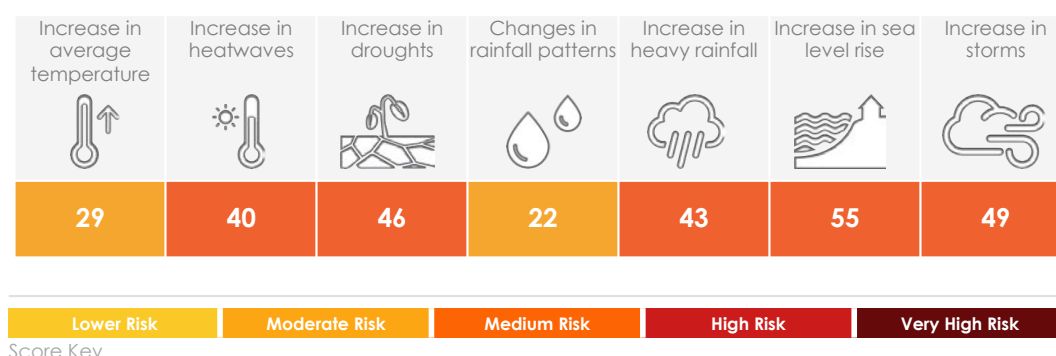


Figure 8 - CRIS main ratings are multi-hazard and hazard-specific (example for a fictional asset called Alpha)

In addition to these core ratings, CRIS furnishes detailed indicators at the issuer level and the portfolio level.

Additional indicators for companies:

- Comparison with sectoral average and best-in-class
- Data quality/availability rating
- Geographic distribution of business activities (revenue or assets)
- Sectoral distribution of revenue
- For top 3 climate hazards, detail of sub-ratings for each sector-country pair

Additional indicators for corporate portfolios:

- Comparison with benchmark portfolio
- Distribution of risk ratings in the portfolio
- Portfolio exposure to most vulnerable sectors
- Top 5 companies (highest risk rating)
- Bottom 5 companies (lowest risk rating)
- Average risk rating by sub-sector and comparison with best-in-class

Additional indicators for countries:

- Comparison with regional average and best-in-class
- Uncertainty of climate trends for each hazard
- Data quality indicator
- Breakdown of climate hazard rating by hazard intensity component and asset vulnerability component
- Further breakdown of gross vulnerability rating by vulnerability component
- For top 3 climate hazards, comparison of hazard rating with those of regional peers

Additional indicators for infrastructure projects:

- Comparison with sectoral average and best-in-class
- Data quality indicator
- Breakdown of climate hazard rating by hazard intensity component and asset vulnerability component
- Breakdown of risk-aggravating context information by climate hazard
- For top 3 climate hazards, comparison of hazard rating with those of regional peers

Below are three examples of detailed analyses run for a corporate asset, a country, and a portfolio of 25 corporate assets. More detailed explanations are given in the sections Implementation steps and Case studies for sovereign and corporate assets.

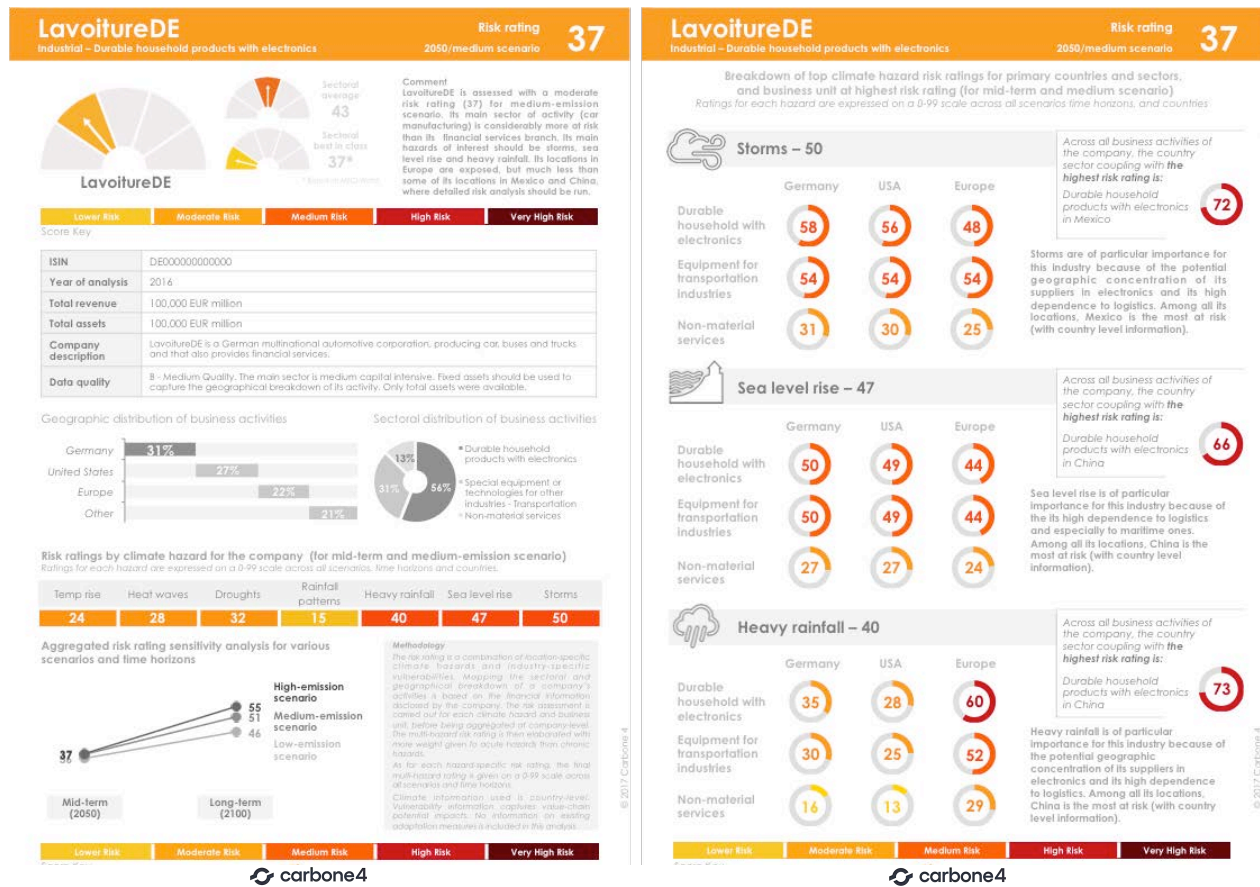


Figure 9 - CRIS analysis run for a corporate asset with multiple business units

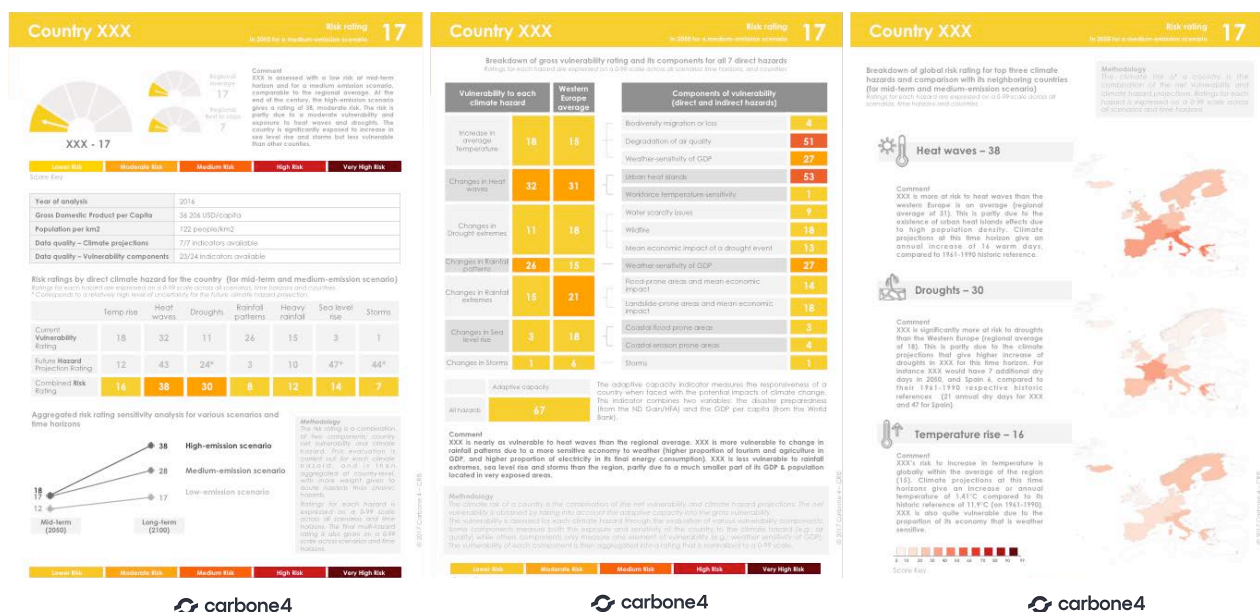


Figure 10 - CRIS analysis run for a country in Europe



Figure 11 - CRIS analysis run for a portfolio of 25 companies

4. What do risk ratings represent

Climate risk ratings provide a first set of comprehensive information on the potential risks due to future climate change impacts on a financial asset. It does not provide a measure of Value at Risk that would be expressed in monetary terms.

CRIS risk ratings capture the increased risks due to future climate change; CRIS ratings does not capture the absolute risk from future climate or weather, but it does capture the increased risk due to the increase in intensity or frequency of the climate-related hazards in the future due to global warming. This is explained in the climate hazard rating: climate data are future climate anomalies that captures the change of intensity (or frequency) of the hazard in the future due to climate change, compared to the historical reference average hazard.

1. General principles

Climate risk is a function of location-specific climate hazards and industry-specific vulnerability. It is a combination of climate projections for specific geographic locations (such as higher temperatures, more intense heat waves, etc.) and an issuer's sector-based vulnerability.

For companies operating in various sectors and countries, mapping a company's activities is based on its financial reporting (fixed assets or revenues depending on the sectoral capital intensity). The intensity of climate hazards, such as extreme temperatures or extreme precipitation in a given location, is based on scientific projections and location-specific aggravation factors. An asset's net vulnerability has two components: its gross vulnerability (a function of exposure and sensitivity) and its adaptive capacity. Sector-specific gross vulnerability profiles have been built for all sectors. Methods to determine vulnerability depend on the type of asset being studied and are explained in the following section.

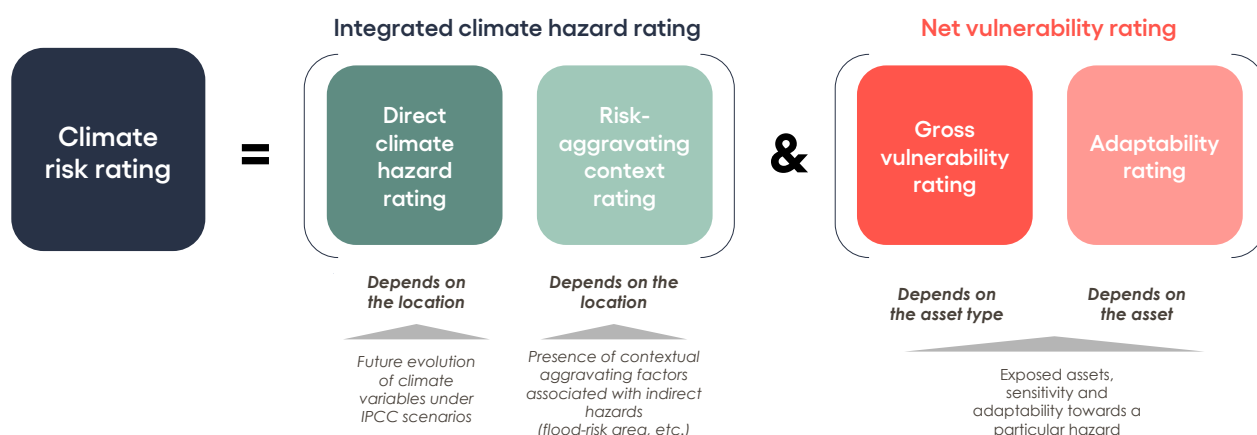


Figure 12 - The main components of CRIS climate risk ratings

CRIS provides qualitative risk ratings. CRIS does not handle damage functions that provide amounts of quantitative damage in monetary terms. Final ratings are attributed on scale of 0 to 99 and do not provide a financial estimation of potential financial losses at either the portfolio or asset level. Nevertheless, ratings are based on a robust analysis of several physical risks for each component of a portfolio. They are based on relative or normalized risk ratings, meaning that the highest and lowest points on the rating scale are determined by the countries or sectors the most and the least at risk for a given climate hazard (e.g. sea level rise). In other words, ratings are determined using a detailed segmentation of physical risks for various points of financial impact and climate hazards, across all sectors and countries. This segmentation segregates the overall ratings and distributes risk ratings over all potential assets and portfolios. Normalization is also used to accommodate the diverse types of information needed to assess climate risks (different units, scales, etc.).

As the rating scale is relative, a low rating does not necessarily imply low risk in absolute terms; it is in the lower part of the gradient in relative terms, but the absolute impact is unquantified. Consistency checks have been carried out in an iterative manner to verify that the values are consistent with the hazards, business sectors, and all other related factors.

2. Main calculation principles

Risk ratings are dimensionless, and they are built upon several steps of calculation that handle intermediate indicators translated on a scale of 0 to 99. At the end of the process, **the final risk ratings are also given on a scale of 0 to 99 across all scenarios and time horizons.** The higher the rating the higher the risk. Five categories of risk are then derived based on the level of risk. The main steps of calculation are described below (More detailed explanation on equations used can be provided upon request).



Figure 13 - Five categories of risk based on the CRIS ratings

The aggregated multi-hazard risk rating is based on the weighted geometric mean of all the risk ratings calculated for each of the 7 hazards. More weight is given to acute hazards (event-driven hazard) than to chronic hazards (long-term shifts) to take into account the fact that they are more difficult to anticipate.

For a company with multiple business segments (various sectors in various countries), **for each hazard, the risk rating is based on the weighted arithmetic mean of all the risk ratings calculated for each of the company's business segments** for this same hazard. Weighting is proportional to the breakdown of the company's revenue in its various segments.

For each hazard, the risk rating of a specific sector in a specific country is a combination of the hazard rating of the country and the vulnerability rating of the sector. For sovereign risk, the vulnerability is country-specific.

For corporate and infrastructure, the climate hazard is a combination of direct hazard rating and risk aggravating context rating. The aggregation is based on a weighted geometric mean that gives more weight to direct hazards.

3. Main methodological principles

The calculation steps previously described call for different types of information:

- The direct climate hazard ratings are based on climate information that is country-specific (sub-country spatial resolution is available for some regions);
- The risk aggravating information is based on thematic indicators that are, by default, country-specific, but can be replaced by site-specific information if available (especially relevant for infrastructure);
- The gross vulnerability ratings are sector-specific for corporate and infrastructure and country-specific for sovereign;
- The adaptability ratings are not included in corporate and infrastructure (to be developed in the next version of CRIS), and are country-specific for sovereign;
- The sectoral and geographical breakdown of a company's activities is based on the financial information disclosed by the company. It is usually sup-country or country level information. It is rarely asset-level information.

Therefore, to calculate the climate risk rating for a given asset (a company, project, or country), the two components of climate hazard and vulnerability depend on a variety of information:

- **Some of this information is unique to the asset being studied.** This financial information is sourced from financial data providers and individual financial reports.
- **Other information is invariable for all assets,** mainly climate hazard ratings and sectoral vulnerability profiles. They form the CRIS datasets and are described in the following section.

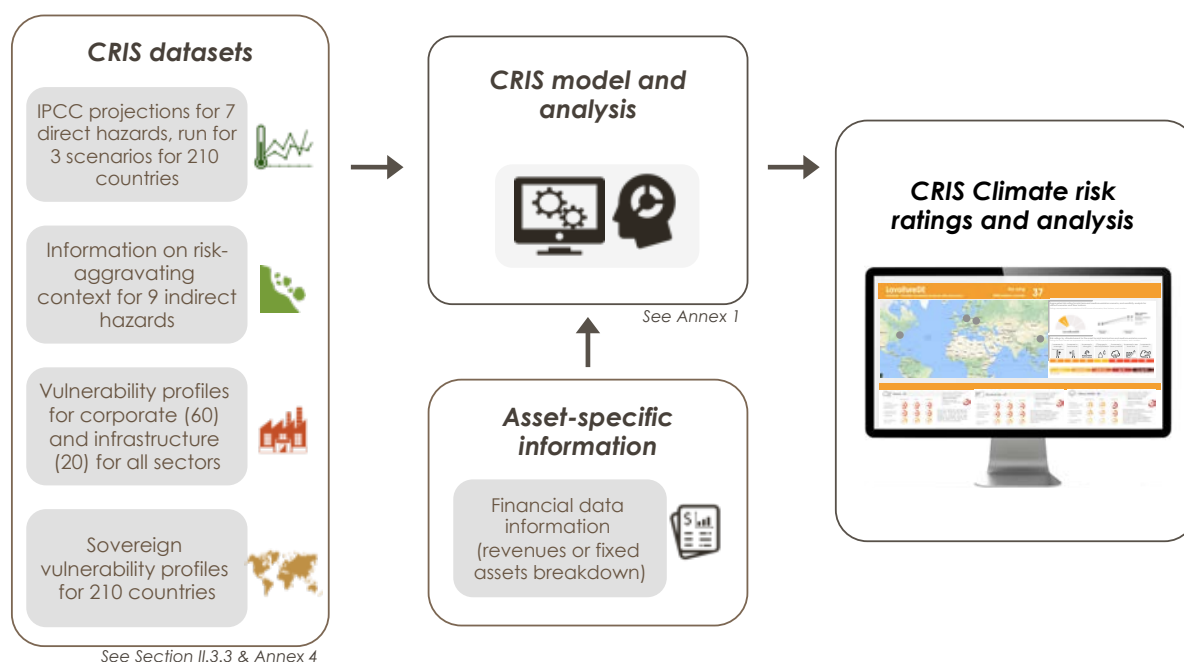


Figure 14 - Functioning principles of CRIS

5. Main datasets

1. Overview

The generic data has been catalogued into four distinct datasets, two of which pertain to information on climate hazards and another two of which pertain to vulnerability.





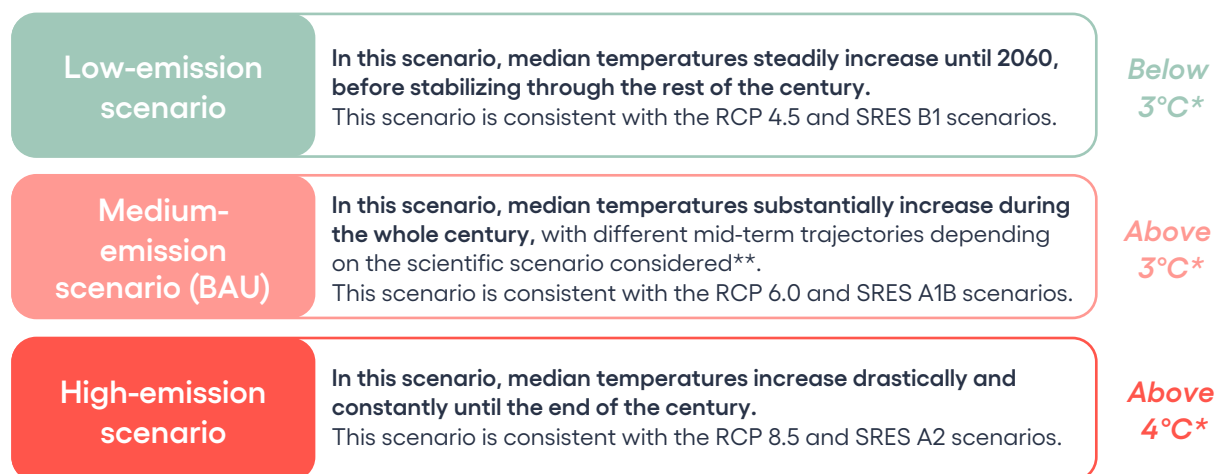
				
	IPCC projections for 7 direct hazards, run for 3 scenarios and 2 time horizons	Information on risk-aggravating context for 9 indirect hazards	Sectoral vulnerability profiles for corporate (60) and infrastructure (20)	Sovereign vulnerability profiles for 210 countries
Coverage	Worldwide	Worldwide	Cross-sectoral	Worldwide
Perimeter	7 direct climate hazards considered, acute and chronic	9 indirect climate hazards considered	All corporate and infrastructure sectors (covering all assets)	Around 210 countries
Time horizon	IPCC projections-based time horizon: mid-century and end of century	Most recently covered for socio-economic information, but most are timeless information	NA	Most recently covered for socio-economic information
Granularity	Country, and infra-country for 6 countries	Country	60 sub-sectors for corporate, 20 for infrastructure	Country
Rating scale	1 to 99 (and 0 if not applicable, for instance sea level rise for countries with no coastline)	1 to 99	1 to 99	1 to 99
Rating components	Future change in Intensity & frequency compared to an historic reference period and uncertainty	Hazard-specific proxies for risk-aggravating factors	Gross vulnerability based on potential impacts on 13 financial items covering asset, expenses, sales and value chain issues	Gross vulnerability and adaptive capacity
Primary external information	IPCC Climate projections (CMIP5 and CMIP3 multi-model and multi-scenario experiences), EMDAT and PSMSL	Worldwide databases (WB, UNEP, etc.)	Documentation review and expert opinions	Worldwide databases (WB, ND-Gain, etc.)
Processing	Statistical approach and normalization	Normalization	Use of 15 sector-specific vulnerability factors	Normalization

Figure 15 - Main features of CRIS datasets

2. Direct climate hazard dataset

CRIS hazard ratings captures the change of intensity (or frequency) of the hazard in the future *due to climate change*, and not the absolute intensity of the hazard in the future.

The direct climate hazard dataset provides projections for each hazard and country (or infra-country for large countries, where data is available). Most climate data is sourced from the IPCC with a multi-model approach. The dataset includes projections for three scenarios (low-emission scenario, medium-emission scenario, and high-emission scenario) and two time horizons (2050 and 2100). For availability issues, both RCP and SRES scenarios had to be used.



*In 2100 relative to the preindustrial period 1861-1980.

**Please note that the mid-term trajectory differs between RCP 6.0 and SRES A1B. The latter rises faster than RCP 6.0 and slower after 2050.

Figure 16 - CRIS analysis are available for three IPCC climate scenarios

Seven direct hazards are covered ; both acute (event-driven) and chronic (long-term shifts) hazards.

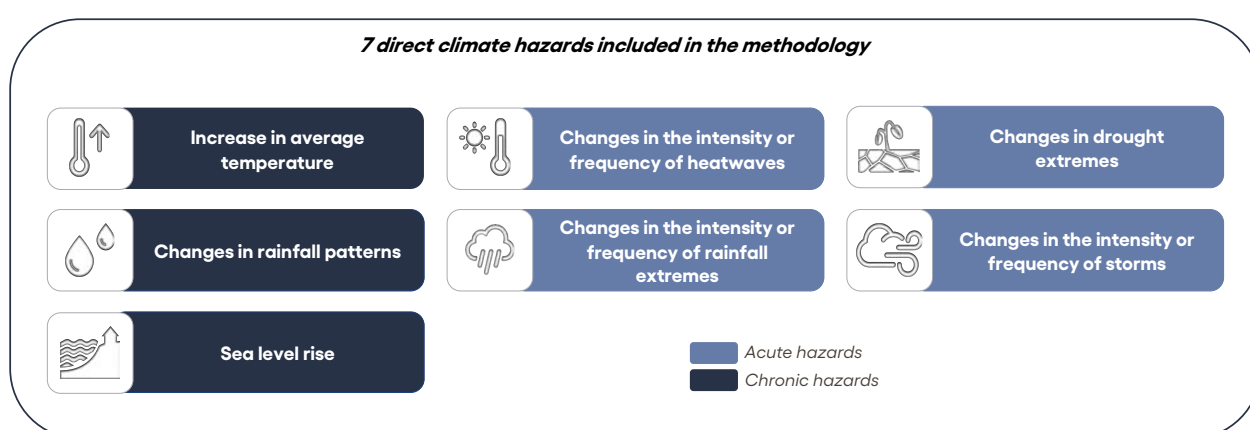


Figure 17 - CRIS analysis covers seven direct hazards

The climate hazard rating is given for each hazard as a rate on a scale of 1 to 99 (0 for sea level rise for countries with no coastline), across all countries, future scenarios, and time horizons. The higher the rate the higher the relative future change of the hazard in a country compared to other countries.

For each hazard, this rating is based on the analysis of the spatial and time distribution of one or two climate variables that capture, when available, information on the magnitude, the duration and the frequency of the hazard (particularly relevant for acute hazards). To build a rating of 1 to 99 for each climate variable and each country, the relative changes are first extracted in the future time horizons as compared to the historic reference period, and then normalized across all scenarios and time horizons.

Below are the ratings calculated for the increase in average temperature for a high-emission scenario and for the end of the century. Canada attains the maximum hazard rating (99) due to exposure to +6,41°C on average for the entire country. France is less exposed, with an average +4°C, and therefore exhibits a hazard rating of 58 for this same time horizon and scenario.

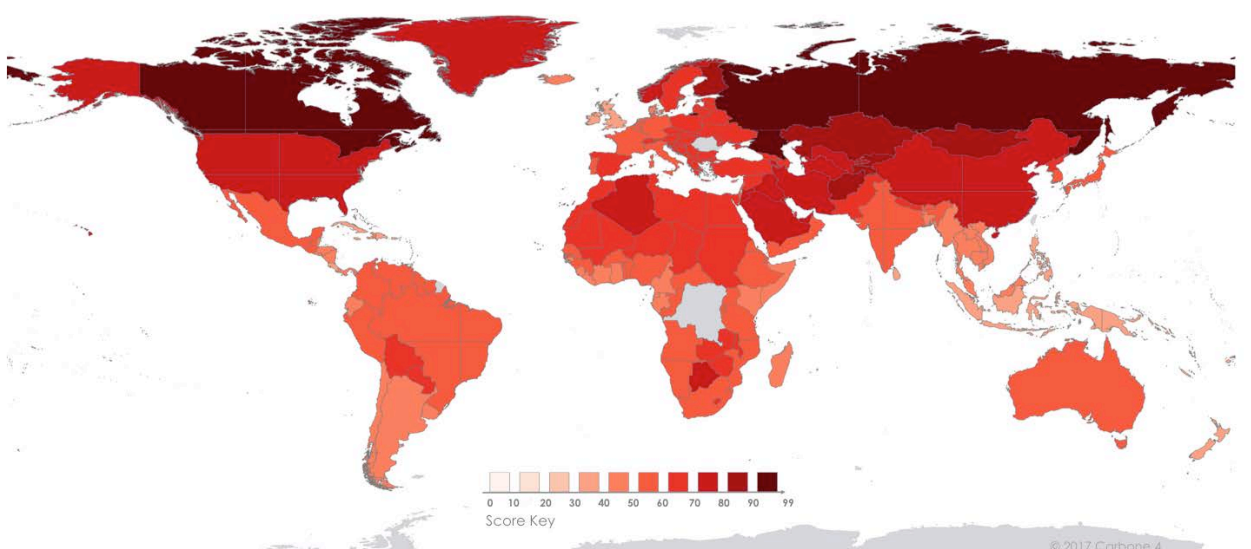


Figure 18 - CRIS ratings capturing increases in annual mean temperature, run for a long-term horizon and a high-emission scenario (countries with no data are in grey)

3. The risk-aggravating context for indirect climate hazards

Climate hazard ratings combine information on a direct hazard associated with information on the risk-aggravating context to capture indirect hazards. For instance, increase in heavy rainfall is a direct hazard directly impacted by climate variables regardless of other parameters. Landslides, on the other hand, depend mostly on climate variables (i.e. heavy rainfall) but also on geophysical parameters (e.g. % high slopes in the area). “Landslide risks” is an indirect hazard and the % of slopes in the area the risk-aggravating context information.

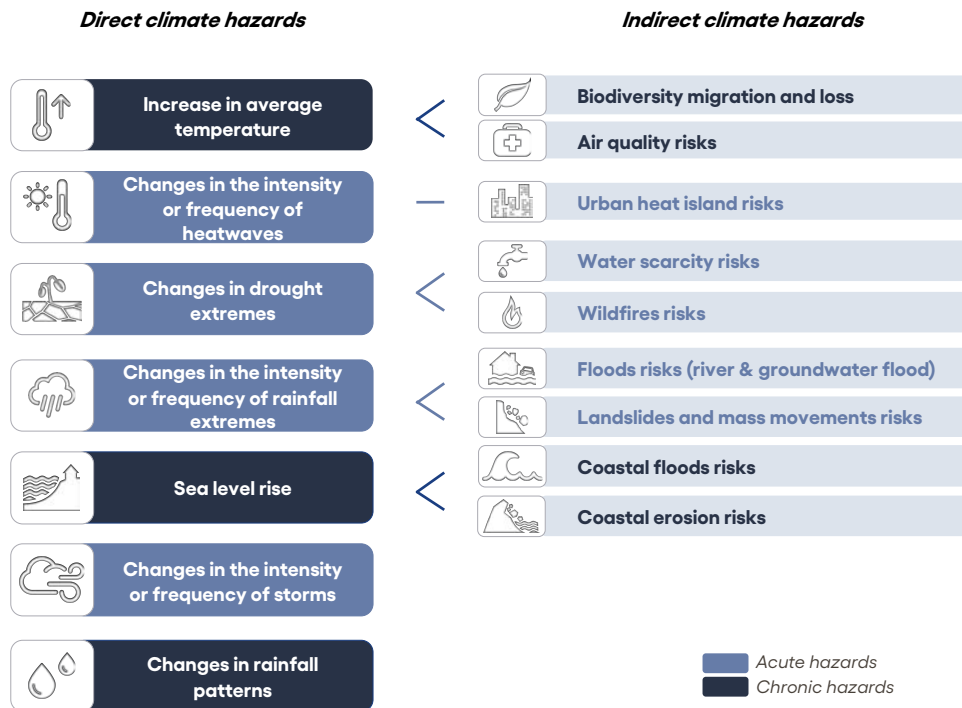


Figure 19 - CRIS covers 7 direct climate hazards and 9 indirect climate hazards

The risk-aggravating context information is given for nine indirect climate hazards and around 210 countries.

The rating is given on a scale of 1 to 99. The higher the rate, the higher the risk-aggravating context compared to other countries. This information is built upon proxies (called Indicators) that capture the vulnerability of the country towards the studied phenomenon. Indicators reflecting the presence of geophysical aggravating criteria were selected in priority; otherwise, indicators reflecting population exposure were selected. To build a rating of 1 to 99 for each indirect hazard and each country, the indicators are analyzed and then normalized across all countries.

Below is given the distribution of the risk-aggravating context for landslide risks for all countries, it is based on the analysis of the % of high slopes in each country and its scoring between 1 and 99.

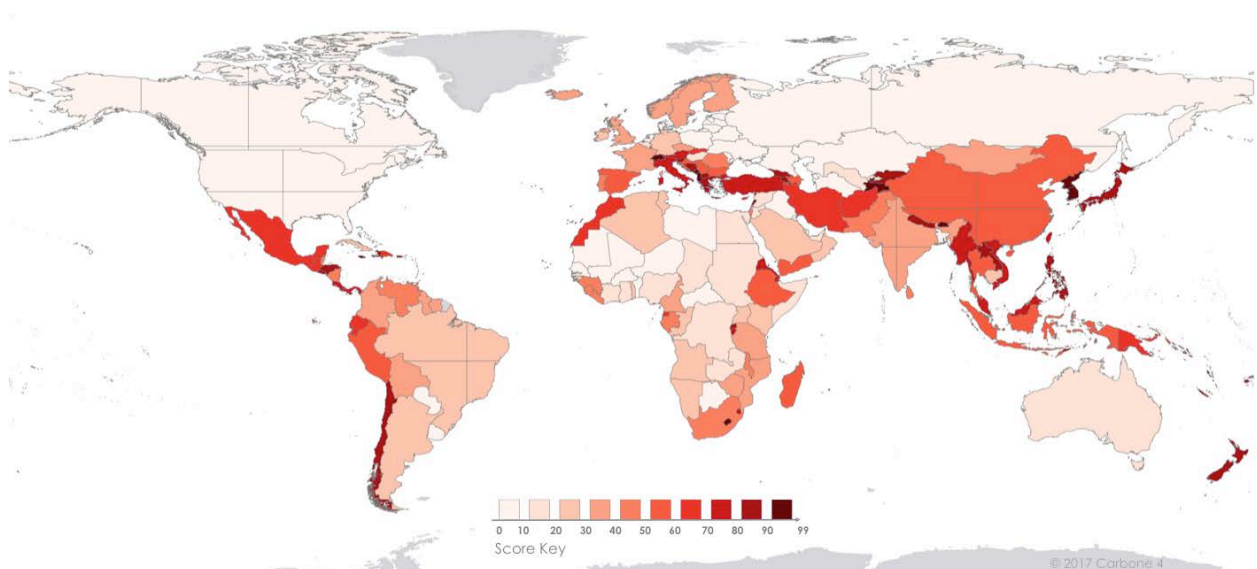


Figure 20 - CRIS ratings capturing the presence of mountainous areas
(used as a risk-aggravating context for landslide risks)

4. Sectoral vulnerability dataset

The sectoral vulnerability dataset compiles each sector and subsector's level of vulnerability to each climate hazard. This dataset is used in the analysis of corporate and infrastructure assets.

For each hazard, the vulnerability is given as a rating on a scale of 1 to 99. The higher the rate, the more vulnerable the sector as compared to other sectors. This rating is based **on the aggregation of the vulnerability of 13 financial items covering assets, expenses, and sales.** This information was built on the identification of all potential impacts that could affect the 13 financial items and the review of **15 cross-sectoral vulnerability factors covering the entire value chain** that can impact the magnitude of these impacts and can be assessed for each sector. This information was elaborated based on an extensive literature review covering sectoral and regional analysis, past event studies, and asset-level expert reports.

Financial items		Potential climate impacts
Assets / CAPEX	Tangible assets (includ. upgrading assets)	Asset deterioration & reduced life, need for investment in tangible assets (buildings, plants, infrastructure, etc.)
	Intangible assets	Depreciation of intangibles assets (licenses, etc.)
	Current assets	Damages or depreciation of current assets (stocks, etc.)
Expenses / OPEX	Purchase and change in stocks of raw materials	Increased costs due to resource scarcity or decreased average quality
	Purchase and change of stocks of consumables and small equipment	Increased costs due to need for more resilient equipment or new needs
	Purchase of non-storable supplies of water and energy	Increased costs due to increased needs or resource scarcity
	Employee wages	Increased costs due to health and security issues
	Day-to-day maintenance and repairs	Increased maintenance costs due to more frequent or new damages
	Insurance costs	Increased insurance costs due to increased potential hazards
	Transport services for goods & employees	Increased costs for logistics due to environmental or other constraints
Revenue / Income	Sales volume	Decrease in the production yield and efficiency of business operations
	Selling price	Decrease in selling price (competition, quality, etc.)
	Markets (risks only)	Decrease in market demand for goods and services

Figure 21 - CRIS sectoral vulnerability dataset is structured according to 13 financial items and their respective climate change potential impacts

Upstream value chain	<ol style="list-style-type: none"> 1. Production depending on water availability 2. Production depending on electric energy availability 3. Production depending on raw materials or on materials sensitive to climate variation 4. Geographic concentration of suppliers/cluster tendency
Process	<ol style="list-style-type: none"> 5. Production relying on long-lived assets 6. Production relying on highly specific and complex assets 7. Weather sensitivity (other than cold) of production and operation process 8. Need to cool processes and workplaces
Workforce	<ol style="list-style-type: none"> 9. Workforce intensity of production 10. Proportion of outdoor workers
Logistics	<ol style="list-style-type: none"> 11. Need for cold chain 12. Use of road and rail transportation 13. Dependency to port facilities and operations
Demand	<ol style="list-style-type: none"> 14. Weather sensitivity of price volatility 15. Weather sensitivity of sales

Figure 22 - CRIS sectoral vulnerability is based on the analysis of 15 factors of vulnerability that influence the magnitude of the potential impacts of climate change on the financial items

Corporate and infrastructure vulnerability profiles are sector-specific. The CRIS sectoral classification scheme covers all business sectors and was conceived according to climate vulnerability profiles. Corporate assets are classified into 60 sectors while infrastructure assets are classified into 20. CRIS classification is GICS, ICB, and NAICS compatible to facilitate use of a company's reported information in CRIS analysis.

5. Sovereign vulnerability

The CRIS sovereign risk rating is intended to complement the financial risk assessments performed by rating agencies. In other words, the CRIS sovereign risk rating is conceived as a type of aggravating factor that is likely to exacerbate existing sovereign risk profiles.

The sovereign vulnerability dataset is hazard-specific and country-specific. Sovereign vulnerability is determined for 7 climate hazards and 210 countries. The vulnerability is given for each hazard as a rating from 1 to 99. The higher the rating, the more vulnerable the country compared to other countries. This rating is built upon the aggregation of various **underlying indicators covering the three main components of vulnerability (exposure, sensitivity, and adaptive capacity)**, and is determined for each hazard on a scale of 1 to 99. The indicators were chosen to capture the potential impacts on infrastructure, natural resources, population, and industrial means that all impact the three main dimensions of the sovereign rating: economic strength (relating to growth, trade and wellbeing), financial strength (public finances and government budget) and social strength (equality of wealth, health). These indicators can either be structural timeless variables (such as a country's km²) or socio-economical evolving indicators (such as the country's population).

Below is given an example of the indicators used to capture sovereign vulnerability to rainfall extremes hazard, it is a combination of 6 indicators.

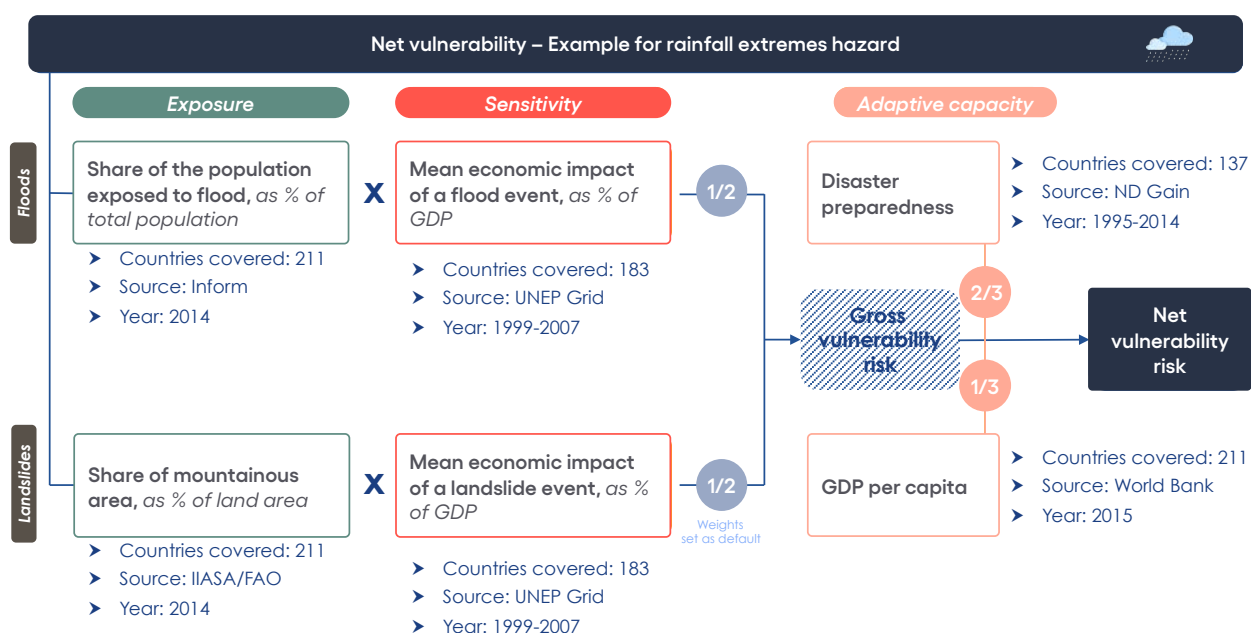


Figure 23 - Example of indicators used for CRIS sovereign vulnerability to rainfall extremes

III. IMPLEMENTATION STEPS

1. *Running CRIS analysis for a listed company*

For corporate analysis, CRIS combines financial data on the company's activity with scientific data on climate hazards and vulnerability profiles for the sectors and countries in which the company operates. For listed companies for which financial information is disclosed publicly, CRIS analysis can already be run. The step-by-step approach is described based on the example of "La Compagnie de l'électricité" (called LCDE afterwards), a fictional name for a European electric utility company.

1. **STEP 1: collecting the sectoral and geographical breakdown of operations**

The geographical and sectoral breakdown of the company's operations is what makes each global risk rating unique.

The first piece of information to collect is the main sector of activity of the company. According to its main sector, the CRIS SCI (Sectoral Capital Intensity) dataset indicates the right proxy to capture its geographical breakdown. If the sector is capital-intensive, fixed assets should be used. If it is not intensive, revenues are sufficient. If intermediate, an average of both indicators should be used.

LCDE's main sector is the production of conventional electricity, a high capital-intensive sector. Fixed assets or PPE, or at least long-lived assets, should be used as a proxy to capture the geographical breakdown of its activities.

Fixed assets or revenues can then be collected through financial databases and other reports where the company discloses its financial information:

- Business segments are typically presented using GICS or NAICS classification. Therefore, the correspondence table can be used to translate the sectors provided into CRIS sectors.
- The geographical information is based on each company's own granularity (mega-region, country, infra-country, etc.). In CRIS, ratings can be given at the country level. Therefore, country-level information should be collected. More detailed information can be found in financial reports and other thematic reports published by the company.
- If the company does not provide the breakdown according to each sector/country coupling, CRIS applies the default hypothesis that each sector is homogeneously distributed in all countries where the company is present.

A data quality rating is provided according to the availability of this information.

For LCDE, Factset/TR databases provide a breakdown of fixed assets based on 2 sectors, 3 countries and the rest of the world. This information is not sufficiently detailed. Therefore, CRIS analysts spent more time analyzing LCDE's external publications (website, CSR reports, etc.). We identified 4 more specific sectors and more than 23 countries where activities are more specialized than in the Factset/TR (e.g. % of renewable production in each country). Total fixed assets were detailed and calculated based on the production capacity and the type of energy produced. This information was given by LCDE at country level. This level of information is less detailed than asset-level data in some cases (Spain, with many plants) but very close to asset-level data in others (UK, where LCDE has only one plant). We will call this level of information "business unit"-level information. We were then able to provide the breakdown of all business units in the company. The data quality rating was set to high quality due to the availability of fixed assets information.

2. STEP 2: building the risk ratings for each hazard

Risk ratings are first built for each hazard, each time horizon, and each scenario.

Following the definition of risk, for each business unit, the risk rating is the combination of a location-specific hazard rating and a sector-specific vulnerability rating. **This information is included in the CRIS datasets and is automatically generated.**

For LCDE, the distribution of the risk ratings for its main sector (production of conventional electricity) when faced with droughts across all countries is shown on the following map. 23 of these ratings were collected to cover the 23 countries in which LCDE operates.

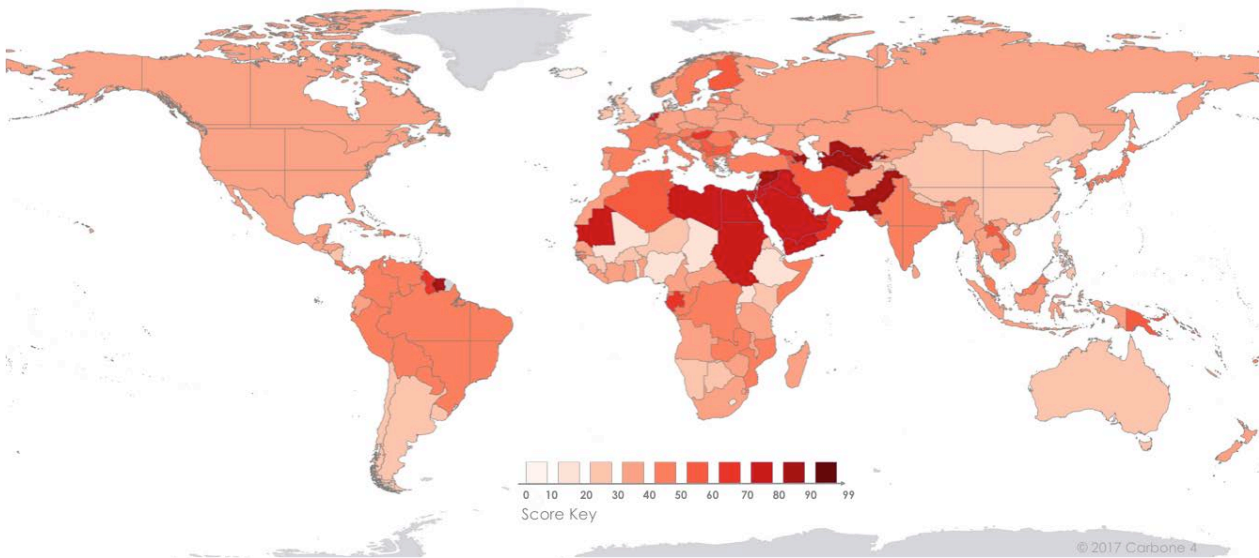


Figure 24 - Hotspots for the production of conventional electricity facing future increase in droughts, based on CRIS ratings run for mid-term and medium-emission scenario for this specific sector and hazard (this rating combines climate projections, risk-aggravating context information, and sectoral vulnerability)

This information is pulled up and combined to produce one rating per hazard, horizon, and scenario. **The risk rating for each climate hazard is calculated as an average of the risk rating of all business segments, weighted by the proportion of each business segment in the overall activities.**

3. STEP 3: building the aggregated risk ratings

Next, the hazard-specific risk ratings can be aggregated into a synthetic risk rating, for each horizon and scenario. **The aggregated multi-hazard risk rating is based on the weighted geometric mean of all the risk ratings calculated for each of the seven hazards.** The weighting system gives more weight to acute hazards than to chronic hazards, to take into account the fact that acute hazards are more difficult to anticipate than chronic hazards.

For LCDE, the hazard-specific ratings and synthetic rating for a medium-emission scenario and mid-term time horizon are as follows.

Risk ratings by climate hazard and aggregated synthetic risk rating for the company, for mid-term time horizon and medium-emission scenario

Ratings for each hazard are expressed on a scale of 0 to 99 across all scenarios, time horizons, and countries.

Temp rise	Heat waves	Droughts	Rainfall patterns	Heavy rainfall	Sea level rise	Storms	Synthetic risk rating
27	42	41	16	35	54	50	42

Figure 25 - LCDE's climate risk ratings according to CRIS analysis for mid-term and a medium-emission scenario

2. Running CRIS analysis for an infrastructure or real-estate asset

For infrastructure, real estate, and private equity, business information will be provided by the users themselves, as this information is not typically disclosed publicly. Nevertheless, the process is very similar to that of listed companies.

1. STEP 1: collecting the asset-specific information

As with the company-level analysis, the first piece of information to collect is the sectors of activity, based on CRIS classification, and the countries of operation.

Additional site-specific information must be collected, corresponding to information on the **risk-aggravating context information**. For instance, is the project located in a flood-prone area? In a coastal area? In a very dense city? This information can be provided by the owner, or through thematic web-based databases: WRI's Acqueduct for floods, NASA for coastal submersion, etc. (a list of potential databases can be provided upon request).

If no information is found on some indirect hazards, the country-level database can be used: country-level average of proxies capturing the exposure to these indirect hazards.

2. STEP 2: calculating the integrated climate hazard ratings

For corporate and infrastructure assets, the climate hazard is a combination of direct and indirect climate hazards. For country-level analysis used for companies, CRIS automatically generates this information, whereas for infrastructure or real-estate, this information can be asset-specific and has to be calculated for each asset. The aggregation of direct hazard projections and risk-aggravating context information is based on a weighted geometric mean that gives more weight to direct hazards (see Equation 4).

3. STEP 3: calculating the risk rating for each hazard

The risk ratings are first built for each hazard, each horizon, and each scenario.

Following the definition of risk, for each business segment, **the risk rating is the combination of a location-specific hazard rating and a sector-specific vulnerability rating** (see Equation 3).

4. STEP 4: building the aggregated risk ratings

The hazard-specific risk ratings can then be aggregated into synthetic risk ratings, for each horizon and each scenario. **The aggregated multi-hazard risk rating is based on the weighted geometric mean of all the risk ratings calculated for each of the seven hazards** (Equation 1). The weighting system gives more weight to acute hazards than to chronic hazards, to take into account the fact that acute hazard are more difficult to anticipate than chronic hazards.

3. Running CRIS analysis for a portfolio

1. STEP 1: building the risk ratings for all underlying assets

To analyze the level of risk for a multi-asset portfolio, the risk ratings first have to be built at the asset level. An asset can either be a company, a piece of infrastructure, a plant, a building, or even a country. To understand how these individual risk ratings are built, see the previous sections.

2. STEP 2: aggregating the risk rating at the portfolio level

The first step is to build the risk rating for each hazard, for each horizon, and each scenario. The hazard-specific portfolio rating is a weighted aggregation of the hazard-specific ratings of all the underlying assets. The weight of each component is based on its share in the portfolio (same process as in building the CRIS risk rating for a company based on its business segments).

The synthetic multi-hazard risk rating is the aggregation of all the risk ratings calculated for each of the seven hazards (same process as in building the aggregated CRIS risk rating at the company level).

4. Running CRIS analysis for sovereign assets

The CRIS sovereign risk rating is intended to complement the financial risk assessments performed by rating agencies. In other words, the CRIS rating is conceived as a type of aggravating factor that is likely to exacerbate existing sovereign risk profiles. CRIS sovereign analyses have already been carried out for 210 countries. They do not require the collection of any new specific financial information.

Following the definition of risk, the hazard-specific risk rating is the combination of location-specific hazard rating and a country vulnerability rating (See Equation 3). The vulnerability is not sector-specific and is given in the respective dataset.

The hazard-specific risk ratings can then be aggregated into a synthetic risk rating, for each horizon and each scenario. **The aggregated multi-hazard risk rating is based on the weighted geometric mean of all the risk ratings calculated for each of the seven hazards** (see Equation 1).

The map below shows the CRIS sovereign risk ratings calculated for a high-emission scenario and long-term time horizon. As detailed in the previous section, CRIS risk rating captures the increased risk coming from the future climate change.

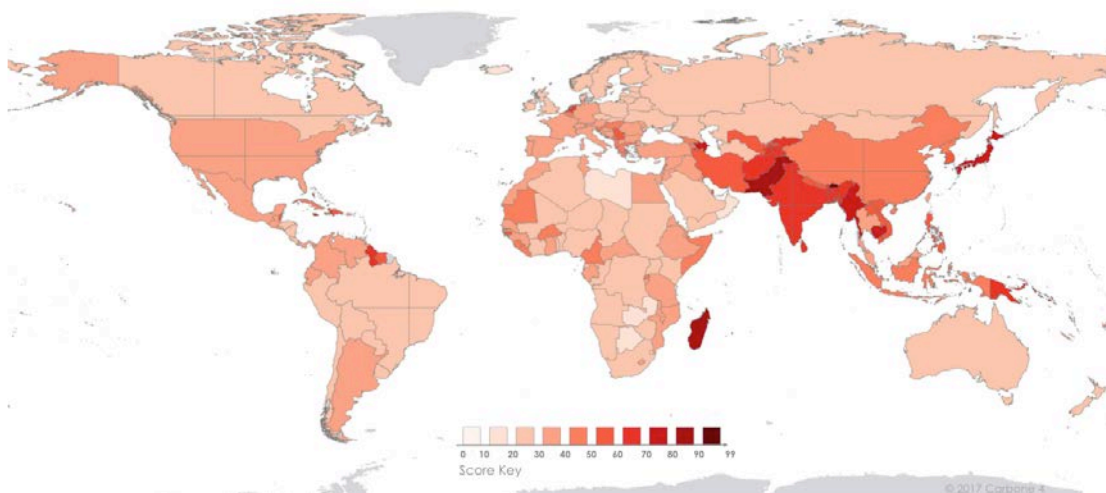


Figure 26 - CRIS sovereign global risk ratings, based on a multi-hazard analysis run for a long-term horizon and a high-emission scenario

IV. CASE STUDIES FOR SOVEREIGN AND CORPORATE ASSETS

1. CRIS analysis of France

1. Data input

Economic and social data on the country were retrieved from various databases, including the World Bank, UNEP, Inform, etc. Climate data are derived from IPCC models, extracted mainly from the World Bank.

Year of analysis	2016
Gross Domestic Product per Capita	36,206 USD/capita
Population per km ²	122 people/km ²
Data quality – Climate projections	7/7 indicators available
Data quality – Vulnerability components	23/24 indicators available

Figure 27 - Country input information

2. Results

France is assessed with a relatively low increase of climate related risks (17) at mid-term horizon and for a medium emission scenario. France faces a level of increased risk comparable to the regional average (i.e. Western Europe).

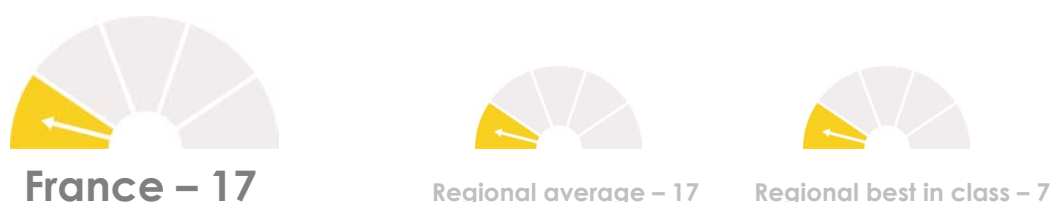


Figure 28 - Global risk rating and regional comparison for France (mid term horizon and medium-emission scenario)

France is facing a low climate risk overall, however with differences between climate hazards. France is more at risk to heat waves and droughts, due to a higher hazard intensity projection rating and vulnerability rating.

	Temp rise	Heat waves	Droughts	Rainfall patterns	Heavy rainfall	Sea level rise	Storms
Current Vulnerability Rating	18	32	11	26	15	3	1
Future Hazard Intensity Rating	12	43	24	3	10	47	44
Combined Risk rating	16	38	30	8	12	14	7

Lower Risk	Moderate Risk	Medium Risk	High Risk	Very High Risk
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Score Key

Figure 29 - Risk ratings by direct climate hazard for France, for mid-term and medium emission scenario

For heat waves:

- France is **more vulnerable to change in heat waves than other countries**, given its high proportion of high-density areas and the related urban-heat-island effects.
- **France is more exposed to increases in heat waves than other countries:** the hottest temperature in France is assumed to rise by +5°C by 2050, while the number of warm days is projected to increase by 16 days within the same timeframe. From these two climate variables, the rating for this hazard is 43, a bit higher than the regional average.

For droughts, France is significantly more at risk than the Western Europe (regional average of 18). This is partly due to the climate projection that gives higher increase of droughts in France for this time horizon. For instance, France would have seven additional dry days in 2050, and Spain six, compared to their 1961-1990 respective historic references (21 annual dry days for France and 47 for Spain).

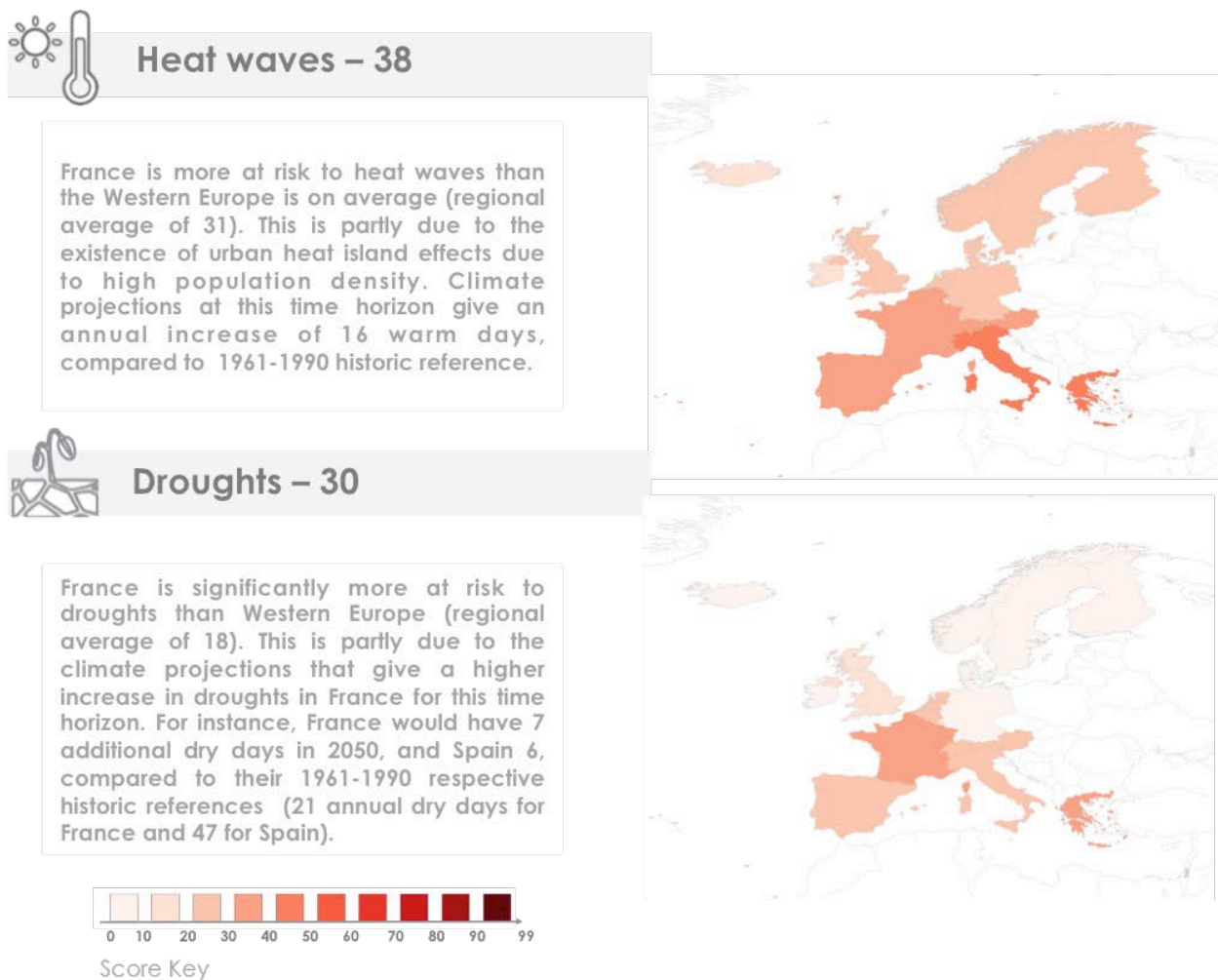


Figure 30 - Focus on France's risk rating for heat waves and droughts and regional comparison (run for mid-term horizon and medium-emission scenario)

3. Methodology

Vulnerability rating

This indicator measures the propensity of countries to be affected by climate hazards, depending on their physical, economic and social characteristics (e.g.: share of high-density areas), on their infrastructures and on their adaptive capacity.

Principles: The net vulnerability rating to each climate hazard is the outcome of three categories of indicators:

- **Exposure:** refers to the presence of natural or man-made assets that could potentially be affected by a climate hazard. For example, exposure to flood events is measured through the indicator “Share of the population exposed to flood” (source: Inform).
- **Sensitivity:** refers to the degree to which a country may be affected by climate change. For instance, sensitivity to floods is measured through the indicator “Mean economic impact of a flood event” (source: UNEP).
- **Adaptive capacity:** refers to the responsiveness of a country when faced with the potential impacts of climate change. This indicator combines two variables: the disaster preparedness (from the ND Gain/HFA) and the GDP per capita (from the World Bank).

The number of indicators used to evaluate vulnerability varies from one (e.g.: weather-sensitivity to GDP for the rainfall patterns hazard) to five indicators (e.g.: drought extremes hazard).

Sovereign vulnerability is expressed on a scale from 1 to 99.

Coverage: 22 exposure and sensitivity indicators are considered in the methodology.

Climate hazards rating

This indicator measures the future change in frequency and intensity of climate hazards.

Principle: seven direct climate hazards and nine indirect hazards are considered in the methodology.

- Direct climate hazards are evaluated through one or two climate variables to capture changes in both intensity and frequency when relevant (e.g.: *very wet days per year for the extreme rainfall hazard*), and future projected changes are expressed in relative changes (compared to the late 20th century).
- In addition, future projections are evaluated through multi-model ensemble outputs run with three IPCC climate scenarios, including a low-emission (below 3°C), a medium-emission (above 3°C), and a high-emission scenario (above 4°C).
- Two time horizons are considered: a mid-term (2050) and a long-term (2100).
- Relative changes are normalized to 1-99 scale across all scenarios, models, and time horizons.

Coverage: The climate data has been built for more than 200 countries and is extracted from the work of the IPCC (RCP or SRES scenarios).

What about the climate risk in different GHG scenarios?

The case study was described in a specific scenario named a medium-emission scenario and in a mid-term horizon (i.e. 2050). In this scenario, median temperatures substantially increase up to 3°C of warming in 2100 compared to the preindustrial period temperature (1861-1980).

The CRIS methodology comprises two other climate scenarios:

1. **A low-emission scenario:** scenario in which more stringent climate policies are implemented, leading to a GHG emissions pathway slightly above the 2°C limit by 2100.
2. **A high-emission scenario:** scenario in which median temperatures increase drastically and constantly until the end of the century, due to the absence of policy changes.

For France, as shown on the graph below:

- Climate risk is intensified in the future, regardless of the scenario considered;
- Climate risk is higher in the high-emission scenario, while France faces lower climate risk in the low-emission scenario.

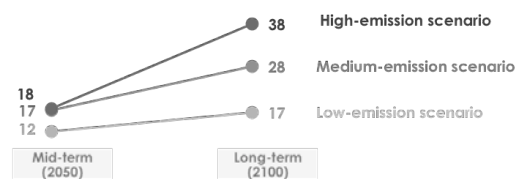


Figure 31 - Climate risk rating of France for various scenarios and time-horizons

2. CRIS analysis for “LaVoitureDE”

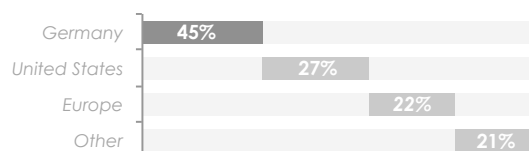
LaVoitureDE (fictional name) is a German multinational automotive corporation producing cars, buses, and trucks, and providing financial services. The following description applies for a mid-term and medium-emission scenario.

1. Data input

The Company’s financial data is retrieved from financial databases. Climate data is derived from IPCC models, mainly extracted from the World Bank.

ISIN	DE0000000000
Year of analysis	2016
Total revenue	100,000 EUR million
Total assets	100,000 EUR million
Company description	LaVoitureDE is a German multinational automotive corporation, producing cars, buses, and trucks and also providing financial services.
Data quality	B - Medium Quality. The main sector is medium capital intensive. Fixed assets should be used to capture the geographical breakdown of its activity. Only total assets were available.

Geographic distribution of business activities



Sectoral distribution of business activities

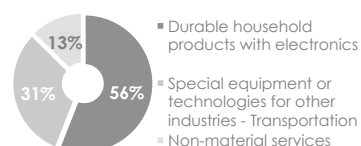


Figure 32 - Company input information

LaVoitureDE is considered a medium capital-intensive company (cf. *SCI ratio*). Hence, the financial information used to map the geographic locations of the company’s business activities should be the average of fixed assets and revenue. Only Total Assets were available, with no further information. The data quality rating was therefore set to B-medium quality.

2. Results

LaVoitureDE is assessed with a moderate risk rating (37) at a mid-term time horizon and for a medium emission scenario. The company faces a level of risk comparable to its sector, based on a sample of 25 companies.

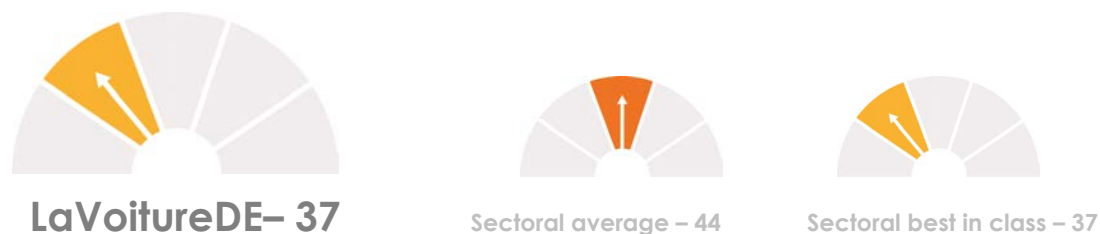


Figure 33 - Global risk rating and sectoral comparison for mid-term and medium-emission scenario

Temp rise	Heat waves	Droughts	Rainfall patterns	Heavy rainfall	Sea level rise	Storms
24	28	32	15	40	47	50
Lower Risk	Moderate Risk	Medium Risk	High Risk	Very High Risk		

Score Key

Figure 34 - Risk rating by direct climate hazard

LaVoitureDE faces moderate climate risk overall, with differences between climate hazards. LaVoitureDE is most subject to risks relative to **storms, sea level rise, and heavy rainfall**, while the change in rainfall patterns represents the lesser risk for the company. **These hazards are of particular interest due to the company's locations and its sectoral activities.**

As a company operating mainly in the automotive industry (classified as industrial producing durable products with electronics within the CRIS classification), LaVoitureDE is more vulnerable to heavy rainfall, storms, and sea level rise for three main reasons:

- Potential **damage to the highly specific assets of the company**, thereby affecting the production process
- Potential **impact on port facilities and road infrastructure** that are frequently used for goods transportation
- Potential **impact on the procurement of materials, which has a tendency for geographic concentration**

The company's locations in Europe are exposed to some intense hazard projections, but much less than some of its locations in Mexico and China, where detailed risk analysis should be run. For instance, for heavy rainfall, across all business units, China received a rating of 73 for a medium-emission scenario and mid-term time horizon. This represents a very high level of risk.



Figure 35 - Breakdown of one of the top risk ratings for primary countries and sectors, and business unit at highest risk rating

What about the climate risk in different GHG scenarios?

The moderate risk rating under a medium-emission scenario in 2050 changes to a medium risk rating for the high-emission scenario in 2100 (+4°C global warming).



Figure 36 - Risk rating sensitivity analysis for various scenarios and time horizons

3. Methodology

Vulnerability rating

This indicator measures the propensity of an economic sector to be affected by climate hazards, depending on its specific characteristics (type of assets, etc.).

Principles: The vulnerability rating combines a generic risk assessment with a sectoral vulnerability evaluation.

- The generic vulnerability measures the potential maximum losses on each of the three financial categories (assets, expenses, and revenues) induced by each climate hazard, regardless of the sector. This information is built on a literature review covering for 13 financial risk areas (e.g.: changes in sales volume for the revenue category).
- The sectoral vulnerability is evaluated through 15 factors that provide information on the sector's sensitivity to climate hazards in each element of the value chain (e.g.: heat waves and the factor 'weather sensitivity of sales'). These factors are assessed for each sector and financial item.

Both vulnerabilities are expressed on a scale from 1 to 99, then aggregated through weighted geometrical averages.

Coverage: This indicator covers all sectors, organized in 60 sectors.

Climate hazards rating

This indicator measures the future change in the frequency and intensity of climate hazards.

Principle: seven direct climate hazards and nine indirect hazards are considered in the methodology.

- Direct climate hazards are evaluated through one or two climate variables to capture changes in both intensity and frequency when relevant (e.g.: *very wet days per year for the extreme rainfall hazard*), and future projected changes are expressed in relative changes (compared to the late 20th century).
- In addition, future projections are evaluated through multi-model ensemble outputs run with three IPCC climate scenarios, including a low-emission (below 3°C), a medium-emission (above 3°C), and a high-emission scenario (above 4°C).
- Two time horizons are considered: a mid-term (2050) and a long-term (2100).
- Relative changes are normalized to a scale from 1 to 99 across all scenarios, models, and time horizons.

Coverage: The climate data has been built for more than 200 countries and is extracted from the work of the IPCC (RCP or SRES scenarios).

Climate risk rating at the company level

Climate risk is a combination of climate hazard and vulnerability, which respectively depend on a company's locations and sectors.

Principle:

- The climate risk evaluation is carried out for each climate hazard and business segment.
- Once the risk is assessed for the seven climate hazards, the climate risk of the company is obtained through the aggregation of these seven hazard-specific ratings.

V. GLOSSARY

Acute hazard: Acute hazards refer to those that are event-driven, including increased severity of extreme weather events, such as cyclones or floods.

Adaptive capacity: The adaptability of a company, country, or project is a measure of its responsiveness when faced with the potential impacts of climate change. Adaptability will depend on the preventive measures put in place, as well as the entity's ability to adjust and recover from potential damage.

Climate hazard: The potential occurrence of a natural or human-induced physical event, trend, or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources (IPCC).

Chronic hazard: Chronic hazards refer to longer-term shifts in climate patterns (e.g. sustained higher temperatures) that may cause sea-level rise or chronic heat waves.

Direct climate hazard: Direct hazards are directly impacted by climate variables regardless of other parameters. They can be directly impact by climate change.

Exposure: Exposure is measured by the presence of natural or man-made assets potentially affected by a climate hazard. A sector may have high exposure to climate hazards, such as the fossil fuel transportation and distribution sector whose infrastructure is concentrated in coastal areas, or low exposure to hazards, such as the banking sector, which has few tangible assets.

Financial impact: A financial impact is when financial items such as physical assets, capital expenditure, operational expenditure, and revenue are affected, whether positively or negatively.

Financial risk: The probability of financial impacts on the underlying assets.

Gross vulnerability: The gross vulnerability of an asset is the propensity to be affected by climate hazards. It is the result of exposure and sensitivity to a climate hazard, and hence is specific to each asset.

Indirect climate hazard: Indirect hazards depend mostly on climate variables but also on geophysical parameters.

Net vulnerability: The net vulnerability of an asset is the result of gross vulnerability and adaptability.

Risk: The combination of the probability of an event and its negative consequence (UNISDR).

Sectoral Capital Intensity (SCI): ratio measuring a sector's dependence on tangible asset investment to create revenues. Capital intensity is defined as the ratio of fixed assets value over net sales value (inverse of the fixed asset turnover ratio). These ratios were built for the major sectors used in CRIS, based on a large sample of corporate financial data (257 companies).

Sensitivity: Sensitivity is the degree to which a sector (and thus the companies operating in that sector) might be affected by climate change. This could be the extent of the anticipated change in working conditions due to increasing heat waves, for example.

Vulnerability: see gross or net vulnerabilities