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ASSESSING INFRASTRUCTURE PORTFOLIOS' EXPOSURE TO CLIMATE CHANGE

CIARA Physical risks
Methodological guide

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The 2-infra challenge initiative has been supported by:

First & Prime sponsors — *Prime sponsor*

AFD, La Banque Postale Asset Management, Climate-KIC, Meridiam — Generali Global Infrastructure

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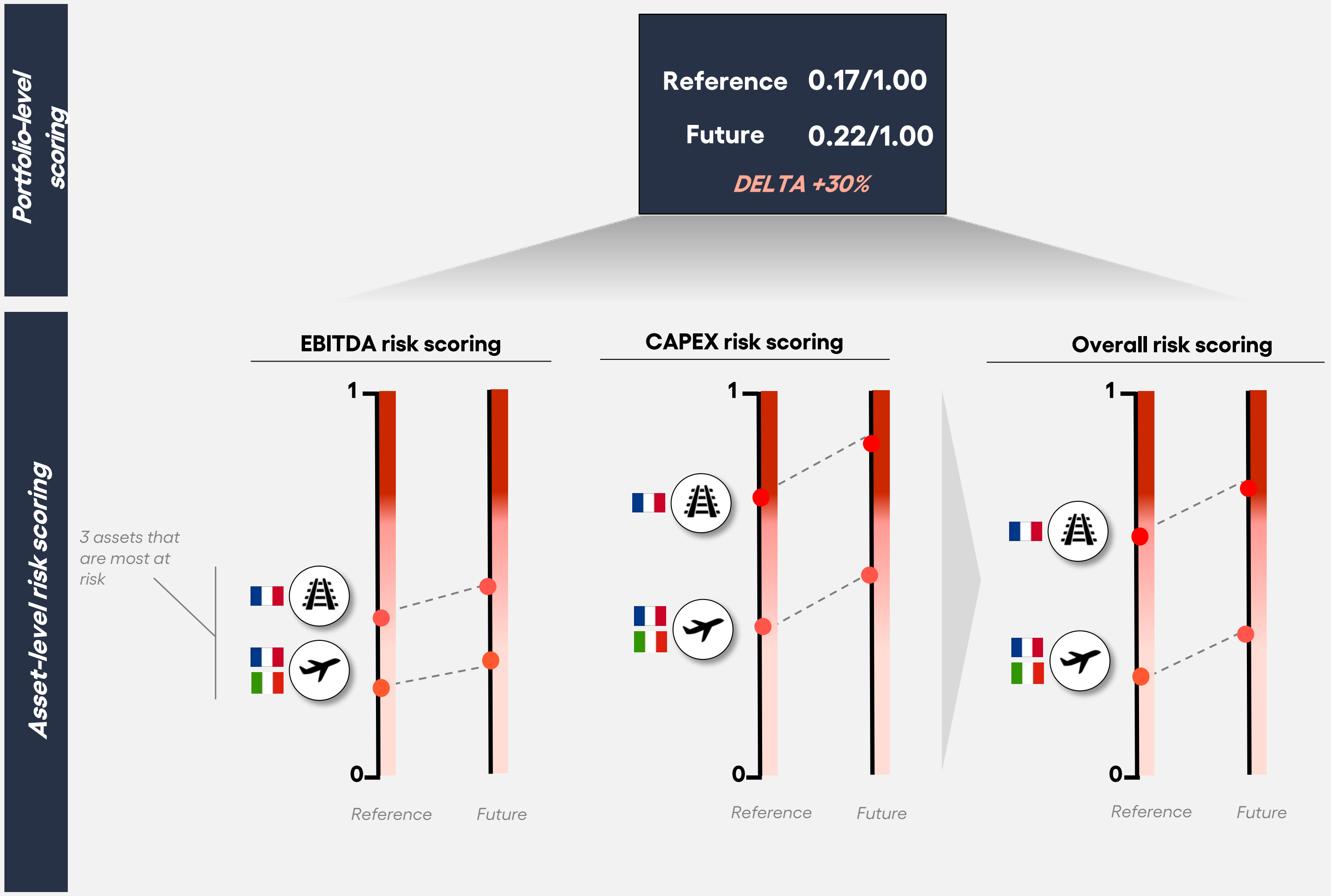
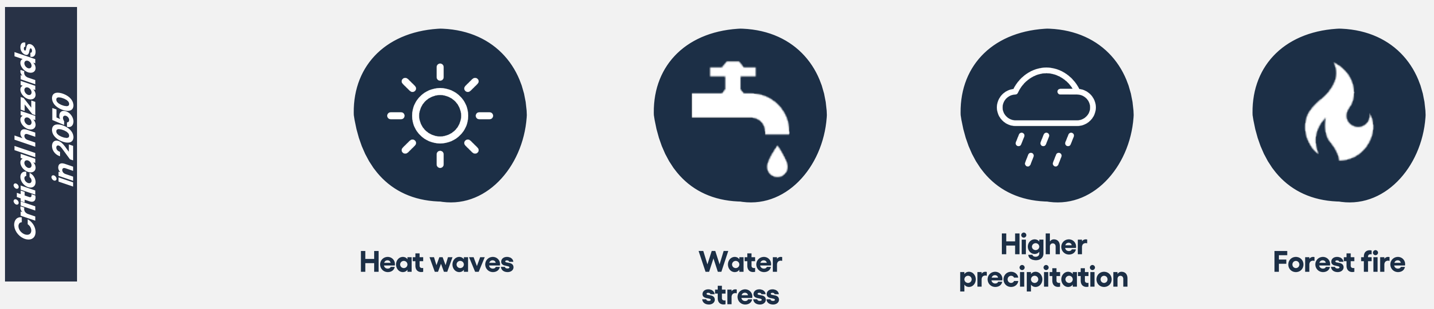
CIARA's physical risks module

- ✓ A scoring module **designed for infrastructure financial players**
- ✓ **Asset-specific** : close to **100 asset profiles** are featured in the module
- ✓ Provides **CAPEX** and **EBITDA physical risks scoring** at **portfolio level** and **asset level**
- ✓ Enables to seize:
  - the increase in risk between 2050 vs. 1995 (reference period), in a high emissions scenario (RCP 8.5)
  - which assets are most at risk
  - what are the critical climate hazards to be prepared for





A very limited set of information is needed to carry out the analysis:

most importantly, **the asset GPS location must be provided** in order to capture precise climate evolutions for the asset location.

Foreword

CIARA (https://ciara.carbone4.com/) was developed by Carbone 4 as a suite of services to help infrastructure investors and asset managers build the climate strategy of their portfolios.

It provides fundamental climate-related metrics associated to infrastructure: carbon footprint, green share, 2°C alignment and climate-related risk scoring (physical and transition risks). CIARA enables infrastructure investors and asset managers to evaluate key TCFD[1] climate metrics at asset and portfolio level.

CIARA enables calculation of key climate-related metrics for infrastructure portfolios

2°C alignment, transition and physical risks assessment methodologies within CIARA services were developed with the support of the "2-infra challenge" initiative, gathering five financial sponsors: the French Development Agency, La Banque Postale AM, EIT Climate KIC, Meridiam and Generali Global Infrastructure.

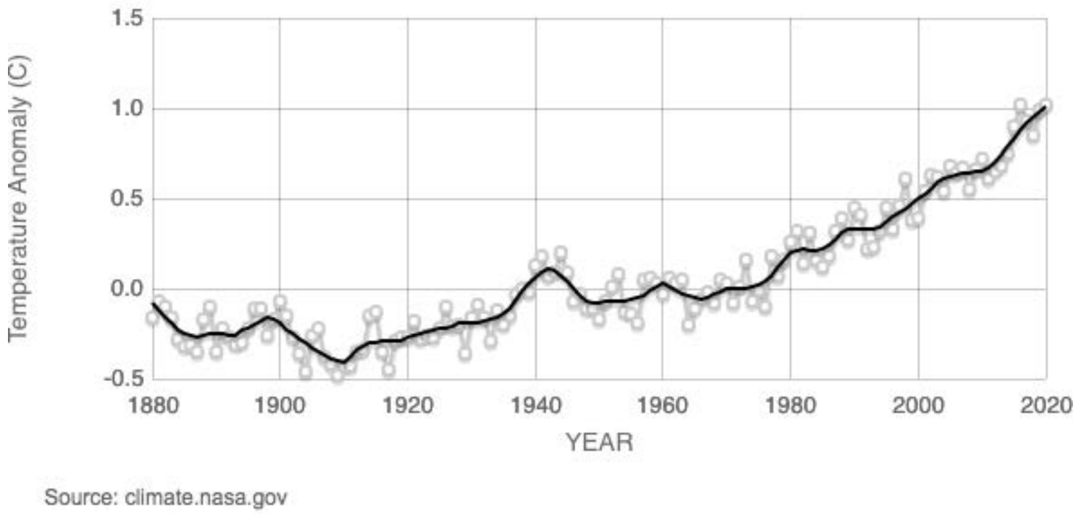
A guide on the 2°C alignment methodology is already available.

[1] The Task force on Climate-related Financial Disclosures was established in 2015 by the Financial Stability Board. It has set up guidance for "more effective climate-related disclosure".

Adapting infrastructure investments to a fast-changing climate: a major challenge

The Earth's climate is rapidly changing

The Earth surface is warming fast: it gained +0.15°C between 2000 and 2010 and +0.36°C between 2010 and 2020[2]. In 2020, global warming reached a +1.2°C level compared to the preindustrial period, making it the hottest year on record, on par with 2016. The last five years are the five warmest years observed since 1850.

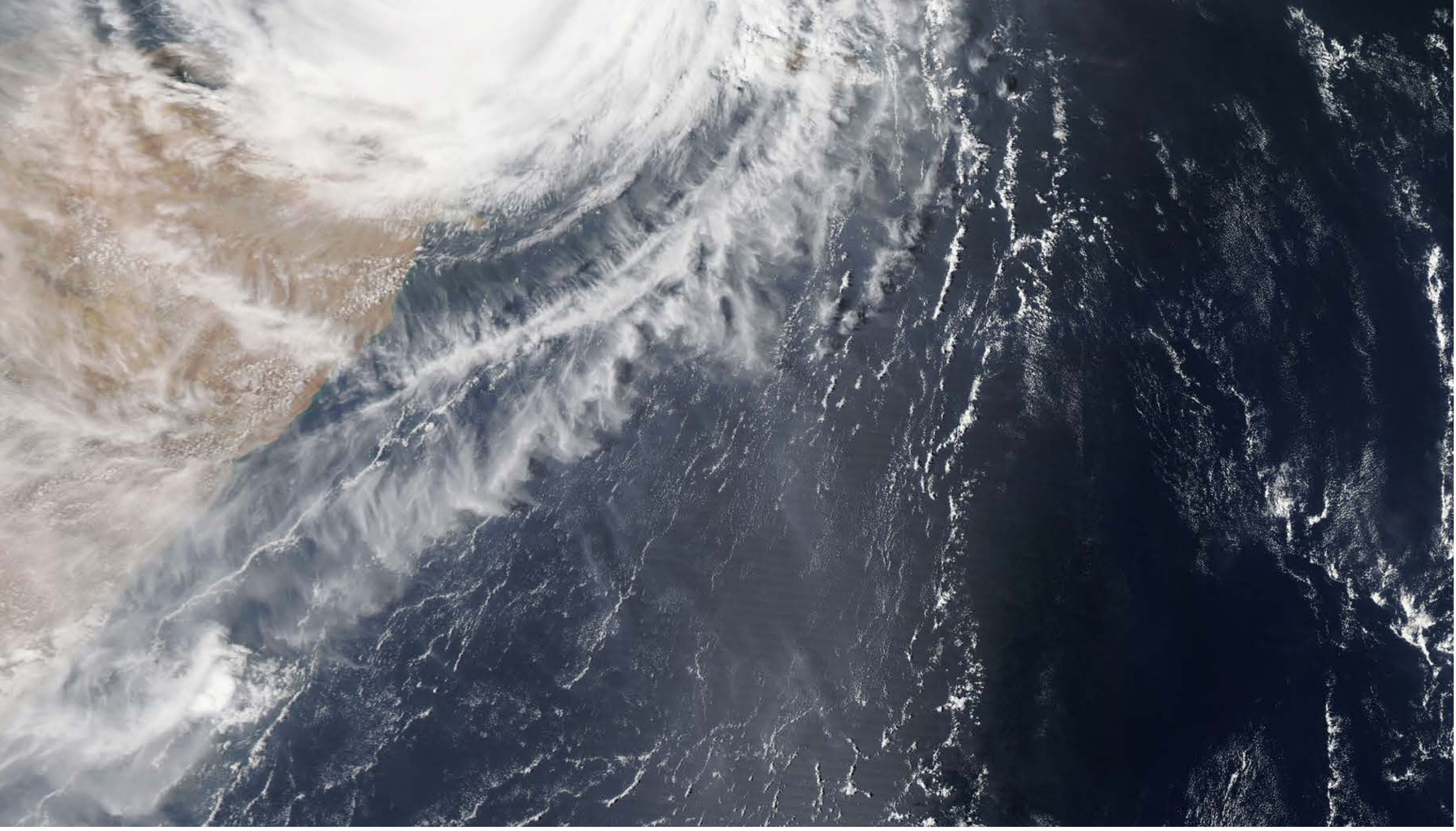


Global temperature anomaly at the Earth surface, relative to 1951-1980 average temperatures

Humanity is entering a new climate era, which it has never experienced in the past. The consequences of global warming are multiple, far from being limited to a temperature indicator. It has cascading consequences on precipitation patterns, sea levels, extreme events such as cyclones, etc. Extreme weather events are getting either stronger or more frequent.

Dry rivers, heat-stressed railways, cooling systems failures, out-of-control mega-fires, biodiversity loss, etc.; **these impacts are already tangible and are set to escalate, even in the most optimistic emissions scenarios.**

[2] Source: NASA's Goddard Institute for Space Studies, smoothed data.



Infrastructure is particularly vulnerable to climate change

Infrastructure is built for decades to centuries, it is difficult if not impossible to relocate and it is often established in areas that are strongly exposed to climate hazards, such as riverbanks or coasts. This is making infrastructure particularly vulnerable to fast-changing climate hazards, prompting financial and operational actors to factor in climate evolutions as early as possible in their strategies.

CIARA's physical risks module is a risk-screening and scoring tool dedicated to infrastructure investors and asset owners.

- *In the pre-investment phase*, a long-term analysis of potential climate evolution and impact might help identify "red flags" in terms of location and technical choices during design and construction. For example, it might help to anticipate the sizing of rainwater drainage systems, of air conditioners, the use of building materials resistant to heat waves, etc.

- *For infrastructure that is already built*, it is a question of identifying the most vulnerable assets in infrastructure portfolios to engage in dialog with security holders: are they aware of the risk involved? Have they taken action to protect themselves against it, whenever possible? What else should be done?

Reminder about the regulatory context
The TCFD and the EU Taxonomy set strong requirements in terms of climate change adaptation reporting

The **Task Force on Climate-related Financial Disclosures** (TCFD) recommends disclosure of "*climate-related risks and opportunities over the short, medium and long-term*" and related "*impacts on the organization's business strategy and financial planning*". Both transition and physical risks should be covered.

The **EU Taxonomy** "*sets mandatory requirements on disclosure, with the aim of providing transparency on environmental performance*". It places climate change adaptation amongst "*the overarching conditions that an economic activity has to meet to qualify as environmentally sustainable*".

Regarding climate change, economic activities are invited to prove their "*substantial contribution*" to climate change adaptation or mitigation, without compromising other environmental objectives (this is the "*do no significant harm*" principle).

These requirements call for organizations to complete "*a robust climate risk and vulnerability assessment*" as a prerequisite to assess "*adaptation solutions*" and to the implementation of an "*adaptation plan*".

Key features and outputs of CIARA's physical risks module

Key methodology features

98 asset types

42 countries
in Europe and North Africa

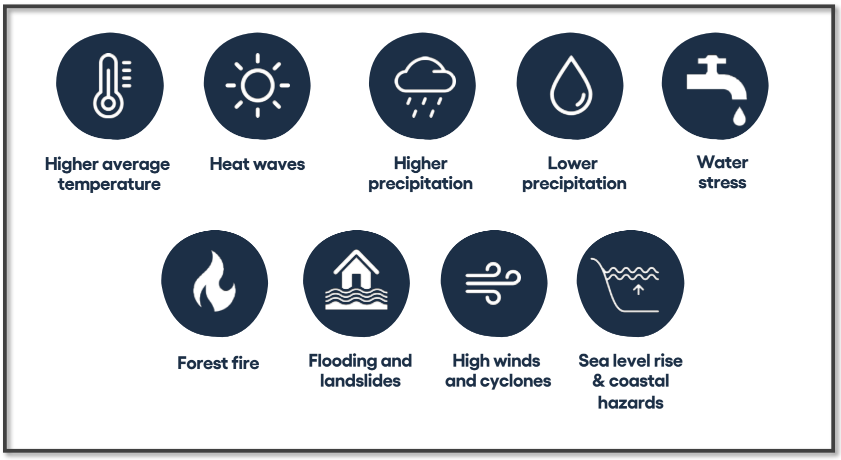
9 climate hazards

- What makes the physical risk module stand out from competing methods is that it was **designed for the infrastructure universe**: the risk measurement is carried out **at asset level** and not at a sectoral level. Each asset type has a **specific**[3] **vulnerability profile** based on Carbone 4's expertise.

- **Close to 100 asset types are proposed** by the methodology, in energy, industry, agriculture and forestry, mobility, water, tertiary buildings, waste and telecoms.

- **42 countries** in the **European Union** and the **Mediterranean rim** regions are covered.

- **9 climate hazards** are considered (see below) and projected to 2050 according to one of the IPCC's tendential scenarios (RCP 8.5[4]).



[3] For example, a buried network and an aerial network are differentiated because they will not be sensitive in the same way to climate hazards.
[4] The Representative Concentration Pathway 8.5 is one of the 4 emissions profiles that are featured in the IPCC 5th Assessment Report. It represents the high-end of scenarios "without additional efforts to constrain emissions". Other scenarios will be available soon or on demand.

Key outputs of the methodology

1. Overall summary scores at portfolio level

At portfolio level, the output is **a risk scoring expressed on a normalized 0 to 1 scale.** That indicator allows the following questions to be answered:

- Is the portfolio at risk?
- How does the risk evolve between the reference period (1986-2005) and the 2050 horizon?

Risk scorings are calculated for both the reference period and the future period, to assess the net increase in risk.

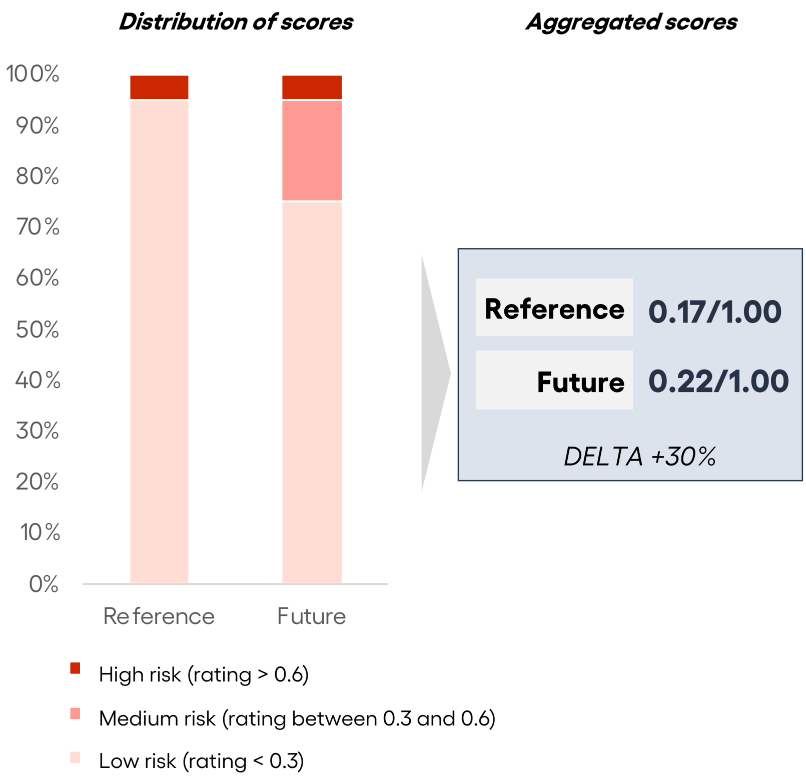
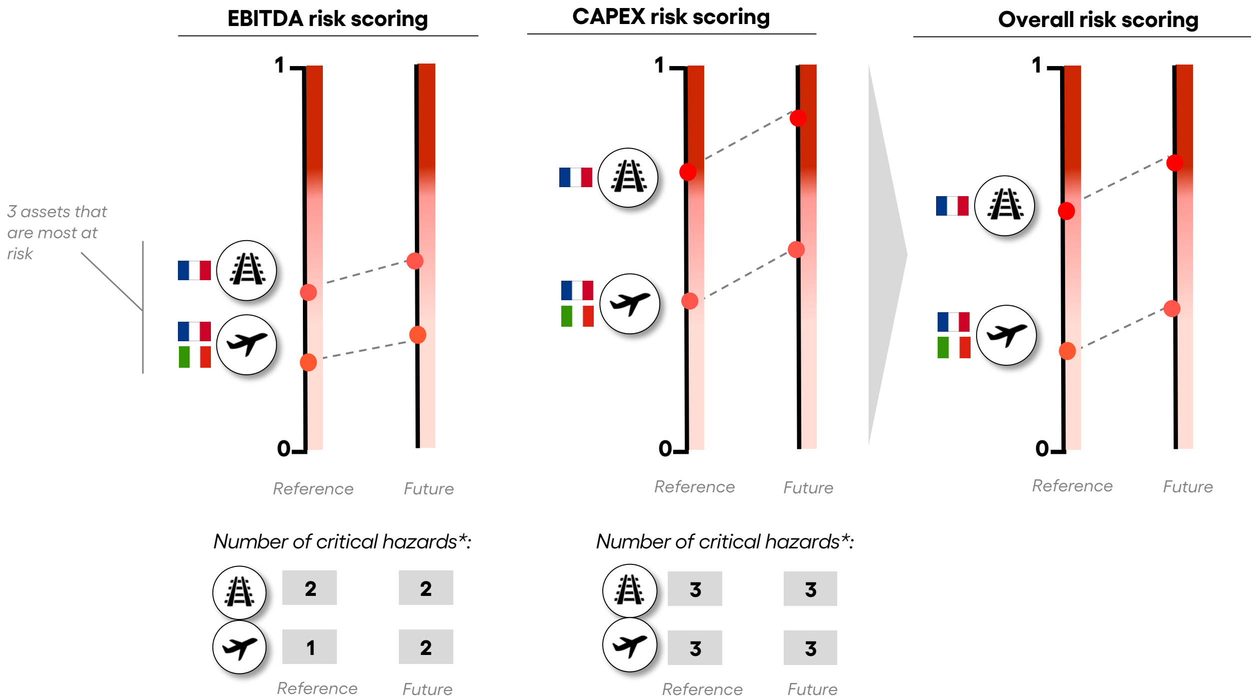


Illustration of overall summary scores at portfolio level

2. Scores at asset level

The portfolio overall scoring may be disaggregated to examine the riskiest assets: the top-three risky assets may be singled out to perform a deeper analysis.

Scoring may also be split between structural damages (e.g., impacts on CAPEX) and operational impacts (e.g., impacts on EBITDA).



* Critical hazards are hazards for which risk scores > 0.6. See explanation below.

Illustration of risk scoring at the asset level for the three riskiest assets
(here a railway network and two airports, illustrative results)

In this (purely illustrative) example:

- out of the overall portfolio, the riskiest assets are a railway network in France, an airport in France and an airport in Italy;
- the French railway network is the riskiest asset both in terms of EBITDA and CAPEX;
- the scoring reflects both the intrinsic vulnerability of the assets and the climate projections under a high emissions scenario.

* Critical hazards are hazards for which risk scores are > 0.6. These are major points of attention for the asset. If the number of critical hazards increases between the reference and future periods, this means that the climate projections of the scenario are detrimental to the asset.

What information is required to carry out the analysis?

An extremely limited set of information is needed to carry out the analysis: most importantly, **the asset GPS location must be provided** to capture precise climate evolutions for the asset location. Location information may be provided as GPS points, GPS plots or perimeters.

3. Zoom on critical hazards for the assets that are most at risk

For the riskiest assets, an even more detailed analysis can be carried out to identify critical hazards and related potential damages. This analysis enables identification of red flags requiring particular attention for infrastructure investors, constructors, managers, etc.

Eventually, it prepares the implementation of adequate actions and a more complete reporting regarding physical climate-related risks.

		Critical hazards in future	Potential damage
EBITDA	1	More frequent & intense heat waves	Rail deformation, traffic disrupted
EBITDA	2	Increase in average & seasonal rainfall	Increased drainage requirements
EBITDA	3	N/A	N/A
CAPEX	1	More frequent and intense heat waves	Material to be replaced
CAPEX	2	Increase in average and seasonal rainfall	Soil erosion, weakening of structure
CAPEX	3	Increased intensity and frequency of droughts	Shrinkage and swelling of clays
EBITDA	1	More frequent & intense heat waves	Lower traffic
EBITDA	2	Increase in average & seasonal rainfall	Increased drainage requirements
EBITDA	3	N/A	N/A
CAPEX	1	More frequent and intense heat waves	Loss in asset value
CAPEX	2	Increased intensity and frequency of droughts	Forest fires
CAPEX	3	Increase in average and seasonal rainfall	Heavy infiltration, soil erosion => damaged take-off lanes

Illustration of critical hazards analysis for the riskiest assets in the portfolio
(illustrative results)

A deeper analysis may be performed for each asset: each score may be disaggregated to weight the contribution of the vulnerability, climate and local context components. The evolution between the reference values and future values for critical hazards may also provide useful information regarding potential climate evolutions.

EBITDA Heat waves

Vulnerability score	Type of damage	Climate indicator	Reference value (average value on the network)	Future value (average value on the network)	
0,9	Rail and catenary deformation, electric disorders	Number of periods where T> 30°C during 3 days	22,6	44,7	+ 98%
	Poorer conditions for outdoor workers	Number of periods with T> Tmax during 7 days	0	2	
	Cooling system malfunction	Number of days with T> 35°C (min. 3 days for damage)	1,9	5,6	X 3

EBITDA risk scoring for heatwaves

Reference	Future
0,78	**0,90**

Breakdown of the "heat wave" scoring for one asset in the portfolio, for EBIDTA
(illustrative results)

What comes next?

CIARA's physical risk module is a first step in screening the hot spots in an infrastructure portfolio. To go further, it is useful to implement **detailed due diligence for the most at-risk assets**. Such due diligence could lead to the refinement of asset vulnerability profiles, the use of ad-hoc climate indicators, the construction of climate shock scenarios, etc. therefore providing a more detailed view of the risk and enabling more relevant adaptation measures.

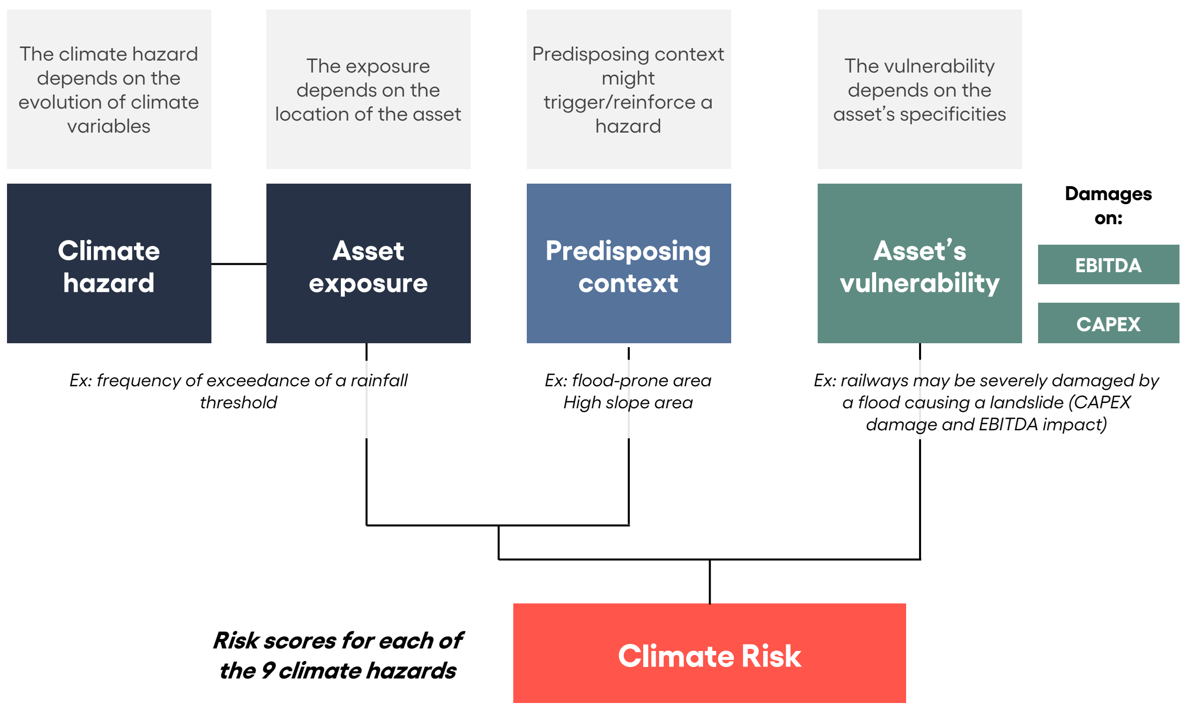
The desirable output for these analyses is **to integrate the issue of climate change at the heart of the investment and management strategy** of infrastructure portfolios and infrastructure operations; to increase transparency and communication on risk exposure and risk mitigation between the different stakeholders involved in the decision chain.

Details on the risk scoring methodology

Physical risk assessment: how does it work?

Physical risks are evaluated based on the specific location of assets and their exposure to a set of **9 chronic or extreme hazards**[5] such as heat waves, extreme rainfalls, sea level rise, etc.

Risk scorings combine climate projections, local context information and asset structural (CAPEX) and operational (EBITDA) vulnerability.



For each climate hazard and for each asset, risk is a combination of climate projections, local context and asset vulnerability

[5] Chronic hazards reflect background trends, changes that occur gradually over time (e.g., increasing average temperature). Extreme hazards refer to sudden, abrupt events (e.g., forest fires or landslides).

- **Asset exposure** is specific to the asset and refers to the asset location. It must be provided by the asset owner or manager.

- **Climate hazard** and **predisposing context** information are coming from public databases, selected and handled by Carbone 4.

- **Asset vulnerability** profiles are coming from a proprietary Carbone 4 database, built up through years of business consultancy, interviews and bibliographic research.

- Ultimately, Carbone 4 summarizes this information in **climate risk scores** that are aggregated at different levels.

The following paragraphs provide information on the primary information that the model uses.

Climate hazards and predisposing context

From the **climate hazards** (which designate a generic climatic phenomenon), climate indicators have been constructed. They refer to a specific climate variable and include a threshold that reflects a breaking point for the asset.

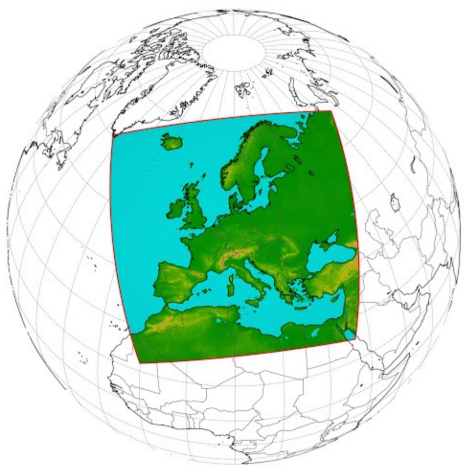
For example,

- knowing that photovoltaic solar panels loose efficiency at temperatures above 25°C, the "heat wave" hazard may be specified for solar PV panels by the climate indicator "number of days in the year with temperature higher than 25°C".
- knowing that air conditioners suffer from major dysfunctions after 3 days with temperature >35°C, the "heat wave" hazard may be specified by the climate indicator "number of 3-day periods in the year with temperature higher than 35°C".

The evolution of this climate indicator between the reference period and the future period (2050) will enable measurement of the evolution of risk related to heat waves for solar PV panels and air-conditioners between these two milestones.

Example of hazards and related climate indicators

Higher average temperature	Cooling degree days
Heat waves	Number of days with T°C higher than X°C
Water stress	Number of consecutive 10 day-periods without rain



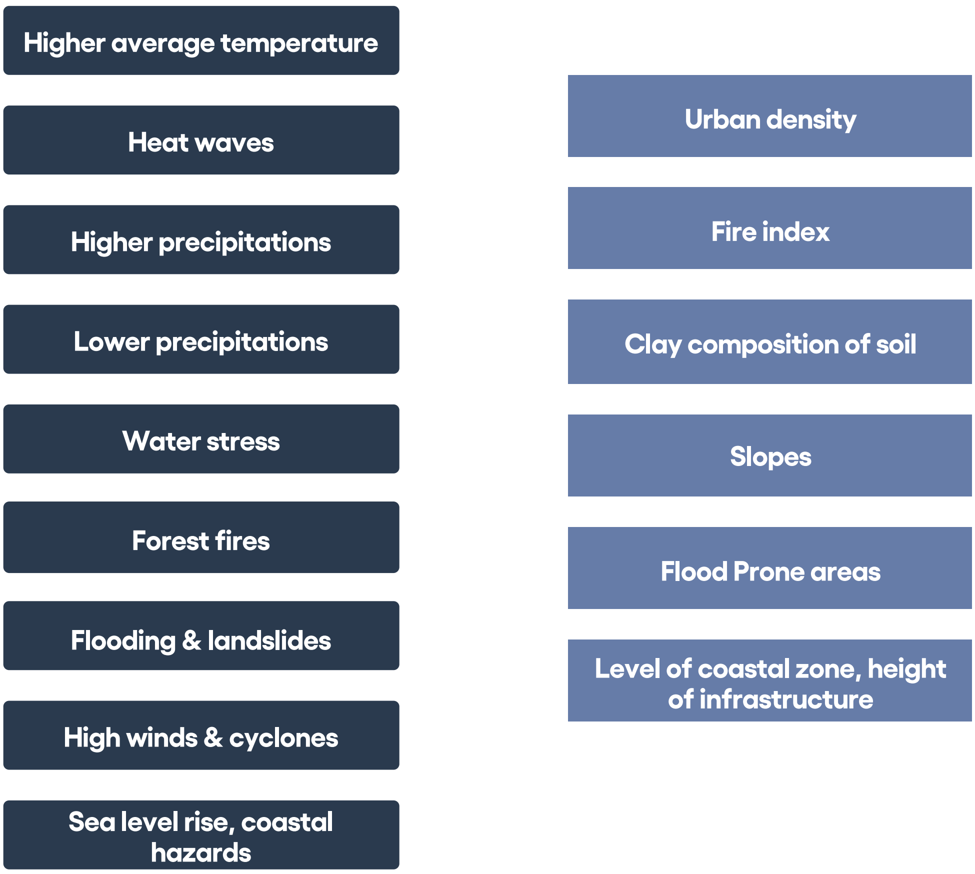
Credit: Euro-cordex.net

From climate hazards to climate indicators

Climate indicators are assessed based on CORDEX[6] simulations. The median of five bias-corrected models is used to calculate two signals: one for historical reference period, and one for the 2050 high emissions scenario (RCP 8.5). The spatial resolution of the climate data is 12 km x 12 km.

In addition to climate hazards, **6 predisposing contexts information** were considered, either to signify the relevance of a hazard to the location of the asset (e.g., sea level rise is only relevant for coastal assets), or to aggravate some hazards (e.g., heat waves are aggravated in urban areas by the urban heat island effect).

Climate hazards and predisposing context information are based on the asset-specific GPS location, which corresponds to the **asset exposure** component of the risk scoring calculation.

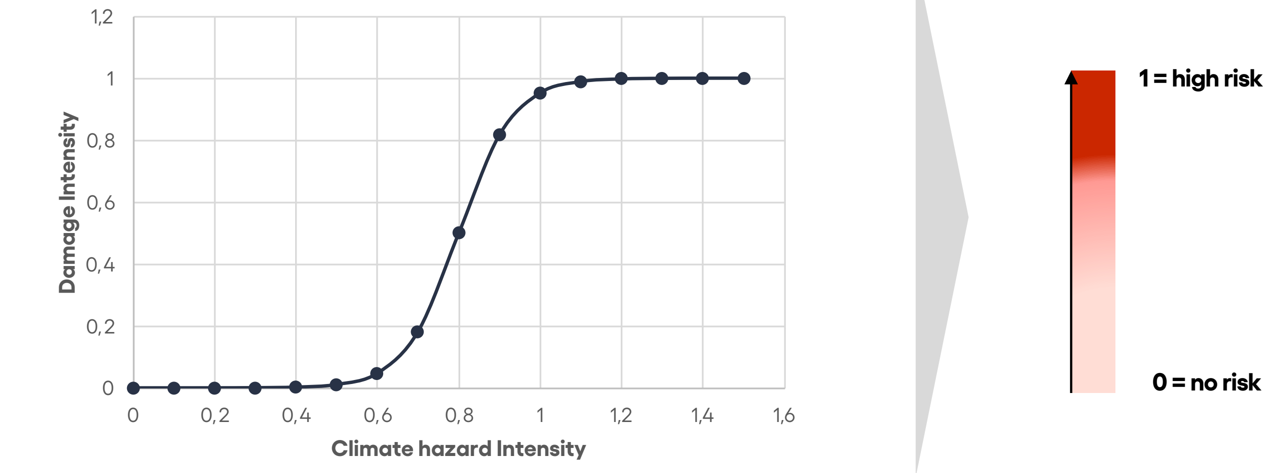


The 9 climate hazards (dark blue, left) and the 6 predisposing context (light blue, right) used by the model

[6] Coordinated Regional Climate Downscaling Experiment. See Euro-cordex.net.

To link climate hazards (and climate indicators) to potential damages for the asset, **17 damage functions** were created. Scores are then produced for each hazard (and for each asset) on a 0-1 scale.

Examples of damage function



Example of damage function
The damage is triggered as soon as the breaking point is reached
(0.6: minor damage, 0.8: major damage, 1: destruction in the above example)

Asset vulnerability

For each asset type, **specific vulnerability profiles** were built using Carbone 4's expertise in climate change adaptation at corporate level.

Asset-specific vulnerability is built as the maximum theoretical damage that can impact the asset. It is assessed based on potential impact on asset operation (EBITDA) and potential impact on asset structural integrity (CAPEX).

CAPEX vulnerability is weighted by the age of the asset, or the date of the last major retrofit (presumably, assets are getting more and more vulnerable as they age).

EBITDA
Higher costs, lower revenues

N/A = 0.0
Low = 0.3
Medium = 0.6
High = 0.9

Example:
Airports suffer from **heat waves** because of:

- ✓ Softer asphalt
- ✓ Less dense air

=> making takeoffs difficult and resulting in a **slower activity or shut down** (ex. Phoenix airport in 2017) : **0,9**

CAPEX
Structural damages

Weighted by construction year/ year of last retrofit

N/A = 0.0
Low = 0.3
Medium = 0.6
High = 0.9

Example:
Railways suffer from **heat waves** because of:

- ✓ Deformation of rails & catenaries
- ✓ Excess dilatation

=> **structural damage**; material need to be replaced (ex. France in 2003) : **0,9**

Vulnerability to the different climate hazards is assessed for each asset type, on a four-level scale

Carbone 4 is the French expert on energy and climate transition. We provide metrics and expertise for the corporate and financial sectors to build business resilience. Our services cover all asset classes.

For more information, please visit www.carbone4.com