CLIMATE RISK ASSESSMENT

1 PROJECT INFORMATION

Project Name: Azores_1

Sector: Rodas

Project Code: HW_A1

Busines Area: Infrasctructures

Company: Cintra

Activity: 6.15. Road construction / maintenance and operation

Country: Portugal

Ferrovial Role: Operator

Infraestructure Type: Greenfield

Start Date (year-month-day): 2020-01-01

End Date (year-month-day): 2050-12-31

Longitude: -25.5761

Latitude: 37.776

2 ABOUT THIS REPORT

All the information in this report is provided for pre-diagnosis purposes on the physical climate risks that may potentially affect the infrastructures promoted, designed, built and/or operated by Ferrovial during its service life and related possible adaptation options.

The climate risk analysis encompasses different three time horizons -short [period 2010-2039, assuming representative for the year 2025], medium [period 2020-2049, assuming representative for the year 2030] and long-term [period 2036-2065, assuming representative for the year 2050]- as well as two different climate scenarios, considering anthropogenic changes using greenhouse gas concentration trajectories (the so-called Representative Concentration Pathways or RCPs). The scenarios considered are RCP4.5 (intermediate scenario) and RCP8.5 (worst-case climate change scenarios).

The risk framework defined by the IPCC is followed, understanding the risk as the combination of three different components: exposure, vulnerability and hazard.

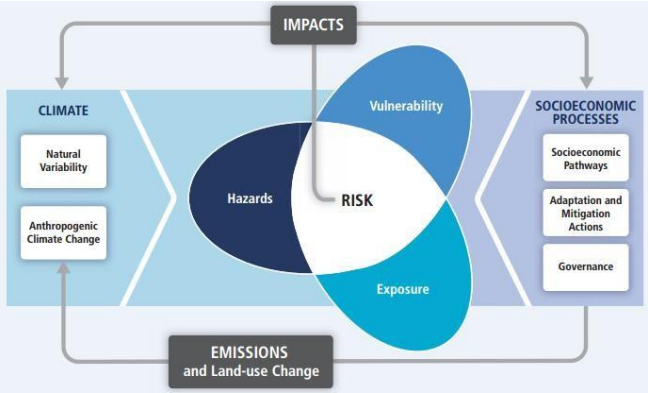

Figure 1. Risk components and interrelations (Source: IPCC, 2014 [1]).

[1] IPCC, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Summaries, Frequently Asked Questions, and Cross-Chapter Boxes. A Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. World Meteorological Organization, Geneva, Switzerland, 190 pp.

TERM	Definition
RISK	The term risk is often used to refer to the potential for adverse consequences of a climate-related hazard, or of adaptation or mitigation responses to such a hazard, on lives, livelihoods, health and wellbeing, ecosystems and species, economic, social and cultural assets, services (including ecosystem services), and infrastructure.
HAZARD	The potential occurrence of a natural or human-induced physical event or trend 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.
EXPOSURE	The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected.
VULNERABILITY	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

TERM	Definition
IMPACTS	The consequences of realized risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather and climate events), exposure, and vulnerability. Impacts generally refer to effects on lives, livelihoods, health and wellbeing, ecosystems and species, economic, social and cultural assets, services and infrastructure. Impacts may be referred to as consequences or outcomes and can be adverse or beneficial.
ADAPTATION	In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. The adaptative capacity is the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.

Table 1. Risk components definitions (Source: IPCC, 2014).

This report supplies information to comply with the taxonomy substantial contribution requirements on the adaptation criteria, and both the “do not significant harm” (DNSH) criteria for mitigation and adaptation. It is important to highlight that, although both sets imply the development of a risk assessment, the substantial contribution criteria for adaptation (as included in Annex II to de Climate Delegated Act) reflect a higher level of ambition, and includes the need for the implementation of the identified adaptation options, while as the substantial contribution criteria for mitigation (as included in Annex I to de Climate Delegated Act) requirements the identification of potential adaptation options as a must.

Based on a catalog of possible adaptation measures, this report includes a set of possible adaptation options with the respective suggested year of implementation. This proposal depends on the increase in the level of risk experienced in the future horizons and scenarios, and on the level of admissible risk defined by the user.

If the necessary information has been provided and is accurate, this report also presents a preliminary estimate of the possible economic consequences on the analyzed infrastructure in terms of reactive CAPEX (additional repair costs due to damages), OPEX increases and revenue losses during its service life. These data should be understood only as an estimate and, if considered to be relevant, as a basis for a further work development with a higher level of ambition.

Please make sure that you understand the limitations of the tools and their results, underlying simplified assumptions, and underlying uncertainties, whose sources include but are not limited to climate scenarios, models, spatial resolution, choice of climate variables and their expression, simplification of impact models, and parametric and limited description of projects.

info For more information on the methodology, use and operation of the tool, as well as its results and limitations, please consult the user's manual.

3 HOW TO READ AND USE THIS REPORT

This report includes the following information:

- An adaptation planning (Section 5) with a summary of the risks (considering both hazard and sensitivity) the infrastructure may face and its evolution over time, and a set of possible adaptation measures selected to reduce these risks and its implementation over time.
- A risk assessment (Section 6) with the breakdown of all the impacts that could produce damages over the infrastructure and its evolution over time, expressed as a potential risk indicator. It is classified by asset, risk driver, a set of possible adaptation measures selected to reduce these risks and its implementation over time.
- A hazard analysis (Section 7) with a detailed study of the hazards that could harm the infrastructure and its climate evolution over time expressed as a hazard index, including all the considered climate variables and its climate evolution over time.
- A financial analysis (Section 8) with a preliminary estimate of the possible consequences on the analyzed infrastructure in terms of CAPEX damages, OPEX increases and revenue losses.

The results provided by the tool and included in this report are grouped into three categories: those involving an increase in climate risk on CAPEX (damage to assets), on OPEX (increased operating and maintenance costs), and on revenues (reduction in expected revenues) of the infrastructure during its service life.

This report should be the starting point for the development of an adaptation plan for the assessed infrastructure. An adaptation plan should include not only a climate risk analysis and an identification of possible adaptation options, but also an implementation, monitoring and evaluation plan (ISO 14090).

warning

The results included in this report refer to the climate risks that may affect the infrastructure during its service life. The materiality of risk will vary depending on the role (constructor - no climate risks, concessionaire - foreseeable risks) of the final recipient.

4 INDEX

5 ADAPTATION PLANNING

This section presents a summary of the increased risk experienced by the infrastructure during its service life. The Potential Risk Index (PRI) is used as an indicator and is presented for different time horizons and climate scenarios (RCPs). This incremental risk analysis is provided separately for CAPEX, OPEX and infrastructure revenues. The ranges of the PRI corresponding to each risk level are shown in the table below.

In addition, a set of possible adaptation options that could be implemented to reduce the increase in risk is presented. For each of them, an implementation time horizon is indicated, depending on the increase in risk experienced by the infrastructure.

INFRASTRUCTURE RISKS

	Near-term 2025		Short-term 2030		Mid-term 2050	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
CAPEX	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR
OPEX	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR
REVENUES	GRAVE	GRAVE	GRAVE	GRAVE	GRAVE	GRAVE

Level of potential risk increase	Potential Risk Increase Indicator ranges
NO VARIATION	(*) 0 ≤ PRI ≤ 5 %
MINOR	5 < PRI ≤ 25 %
MODERATE	25 < PRI ≤ 40 %
SERIOUS	40 < PRI ≤ 60 %
GRAVE	> 60 %
(*)Risk reduction situations are not accounted	

POSSIBLE ADAPTATION OPTIONS SELECTED

Buildings

- Improve access to facilities (implementation year 2030)
- Improve building insulation (implementation year 2030)
- Insulate buildings and warehouses (implementation year 2030)
- Roof protection (implementation year 2050)

6 RISK ASSESSMENT

This section presents a summary of the increased risk experienced by the infrastructure during its service life, as well as a summary and detailed analysis of the increased risk that each of the assets comprising the infrastructure will experience.

The Potential Risk Index (PRI) is used as an indicator and is presented for different time horizons and climate scenarios (RCPs). This incremental risk analysis is provided separately for CAPEX, OPEX and infrastructure revenues. The ranges of the PRI corresponding to each risk level are shown in the table below.

In addition, a set of possible adaptation options that could be implemented to reduce the increase in risk is presented. For each of them, a possible implementation time horizon is suggested, depending on the evolution of risk increase experienced by the infrastructure.

Level of potential risk increase	Potential Risk Increase Indicator ranges
NO VARIATION	(*) 0 ≤ PRI ≤ 5 %
MINOR	5 < PRI ≤ 25 %
MODERATE	25 < PRI ≤ 40 %
SERIOUS	40 < PRI ≤ 60 %
GRAVE	> 60 %
(*)Risk reduction situations are not accounted	

6.1 INFRASTRUCTURE RISKS

	Near-term 2025		Short-term 2030		Mid-term 2050	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
CAPEX	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR
OPEX	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR
REVENUES	GRAVE	GRAVE	GRAVE	GRAVE	GRAVE	GRAVE

6.2 ASSET RISKS SUMMARY

Buildings

	Near-term 2025		Short-term 2030		Mid-term 2050	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
CAPEX	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR
OPEX	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR
REVENUES	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR

Drainage system

	Near-term 2025		Short-term 2030		Mid-term 2050	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
CAPEX	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR
OPEX	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR
REVENUES	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR

ITS/ECTS and toll plazas

	Near-term 2025		Short-term 2030		Mid-term 2050	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
CAPEX	SERIOUS	SERIOUS	SERIOUS	SERIOUS	SERIOUS	SERIOUS
OPEX	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR
REVENUES	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR

Pavement

	Near-term 2025		Short-term 2030		Mid-term 2050	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
CAPEX	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR
OPEX	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR
REVENUES	SERIOUS	SERIOUS	SERIOUS	SERIOUS	SERIOUS	SERIOUS

Signaling, equipment and safety

	Near-term 2025		Short-term 2030		Mid-term 2050	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
CAPEX	SERIOUS	SERIOUS	SERIOUS	SERIOUS	SERIOUS	SERIOUS
OPEX	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR
REVENUES	GRAVE	GRAVE	GRAVE	GRAVE	GRAVE	GRAVE

Slopes and embankments

	Near-term 2025		Short-term 2030		Mid-term 2050	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
CAPEX	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR
OPEX	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR
REVENUES	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR

Structures

	Near-term 2025		Short-term 2030		Mid-term 2050	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
CAPEX	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR
OPEX	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR
REVENUES	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR

Tunnels

	Near-term 2025		Short-term 2030		Mid-term 2050	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
CAPEX	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR
OPEX	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR
REVENUES	MINOR	MINOR	MINOR	MINOR	MINOR	MINOR

6.3 DETAILED BREAKDOWN OF ASSET RISKS AND POSSIBLE ADAPTATION OPTIONS

This subsection provides a breakdown of the risk driving the increase in risk per asset in order to support the selection of the most appropriate adaptation options.

7 HAZARD ANALYSIS

This section presents an assessment of the changes in the climate hazards that could adversely affect the infrastructure and its assets during its service life.

A Hazard Index (HI) is used as an indicator and is presented for different time horizons and climate scenarios (RCPs). The ranges of the HI corresponding to each variation level are shown in the table below.

Firstly (Section 7.1), a summary presents the main changes in four groups, according to the proposed by the Taxonomy. For each group, two indicators are shown: one for chronic hazards (long term, slow varying hazards) and one for acute (short term, extreme hazards).

Secondly (Section 7.2), an in-depth analysis shows the detailed information regarding the changes in the climate hazards for each hazard variable involved in the risk assessment of the infrastructure analyzed. Furthermore, the specific assets affected by each climatic hazard are also listed below the tables.

Lastly (Section 7.3), all the climate data for each climate variable considered in the risk assessment carried out by the tool is included.

HAZARD CHANGE										
Hazard reduction										**Hazard Increase**
Extreme	Very High	High	Medium	Low	No variation	Low	Medium	High	Very High	Extreme

7.1 SUMMARY

7.2 HAZARD ANALYSIS

Hazard – climate variables relationship

TEMPERATURE RELATED	CLIMATE VARIABLE	Units
Chronic		
Heat stress	The average number of days per year with daily maximum temperature >= 40°C	days/ year
Changing temperature (air, freshwater, marine water)	Mean annual temperature	°C
Temperature variability	Mean annual temperature	°C
Acute		
Cold wave/frost	The average number of days per year with daily minimum temperature < -31°C	days/ year
Heat wave	The average number of days per year with daily maximum temperature >= 40°C	days/ year
Wildfire	WRI water stress. water stress measures total annual water withdrawals (municipal, industrial, and agricultural) expressed as a percent of the total annual available flow	%

TEMPERATURE RELATED	CLIMATE VARIABLE	Units
WATER RELATED		
Chronic		
Sea level rise	Relative sea level rise	m
Changing precipitation patterns and types (rain, hail, snow/ice)	Mean annual rainfall (including frozen precipitation)	mm
Precipitation or hydrological variability	Mean annual rainfall (including frozen precipitation)	mm
Water stress	WRI water stress. water stress measures total annual water withdrawals (municipal, industrial, and agricultural) expressed as a percent of the total annual available flow	%
Acute		
Heavy precipitation (rain, hail, snow/ice)	25-year return period of maximum 1-day precipitation	mm
Heavy precipitation (rain, hail, snow/ice)	Winter months accumulated snow	mm
Flood (coastal flooding)	The # of hours per year with coastal flooding in a berth with a freeboard of 0.60 mS	hours/ year
Flood (overtopping)	The # of hours per year with overtopping > 0.1/s/m of a rubble mound breakwater for a freeboard of 10 m.	hours/ year
Drought	The annual probability of experiencing SEVERE short-term term drought, determined by the Standardized Precipitation Evaporation Index	%
WIND RELATED		
Chronic		
Changing wind patterns	Annual mean windspeed at 10 m	mps
Acute		
Storm (including blizzards, dust and sandstorms)	Number of high wind days (15 m/s)	days/ year
Cyclone, hurricane, typhoon	The annual exceedance probability of experiencing Saffir-Simpson Hurricane Scale Category 1 winds (60-sec gust 10-m wind speed of at least 64 kt, which translates to a 3-sec gust windspeed of approximately 79 kt for an on-shore wind off the sea)	%
SOLID MASS RELATED		
Chronic		
-		
Acute		
Landslide	Number of days per year with heavy precipitation	days/ year

7.3 CLIMATE DATA

8 FINANCIAL CONSEQUENCES

This section summarizes the financial consequences derived from the climate hazards affecting the CAPEX, OPEX and revenues, for the different time periods and RCP scenarios.

First, the total economic consequences for the infrastructure studied is shown, and in the tables below, these total economic consequences are shown by physical assets.

warning Decimal point is used in all figures.

INFRASTRUCTURE CONSEQUENCES ESTIMATION

ASSETS CONSEQUENCES ESTIMATION

9 CHANGES AND COMMENTS TO THE REFERENCE VALUE