REPORT

New International Airport of Cabinda (NAIC Project) - Angola

Environmental and Social Impact Assessment - Chapter 15 - Climate Change Risk Assessment_Physical Risks

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15.0 CLIMATE CHANGE RISK ASSESSMENT – PHYSICAL RISKS

This is the Climate Change Risk Assessment (CCRA) chapter relevant to the physical risks, prepared in response to the Principle 2 of the EPIV. According to EPIV, the CCRA is required to be undertaken:

- For Category A projects. For these projects, the CCRA has to include consideration of relevant climate-related 'Physical Risks' as defined by the Task Force on Climate-Related Financial Disclosure (TCFD)[1].
- For all projects, in all locations, when combined Scope 1 and Scope 2 emissions are expected to be more than 100,000 tons of CO_2 equivalent annually. For these projects, the CCRA is to include considerations of climate-related 'transition risks' (as defined by the TCFD). The CCRA must also include a completed alternatives analysis which evaluates less greenhouse gas (GHG) intensive alternatives.

15.1 INTRODUCTION

Climate change is a multifaceted and complex issue that can lead to serious environmental and socioeconomic consequences and even threaten the security of countries. The impacts of climate change have become one of the most important challenges for the life of future generations.

The TCFD Recommendations on Climate-related Financial Disclosures state that "physical risks resulting from climate change can be event driven (acute) or longer-term shifts (chronic) in climate patterns".

Acute physical climate risks can include increased severity and frequency of droughts, storms, floods, heat waves and wildfires. **Chronic physical climate risks** can include sea level rise and longer-term temperature increase. Climate-related physical risks may include a variety of effects:

- Direct damage to assets, as a result of extreme weather events (i.e., drought, storms) or rising sea levels.
- Changes in water availability, sourcing and quality, often with consequent social impacts.
- Disruption to operations, ability to transport goods and supplies and impacts on employee/community safety, and more.

[1] See Task Force on Climate-Related Financial Disclosures (October 2022), and Recommendations of the Task Force on Climate-related Financial Disclosures (June 2017).

15.2 OVERVIEW OF THE CLIMATE CHANGE PHYSICAL RISK ASSESSMENT METHODOLOGY

According to the **ISO 14091 Standard "Adaptation to climate change – Guidelines on vulnerability, impacts and risk assessment**[2]", CCRA fulfils diverse objectives depending on a client's information needs, and on challenges caused by climate change. These can include the following:

- Raising awareness: CCRA helps increasing awareness of the consequences of climate change.
- Identification and prioritization of risks: many factors contribute to a system's sensitivity, exposure and adaptive capacity. CCRA provides insight into these factors, and this helps the client to prioritize the risks to be addressed.
- Identification of entry points for climate change adaptation intervention: the final results and the CCRA process can help identifying possible adaptation responses. CCRA can show where early action is required.
- Tracking changes in risk and monitoring and evaluating adaptation: repeating CCRA can help to track changes over time and generate knowledge on the effectiveness of adaptation.

This section of the CCRA chapter presents an overview of the methodology for CCRA for physical risks and applies it to the current Project. The assessment will result in the identification of physical risks that may affect the Project within a certain time frame, and in a number of adaptative measures that the Client may consider and implement to mitigate these risks.

WSP developed a CCRA based on existing methodologies for the assessment of climate change risks and vulnerability as part of adaptation strategies. Guidelines and methodologies from the **ISO 14091** as well as the **Intergovernmental Panel on Climate Change (IPCC)**[3] and the **World Bank Group**[4] were used as a guidance for defining factors that contribute to determine the risk. These methodologies consider a variety of risk components whose definitions are as follows:

- Climate-related Hazard: natural or human induced climate-related hazard, such as flood, wildfire, extreme heat, that can occur at the Project Site. The changes in intensity of hazard related events and of their probability over-time are influenced by climate change.
- Exposure: the possibility for a Project in a specific site to be adversely affected by a certain hazard because of the presence of certain Project services, resources, infrastructures, people and other Project's intrinsic elements that are prone to be affected. A Project, depending on its intrinsic nature and characteristics, may or may not be exposed to a certain hazard that occur at the Project Site. Exposure is therefore an indicator of if the Project "can or cannot be affected" by a certain hazard.
- Sensitivity: propensity or predisposition of elements of the Project to be affected by a certain hazard. Sensitivity is a measure of "how much" a Project exposed to a certain hazard can be affected.
- Adaptive capacity: the ability of the Project to adjust to climate hazard-related events, to mitigate potential damages, to take advantage of opportunities, or to respond to the consequences.

[2] ISO 14091 gives guidelines for assessing the risks related to the potential impacts of climate change. It describes how to understand vulnerability and how to develop and implement a sound risk assessment in the context of climate change.

[3] The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change.

[4] The World Bank Group (WBG) is a family of five international organizations that make leveraged loans to developing countries.

- Vulnerability: expresses the magnitude of potential effects and consequences of climate hazard-related events on elements of the Project. Vulnerability results from the combination of Sensitivity and Adaptive capacity.
- Risk: the result of the combination of Hazard probability or intensity at a certain time and the Vulnerability.

This methodology assesses all different climate-related hazards independently, at present and in the future, over a time consistent with the temporal scope of the assessment, and according to multiple future carbon emission scenarios. For each specific hazard, the risk components are assigned a qualitative class ("i.e., "high", "medium", "low") and then combined using qualitative matrices, as explained in Figure 1. The result is a class of Risk ("low", "medium", "high" or "extreme") for each climate-related hazard considered in the analysis. The following figure shows risk assessment process for a specific hazard "h" the Project is exposed to.

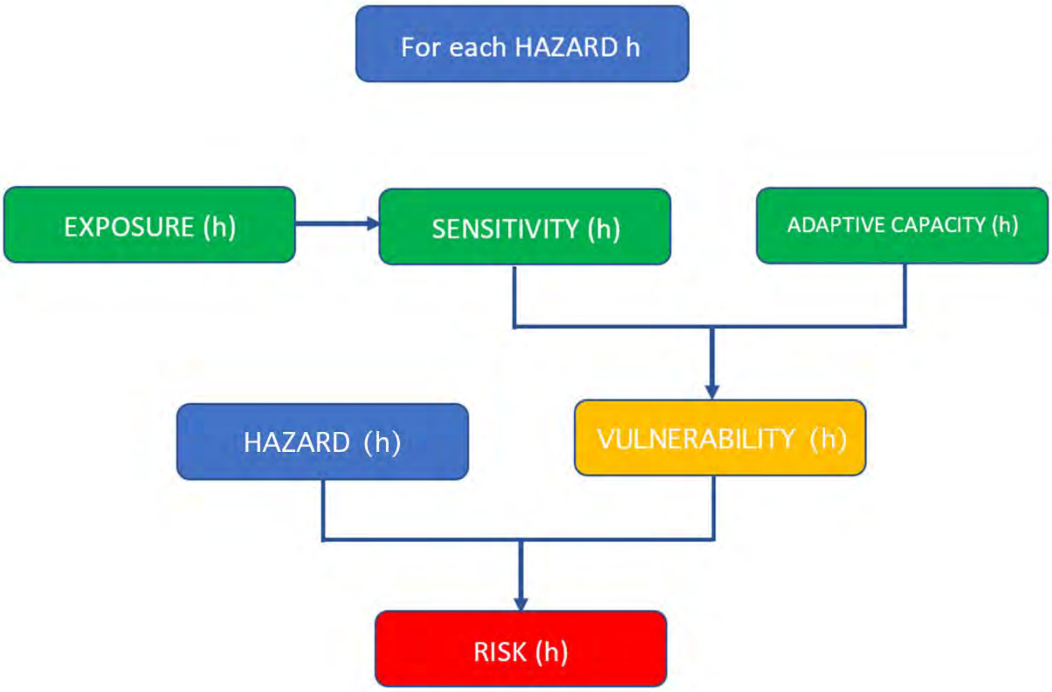

Figure 1: Workflow of the risk assessment for a specific hazard "h" the Project is exposed to, showing how different risk factors are combined across the analysis.

15.3 PHYSICAL RISKS ASSESSMENT

The CCRA takes into consideration all facilities of NAIC Project as described in Chapter 02 - Project Description.

15.3.1 Assessment of Hazards

15.3.1.1 Climate Overview

The Project is located in the Province of Cabinda, Angola, approximately 36 km north of the city of Cabinda. Information collected from the **World Bank Group – Climate Change Knowledge Portal**[5] and reports released by **USAID's Climate links**[6] were used for an overview of the current climate and the mean climate projections.

The Province of Cabinda is located on the coast of the Atlantic Ocean and according to the Köppen-Geiger Climate Classification, it has a tropical savanna climate (Aw), with particularly dry winters. This is a type of transitional climate found between the equatorial climate type and the hot deserts. The rainy season lasts from October to May, being November and March the wettest months. The dry season, on the other hand, occurs in winter, from June to September, being June and July the driest months. As in the rest of the country, rainfall pattern is highly controlled by the ITCZ (Inter-Tropical Convergence Zone) as it moves between the equator and the tropics, bringing rainfall as it migrates southward from the equator in October.

Temperature observations show that Angola has warmed significantly in recent decades. Between 1960 and 2006, the average annual temperature increased by about 1.5°C, which represents an average rate of 0.33°C per decade. The rates of increase were different in the different seasons of the year, being faster in winter, at about 0.47°C per decade, and slower in summer, at about 0.22°C per decade. In the Province of Cabinda alone, the average annual temperature increased by about 0.36°C per decade from 1991 and 2020.Temperature projections for Angola vary based on differences between models and assumptions about future greenhouse gas emissions. However, without significant emission reductions, median projections for the 2090s are between 2.3°C and 4.5°C above the 1970-1999 average.

Historical climate trends show that from 1991 to 2020, the annual precipitation in the Province of Cabinda increased by 69 mm per decade (or 5.8 mm per month). However, when considering precipitation data from the whole country, the historical findings differ, and it is observed that since 1960 the average annual precipitation in Angola has decreased at an average rate of about 2 mm per month (2.4%) per decade, largely due to decreases from March to May. Precipitation data are spatially limited in Angola, and the causes of this trend are not fully understood; however, despite variations in precipitation models, it is generally agreed that precipitations will decrease in the future, including the Province of Cabinda, however the strongest fall is expected in the country's southern region.

15.3.1.2 Identification of Relevant Climate-related Hazards

According to ISO 14091, the first step in the CCRA requires to identify the climate-related hazards that may affect the Project site and, among them, those the Project may be exposed to. Additional available literature (i.e., **IPCC Report on Impacts, Adaptation and Vulnerability**, **UNEP Finance Initiative**[7], **World Bank**

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[5] The Climate Change Knowledge Portal (CCKP) provides global data on historical and future climate, vulnerabilities, and impacts.

[6] USAID. 2018. "Climate Risk Profile: Angola." U.S. Agency for International Development. Climate Risk Profile: Angola | Global Climate Change (climatelinks.org).

USAID. 2012. "Climate Change Adaptation in Angola". U.S. Agency for International Development. Climate Change Adaptation in Angola Fact Sheet | Global Climate Change (climatelinks.org).

[7] United Nations Environment Programme Finance Initiative (UNEP FI) is a partnership between UNEP and the global financial sector to mobilize private sector finance for sustainable development.

National & Policy Climate and Disaster Risk Screening tool[8], **Coast Adapt Risk Assessment tool**[9]) was considered to define a framework and guide the hazard identification process.

Key questions to consider in the hazard identification process are the following:

- Which are the past events and the main issues that affected the site as a consequence of climate change?
- Which are the climate-related hazards that may become relevant in the future?

Information from **World Bank Group – Climate Change Knowledge Portal, Vulnerability** were consulted to identify the most relevant hazards at the Country level. The Country level overview was integrated with the contents of the Country Climate and Development Report (CCDR), released in December 2022 and developed by the World Bank in partnership with the Angolan government. In addition to this, **THINK HAZARD portal**[10] (implemented by Global Facility for Disaster Reduction and Recovery (GFDRR) in collaboration with World Bank and providing high level hazard assessment worldwide) was used to refine the investigation at the level of the Province of Cabinda. Finally, **Global Forest Watch**[11] was consulted to collect additional information, in particular regarding wildfire hazard situation in the Project region.

The outcomes of this processes resulted in the following list of selected hazards. They are listed together with the main justification for their inclusion in the risk assessment.

15.3.1.2.1 Flooding Hazard

Flooding is a recurring natural hazard throughout Angola. In the first part of the 21st century, floods have been particularly devastating to the cities of Ondjiva, Luanda, Benguela, and Namibe where water inundated houses, commercial buildings, and disrupted transportation for extended periods of time. Rural areas are also highly vulnerable to flooding as many residents live on riverbanks, leading to loss of possessions, loss of crops, and increasing the risk of water borne diseases during floods.

What is more, sea level rise is expected to increase along Angola's coast putting 50% of the population at risk, as well as affecting coastal erosion rates and sedimentation patterns.

Climate-related disasters (floods, storms, droughts) cost Angola nearly US$1.2 billion between 2005 and 2017, and on average droughts alone affect about a million Angolans every year.

Flooding (both pluvial and fluvial as well as coastal flooding) already pose very large threats to Angolan cities; flash flooding in Cabinda Province in January 2020, for instance, damaged about 150 homes, blocked several roads, damaged severely a bridge, and 2 people died due to the collapse of a building; Also, in December 2022, flights making the Luanda-Cabinda route were cancelled at the existing Cabinda airport, due to flooding on the airport's runway caused by heavy rains.

Therefore, this hazard has been scoped in for the climate change risk assessment.

15.3.1.2.2 Extreme Heat Hazard

The mean annual temperature in Angola has increased by an average of 0.2°C per decade since 1951, adding up to a 1.4°C temperature increase since mid-last century. Temperatures are projected to keep rising. This can

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[8] Climate and Disaster Risk Screening represents a proactive approach to considering short- and long-term climate and disaster risks in project and national/sector planning processes.

[9] Coast Adapt is an information delivery and decision support framework, helping to assess the risks from climate change and sea-level rise.

[10] https://thinkhazard.org/en/

[11] Global Forest Watch (GFW) is an online platform that provides data and tools for monitoring forests. By harnessing cutting-edge technology, GFW allows anyone to access near real-time information about where and how forests are changing around the world.

have significant implications for extreme heat. In the Province of Cabinda alone, relevant increasing trends for average annual temperatures in the period 1990-2020 have been observed, with an increase of 0.36°C per decade in the mentioned period.

According to climate projections retrieved from the Climate Change Knowledge Portal[12], in an intermediate scenario for evolution of GHG emissions[13], the Province of Cabinda could have around 80 days/year with temperatures above 35°C by the end of the century.

An analysis cited by the IPCC found that even if the global temperature increase is kept below 1.5°C, Angolans born in 2020 will experience 7–8 times more heat waves in their lifetime than those born in 1960. When compatible with current climate pledges (about 2.4°C of global warming), they would experience over 10 times more[14].

Urban heat island may also represent a risk for the Project area in the future: although the Project is currently situated in a region with low population density, 36 km from the capital of the Province, it is expected that the construction of the airport together with the current industrial expansion of the area, will bring population and urbanization increase. Heat waves are exacerbated by the urban heat island effect. A recent study[15] of more than 150 large African cities projects the number of people that will be exposed to dangerous heat conditions, to be 20 to 52 times higher at the end of this century than today.

Therefore, this hazard has been scoped in for the climate change risks assessment.

15.3.1.2.3 Extreme Cold Hazard

Considering data on minimum temperatures ever registered in Angola, extreme cold is not a relevant climate-related hazard. This is further motivated considering that temperatures are expected to increase in the future. In the Province of Cabinda, in July, which is typically the coldest month of the year, average minimum temperatures moved from 17.9°C for the period 1901-1930 to 18.7°C in the period 1991-2020. According to all scenarios, minimum temperatures are expected to further increase in the future.

Therefore, this hazard has been scoped out for the climate change risks assessment.

15.3.1.2.4 Drought Hazard

Although the central and western regions of Angola are the ones expected to face a significant consolidation of droughts conditions, the coastal area will also be affected with an increase in frequency and intensity of drought events[16].

Droughts have already large impacts on agricultural production and the population, as evident by the drought in 2000 that affected 25,000 people. Additionally, if droughts intensify, they will pose serious threats to food security, people's main livelihood activity (agriculture), and water resources.

Climate-related disasters (floods, storms, droughts) cost Angola nearly US$1.2 billion between 2005 and 2017, and on average droughts alone affect about a million Angolans every year.

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[12] Angola - Mean Projections Expert | Climate Change Knowledge Portal (worldbank.org).

[13] SSP2 – 4.5: intermediate scenario in which CO_2 emissions hover around current levels before starting to decline mid-century, but fail to reach net zero by 2100. Socio-economic factors follow their historical trends without significant changes. Progress towards sustainability is slow, with development and income growing unevenly. In this scenario, temperatures rise by 2.7°C by the end of the century.

[14] Thiery, W. et al. 2021. "Intergenerational Inequities in Exposure to Climate Extremes." Science 374 (6564): 158–60. doi:10.1126/science.abi7339. See also discussion in Trisos et al., 2022. "Africa."

[15] Projections of Human Exposure to Dangerous Heat in African Cities Under Multiple Socioeconomic and Climate Scenarios (wiley.com)

[16] NDC Angola.pdf (unfccc.int)

Therefore, this hazard has been scoped in for the climate change risks assessment.

15.3.1.2.5 Severe Storms Hazard

Severe storms, in combination with other climate-related disasters such as floods and droughts cost Angola nearly US$1.2 billion between 2005 and 2017.

Therefore, this hazard has been scoped in for the climate change risks assessment.

15.3.1.2.6 Extreme Precipitations Hazard

The severity of heavy precipitation events is projected to increase throughout the Angolan territory (being more accentuated in the coastal zone)[16], though rainfall events will likely be less frequent, with longer dry periods in between. Future extreme storm risk (expressed as the maximum five-day precipitation index) is projected to be 5–10 percent higher in 2020–2040 than the 1981–2010 average, rising to 10–15 percent higher in some regions (especially near the coast, including Cabinda Province)[17] for the period 2040–2060 under RCP8.5.

Soil erosion threatens many parts of Angola, both rural and urban, though it is more of an urban problem. Extreme rainfall events can trigger massive mudslides in poorly constructed urban areas and along degraded and deforested slopes. Additionally, increases in the intensity of rains with climate change will have serious implications on agriculture, sedimentation rates, infrastructure, and industry.

Extreme precipitation amplification may also increase the intensity and frequency of flooding, imposing heavy costs to aquatic and terrestrial ecosystems, human health and the economy.

Therefore, this hazard has been scoped in for the climate change risks assessment.

15.3.1.2.7 Wildfires Hazard

According to Think Hazard portal, in the Province of Cabinda the wildfire hazard is classified as high, which means that there is greater than a 50% chance of encountering weather that could support a significant wildfire that is likely to result in both life and property loss in any given year. Based on data available in the Global Forest Watch, in 2021, the Province of Cabinda lost 120 ha of tree cover in wildfires.

Therefore, this hazard has been scoped in for the climate change risks assessment.

15.3.1.3 Exposure Assessment

Once hazards potentially affecting the Project site were identified, the exposure of the Project to each hazard was addressed. The key question in the exposure assessment is the following:

- In case of any of the selected climate-related hazard hitting the Project site, would the Project be impacted?

The evaluation considered the intrinsic characteristics and features of the Project.

Table 1: Exposure assessment

HAZARD	ELEMENT EXPOSED	EXPOSURE	JUSTIFICATION
FLOODING FROM SEA LEVEL RISE OR RIVER OVERFLOW	Infrastructures/People	NO	Flooding from sea level rise or river overflowing could cause damages to buildings and other Project facilities, as well as disruptions to access roads and affect people. The Project site is located about 4 km from the Atlantic

[17] Angola Country Climate and Development Report (2022). *World Bank Document.

HAZARD	ELEMENT EXPOSED	EXPOSURE	JUSTIFICATION
			Ocean; however, it is situated on a plateau, and has an elevation of around 140 m asl. No water bodies are present in the Project area. The rivers that surround the plateau where the Project is situated, including their floodplains, are in low-lying areas and do not represent a risk of flooding for the Project. As such, NAIC can be considered not exposed to flooding due to sea level rise or river overflowing and this hazard will be scoped out from the analysis.
EXTREME HEAT	Infrastructures/People	YES	Buildings and other facilities could be affected by extremely hot temperatures. Similarly, people would be impacted by temperatures which are already high, and they are expected to increase even further.
DROUGHT	Infrastructures/People	YES	The NAIC will depend highly on water for its vital functions. Airports are facilities having large water consumption, generally for non-potable purposes such as water-cooling systems, fire control, cleaning and washing of vehicles, runways and aircrafts and public uses (WC, food service).
SEVERE STORMS	Infrastructures/People	YES	Lightings, intense rain accompanied with strong wind and potentially hail would cause disruptions to flight arrivals and departures, ground crew, buildings, power lines and other airport infrastructures, and be a potential threat to people. Severe storms could also cause local flooding which could represent an additional disturbance.
EXTREME PRECIPITATIONS	Infrastructures/People	YES	Airport runway, buildings and infrastructure, such as access roads and power lines would be highly exposed in case of extreme precipitations. People would be also impacted in case of flooding due to intense rain.
WILDFIRES	Infrastructures/People	YES	The Project site is predominantly vegetated with herbaceous vegetation and shrubland. In addition, many forested areas are present around NAIC: the site is surrounded by a mix of evergreen and semi-deciduous forests,

HAZARD	ELEMENT EXPOSED	EXPOSURE	JUSTIFICATION
			with some patches of open forest and herbaceous wetlands. Therefore, elements that may ignite wildfires are present.

As per Table 1, the Project was considered exposed to all relevant climate-related hazards potentially affecting the Project site, with the exception of Flooding from sea level rise or river overflow. Therefore, they were scoped in for further assessment.

15.3.1.4 Hazards input data

Climate Score Global 2.0, implemented by Jupiter Intelligence[18], was used as the data source for assigning a class of either probability or intensity to each scoped-in climate-related hazard.

Climate Score Global quantifies climate-related hazards at any given location globally predicting how future climate conditions will influence the intensity or the frequency of extreme meteorological events or natural disasters such as future floods, extreme heat events and droughts. The tool employs dozens of respected climate models coupled with machine learning, land use and elevation data, as well as models for hydrology, and severe weather. Data present a very high spatial resolution (90-meter globally), quantifying a set of hazards-specific metrics in 5-year increments from 2020 through 2100 (plus the baseline 1995) and for three climate scenarios, made by a combination of Shared Socioeconomic Pathways (SSPs) and Representative Concentration Pathways (RCPs) [19]:

- Optimistic scenario: projected socioeconomic global changes towards sustainability (SSP1). Carbon dioxide emissions start declining by 2020 and go to zero by 2100 (RCP2.6).
- Intermediate scenario: projected socioeconomic global changes do not shift markedly from historical patterns (SSP2). Emissions reach the peak around 2040, then decline (RCP4.5).
- Pessimistic scenario: projected socioeconomic global changes towards deeper fossil-fuelled development (SSP5). Emissions continue to rise throughout the entire 21st century (RCP8.5).

Data come in a spreadsheet where a given location (identified with longitude and latitude coordinates) is assigned multiple metrics (data type numerical values or bands) and qualitative classes for each hazard.

Table 2 shows as an example the metrics provided to characterize the Extreme Heat hazard while Figure 2 provides an example of classification criteria:

[18] Climate Score Global https://jupiterintel.com/products/

[19] Shared Socioeconomic Pathways (SSPs) are scenarios of projected socioeconomic global changes up to 2100. They are used to derive greenhouse gas emissions scenarios with different climate policies. Representative Concentration Pathways (RCPs) are greenhouse gas concentration possible future trajectories adopted by the IPCC.

Table 2: Overview of all metrics provided to characterize the Extreme Heat hazard.

Metric	Description	Example
HT_days Exceeding*C_mean	Days per year with temperature >35°C or >38°C based on the mean of the high temperature distribution from Global Circulation Models[20](GCMs).	14
HT_days Exceeding*C_band	Band that HT_daysExceeding*C_mean maps to.	10-20 days
HT_days Exceeding*C_lower	Days per year with temperature >35°C or >38°C based on the 5th percentile of the high temperature distribution from GCMs.	10
HT_days Exceeding*C_upper	Days per year with temperature >35°C or >38°C based on the 95th percentile of the high temperature distribution from GCMs.	19
HT_daysExceeding99Pct_mean	Days per year with temperature exceeding the local historical 99th percentile temperature based on the mean of the high temp. distribution from GCMs.	5
HT_daysExceeding99Pct_band	Band that HT_daysExceeding99Pct_mean maps to.	5-10 days
HT_daysExceeding99Pct_lower	Days per year with temperature exceeding the local historical 99th percentile temperature based on the 5th percentile of the high temperature distribution from GCMs.	7
HT_daysExceeding99Pct_upper	Days per year with temperature exceeding the local historical 99th percentile temperature based on the 95th percentile of the high temperature distribution from GCMs	1

Metric	Tier	Label	Min Value	Max Value
daysExceeding*C daysExceeding99Pct	Lowest	< 5 days	0	5
daysExceeding*C daysExceeding99Pct	Low	5-10 days	5	10
daysExceeding*C daysExceeding99Pct	Medium	10-20 days	10	20
daysExceeding*C daysExceeding99Pct	High	20-30 days	20	30
daysExceeding*C daysExceeding99Pct	Highest	> 30 days	30	365

Figure 2: Classification criteria for the metrics of Extreme Heat hazard.

15.3.1.5 Hazards Characterization

Jupiter's Hazard input data were obtained for the Project location, identified through the coordinates of a representative point. The point corresponds to the centre of the polygon shown in Figure 3.

[20] Global Circulation Models (GCMs) are numerical models representing physical processes in the atmosphere, ocean, cryosphere and land surface. They are the most advanced tools currently available for simulating the response of the global climate system to increasing greenhouse gas concentrations.

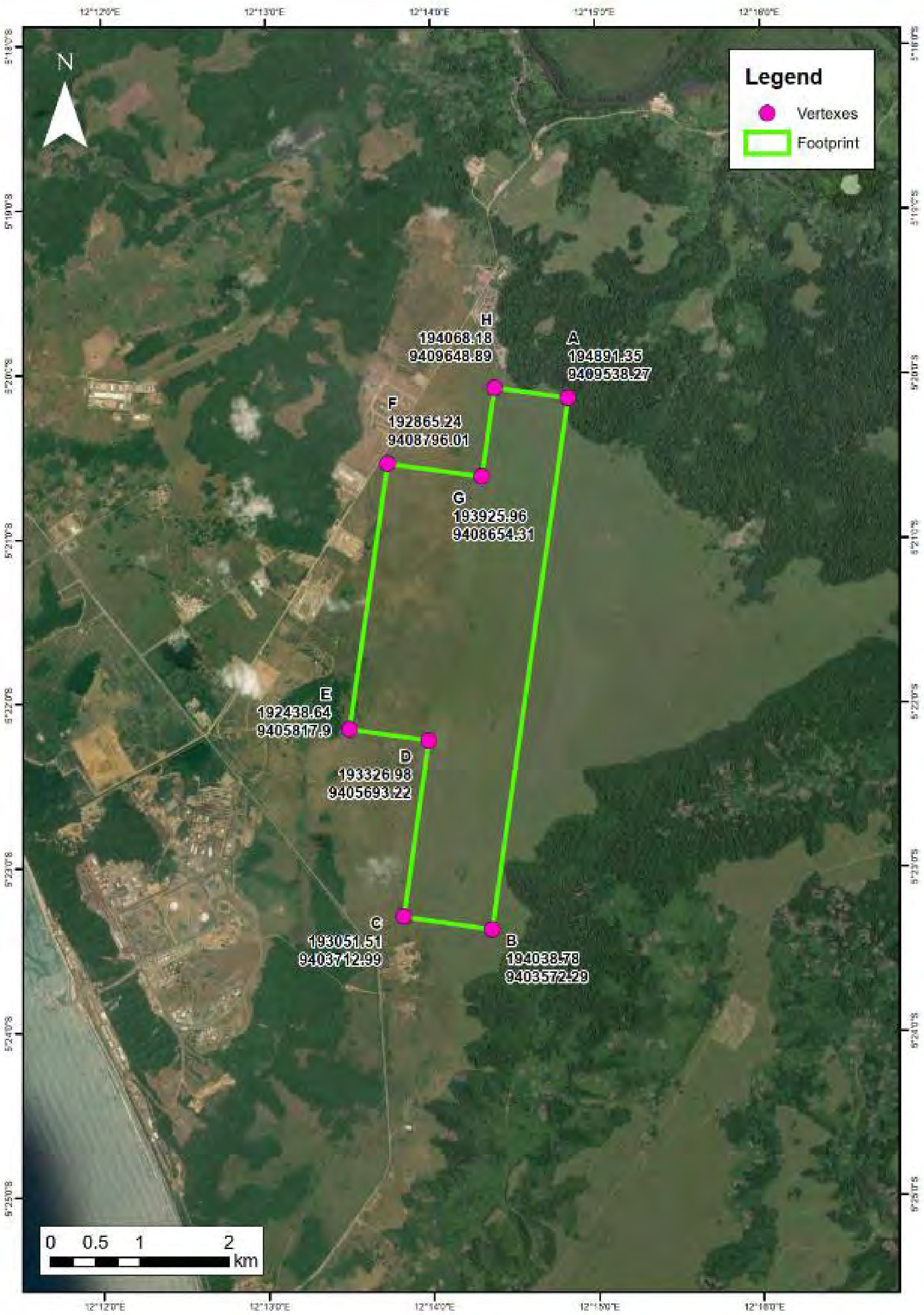

Figure 3: Project footprint. A representative point was marked in the centre of the polygon for Jupiter's Hazard input data.

Among all possible metrics available, the most representative were selected for each hazard. They are shown in Table 3:

Table 3: Most representative metrics selected to characterize each hazard.

HAZARD	METRIC
EXTREME HEAT	Mean days per year with high temperature exceeding the local historical (1980-2010) 99th percentile high temperature.

HAZARD	METRIC
DROUGHT	Months per year where the rolling 6-month average Standardized Precipitation Evapotranspiration Index is below -2 based on the means of several parameters from GCMs.
SEVERE STORMS	Mean number of days per year where environmental conditions are conducive to severe thunderstorm formation.
EXTREME PRECIPITATIONS	Mean maximum daily total water equivalent precipitation (in mm) experienced at the 100-year return period.
WILDFIRES	The maximum value, found across all months, of the probability of a wildfire occurring at some point in an individual month within 100km of the location, based on the means of several parameters from GCMs.

According to the Hazard input data and the metrics considered, the following are the main considerations to describe the scoped-in hazards and their evolution over time at the Project site. For each Hazard, the related figure shows the evolution across the temporal scope. Different colours refer to the 3 different emission scenarios (green lines: optimistic; orange lines: intermediate; red lines: pessimistic). Different styles refer to the 3 different statistics of each metric (solid line: mean; dashed line: 95^{th} percentile (upper); dotted line: 5^{th} percentile (lower)). Mean values of each metric have been used to describe trends over time. The upper and lower percentiles have been used to provide considerations about the level of confidence of the prediction. Wider discrepancy compared to medium values show a low level of confidence while a smaller discrepancy shows a higher level of confidence.

Horizontal grey dashed lines represent the hazard class limits. Please note that a higher level of hazard for a better scenario may happen in the near future. What matters and should be looked at is the overall trend within the long term that clearly indicates higher hazard levels for the worst scenario.

15.3.1.5.1 Extreme Heat Hazard

Extreme heat hazard is expected to increase in the future, according to all scenarios. However, as shown in Figure 4, the trend is very much variable depending on the emission scenario. At present, there are about 9-10 hot days per year with temperatures above the local mean high temperatures, corresponding to a “low” hazard level (see Figure 2 above for the classes).

For the optimistic scenario, values slightly increase, reaching the “medium” level (corresponding to 11 hot days per year) around 2025. Values keep increasing with a peak in 2060 with around 22 hot days per year, considered a “high” hazard level. For the rest of the century, values remain stable around this same value.

For the intermediate scenario, until around 2050 the trend is quite similar to the optimistic scenario, showing a slight but constant increase. However, in the second part of the century, values grow at a much higher pace, reaching 22 hot days per year (corresponding to a “high” hazard level) in 2050, 40 hot days per year in 2080 and almost 49 days per year in 2100, corresponding to the “highest” hazard level.

For the pessimistic scenario the trend is similar to the other two scenarios only until 2025. After that the increase is almost exponential: around 14 hot days in 2030 (“medium” hazard level), 23 hot days in 2040 (“high” hazard level), almost 37 hot days in 2050, around 91 in 2070 and 197 hot days in 2100 (the last three values considered as “highest” hazard level).

Comparing the selected mean metric with the upper and lower, it can be noticed that values sensibly diverge in all scenarios, for the entire temporal scope. This can result (in the worst case) in a situation where 2 or even 3 different hazard classification (hazard levels) are found in a same time period. Therefore, the level of confidence can be considered "Low".

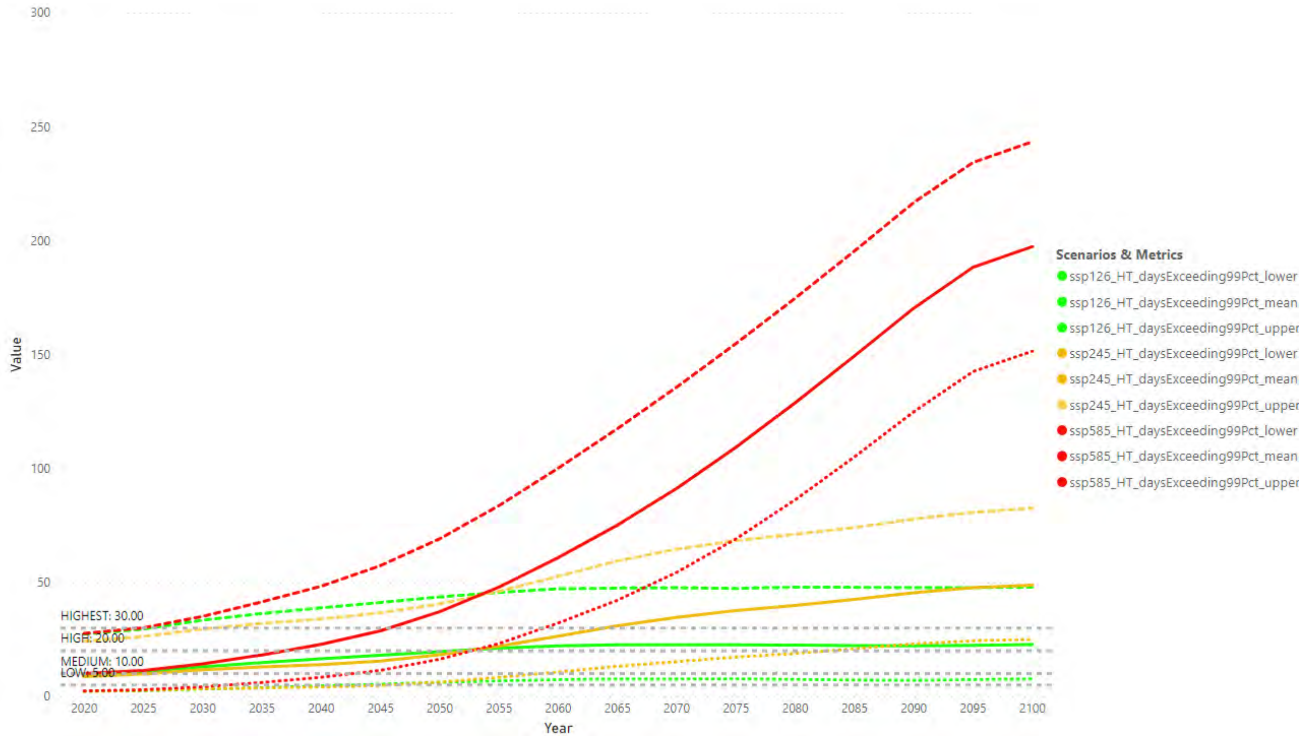

Figure 4: Extreme heat hazard (Value = Mean days per year with high temperature exceeding the local historical (1980-2010) 99th percentile high temperature).

15.3.1.5.2 Drought Hazard

According to the selected metric to describe drought conditions (Months per year where the rolling 6-month average Standardized Precipitation Evapotranspiration Index is below -2), there is an increasing trend over the years according to all scenarios and the likelihood of having drought conditions in the Project area increases over time. Values are around 0.25 months at present, representing a “medium” hazard level. Classification criteria for the metrics of Drought hazard are shown in Figure 5 below.

Metric	Tier	Label	Min Value	Max Value
monthsExtreme*moSPEI	Lowest	< 0.1 months	0.0	0.1
monthsExtreme*moSPEI	Low	0.1-0.25 months	0.1	0.25
monthsExtreme*moSPEI	Medium	0.25-0.5 months	0.25	0.5
monthsExtreme*moSPEI	High	0.5-1.0 months	0.5	1.0
monthsExtreme*moSPEI	Highest	> 1.0 month	1.0	12.0

Figure 5: Classification criteria for the metrics of Drought hazard.

As shown in Figure 6, for the optimistic scenario, the values curve shows a slight increase along the years. From 2020 to 2080, values keep within the “medium” hazard level category, varying between 0.3 and 0.48 months during this period. In 2085, values rise to 0.52 months, achieving a “high” level hazard. Values then keep within this same classification until the end of the century without relevant changes.

For the intermediate scenario, the values curve also shows a slight increase along the years. In 2025, the value is 0.25 months, corresponding to a “low” hazard level. However, in 2030, the curve enters in the “medium” hazard level, with a value of 0.28 months. After that, the curve rises slightly, and stays in this same category until 2065, with a value of 0.44 months. In 2070, it achieves 0.5 (“high” hazard level) and the continuous increase reaches 0.64 months by the end of the century.

For the pessimistic scenario, the trend is similar to the other emission scenarios until 2045. After that, the increase is much more pronounced. The “high” hazard level is reached sooner, already in 2050, with a value of 0.53 months. In 2070, the value is 1.0, corresponding to the highest hazard level. In 2100, the value is 1.85 months.

In this case, the variability between the upper and lower metrics is very high and the values significantly diverge in all scenarios. Therefore, the level of confidence of the hazard assessment should be considered "Low”.

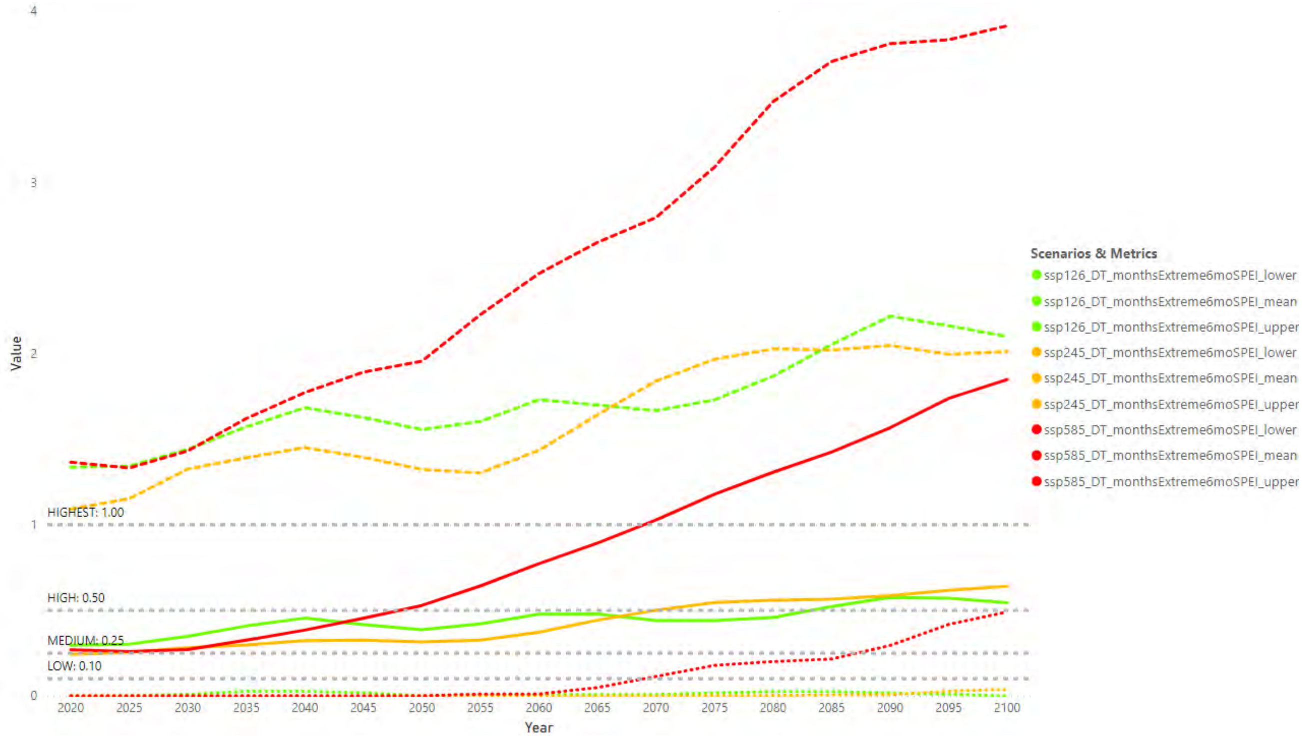

Figure 6: Drought hazard (Value = Months per year where the rolling 6-month average Standardized Precipitation Evapotranspiration Index is below -2 based on the means of several parameters from GCMs).

15.3.1.5.3 Severe Storms Hazard

The mean number of days per year where environmental conditions are conducive to severe thunderstorm formation is around 5-10 at present, which correspond to a “low” hazard level. Classification criteria for the metrics of Severe Storms hazard are shown in Figure 7 below.

Metric	Tier	Label	Min Value	Max Value
daysSevereTStormProbable	Lowest	< 5 days	0	5
daysSevereTStormProbable	Low	5-10 days	5	10
daysSevereTStormProbable	Medium	10-20 days	10	20
daysSevereTStormProbable	High	20-30 days	20	30
daysSevereTStormProbable	Highest	> 30 days	30	365

Figure 7: Classification criteria for the metrics of Severe Storms hazard.

The trends in the future are quite different according to different emission scenarios.

For the optimistic scenario, the frequency of severe storms is expected to remain stable across the entire timeframe considered (2020 – 2100), varying between 7-8 days (“low” hazard level).

The trend for the intermediate scenario is quite similar to the optimistic scenario, with values varying from 6.5 to 8.7 days during the entire timeframe, also corresponding to a “low” hazard level.

For the pessimistic scenario, the increasing trend is much more pronounced. In 2030, the mean number of days per year where environmental conditions are conducive to severe thunderstorm formation is predicted to be around 10.1 days (“medium” hazard level). The trend rises along the years, reaching 13.5 days in 2070 and 17 days in 2100, which also correspond to a “medium” hazard level.

The variability between the upper and lower metrics is very high and the values significantly diverge in all scenarios. Therefore, the level of confidence of the hazard assessment should be considered "Low”.

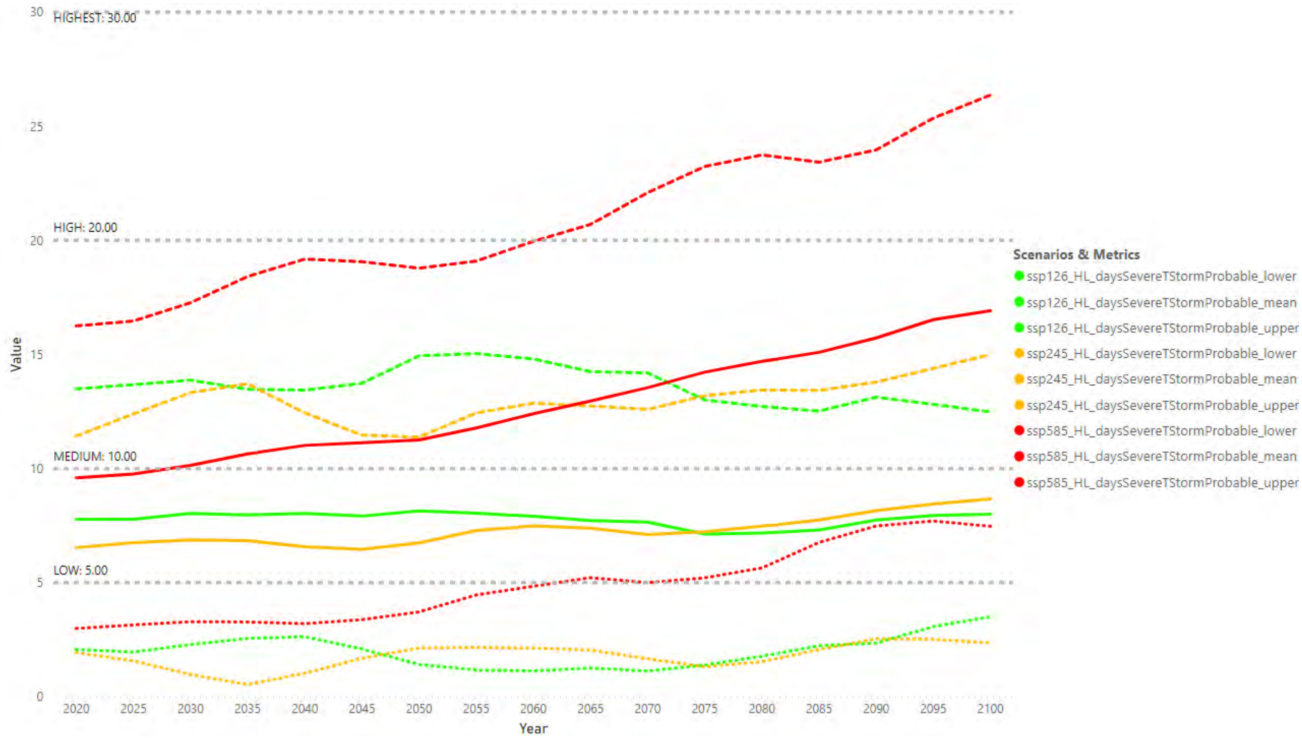

Figure 8: Severe storms (Value = Mean number of days per year where environmental conditions are conducive to severe thunderstorm formation).

15.3.1.5.4 Extreme Precipitations Hazard

The Mean maximum daily total water equivalent precipitation (in mm) experienced at the 100-year return period is around 300 mm at present, which correspond to the “highest” hazard level.

Metric	Tier	Label	Min Value	Max Value
oneDayPrecip*yr	Lowest	< 100 mm	0	100
oneDayPrecip*yr	Low	100-150 mm	100	150
oneDayPrecip*yr	Medium	150-200 mm	150	200
oneDayPrecip*yr	High	200-250 mm	200	250
oneDayPrecip*yr	Highest	> 250 mm	250	9999

Figure 9: Classification criteria for the metrics of Extreme Precipitation hazard.

For the optimistic scenario, the intensity of extreme precipitations keeps stable during the timeframe considered, with values constantly around 290 mm, thus it is expected that no alterations will happen in relation to the current situation (always having in mind that the mean values are considered).

For the intermediate scenario, extreme precipitation values present a very small variability during the timeframe considered, with a maximum of 318 mm in the year of 2065 and a minimum of 296 mm in the year of 2100. A slight increasing pattern is observed to start around the year of 2045 (302 mm), going until 2065, however after that, the curve shows a decreasing pattern up to 2100. Just as in the optimistic scenario, this scenario do not present significant alterations from the present situation.

For the pessimistic scenario, extreme precipitations keep stable until the year of 2045 (304 mm), when the curve start to slightly increase achieving a plateau in 2080 (340 mm), which is maintained until 2100. Although this scenario presents a little more variability, the variations are still considered small compared to the present situation.

The variability between the upper and lower metrics is very high and the values significantly diverge in all scenarios. Therefore, the level of confidence of the hazard assessment should be considered “Low”.

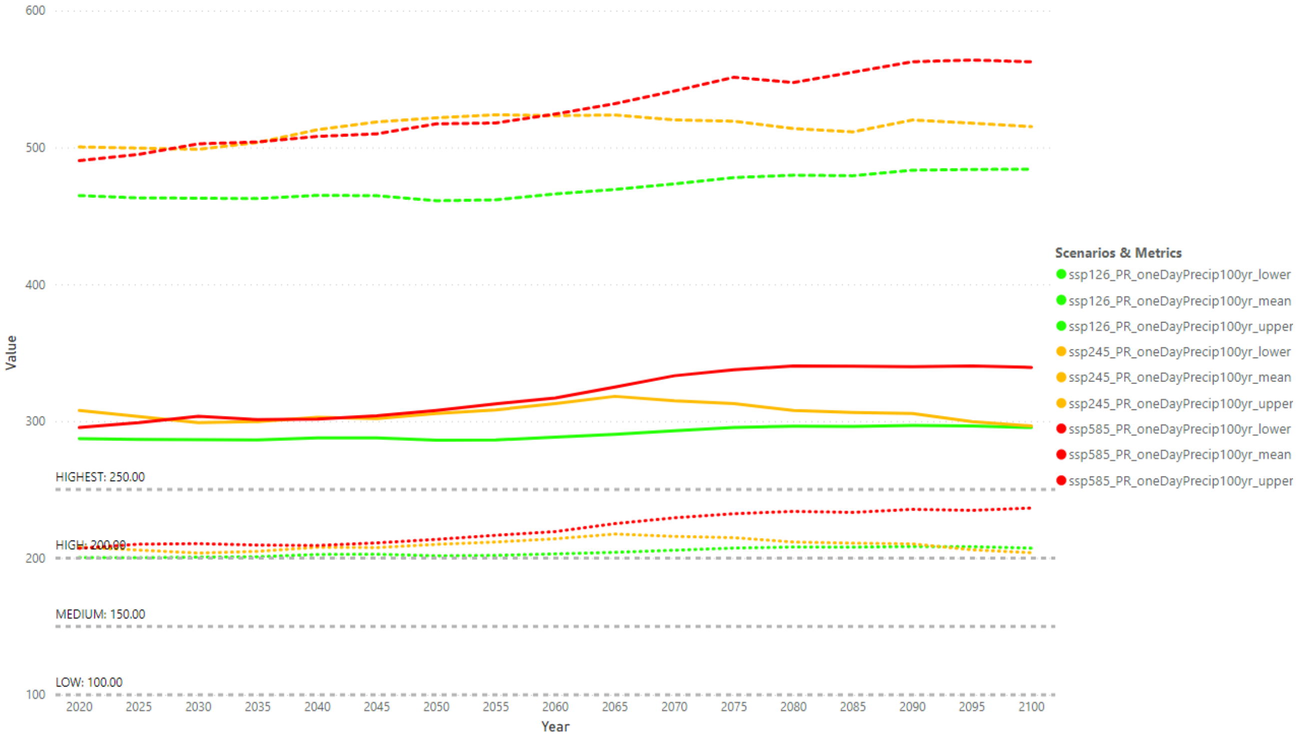

Figure 10: Extreme precipitations (Mean maximum daily total water equivalent precipitation (in mm) experienced at the 100-year return period).

15.3.1.5.5 Wildfires Hazard

The maximum value of the probability of a wildfire to occur within 100 km of the Project location is currently around 1.7 wildfires, which is considered a “lowest” hazard level as per the classification criteria below (Figure 11).

Metric	Tier	Label	Min Value	Max Value
annualFiresPerSqKm	Lowest	< 2	0	2
annualFiresPerSqKm	Low	2-4	2	4
annualFiresPerSqKm	Medium	4-8	4	8
annualFiresPerSqKm	High	8-20	8	20
annualFiresPerSqKm	Highest	> 20	20	9999

Figure 11: Classification criteria for the metrics of Wildfires hazard.

Considering the optimistic scenario, the probability of wildfires to happen keep stable during the entire timeframe considered, with values between 1.6 and 1.8 wildfires, which is considered the “lowest” hazard level, therefore no significant alterations are expected to happen in relation to the current situation (always having in mind that the mean values are considered).

A very similar pattern is observed for the intermediate scenario, however, in this case, the curve shows a slight increase and the probability of a wildfire to happen surpasses the value of 2 wildfires in the year of 2095 and 2100 (2.02 wildfires number), which are configured as “low” hazard level.

For the pessimistic scenario, a small but constant increase in the curve is observed in the entire timeframe considered. It starts with the value of 1.7 in 2020 (“lowest” hazard level) and reaches 2.03 in 2075 (“low” hazard level) and 2.56 wildfires number in 2100 (also “low” hazard level).

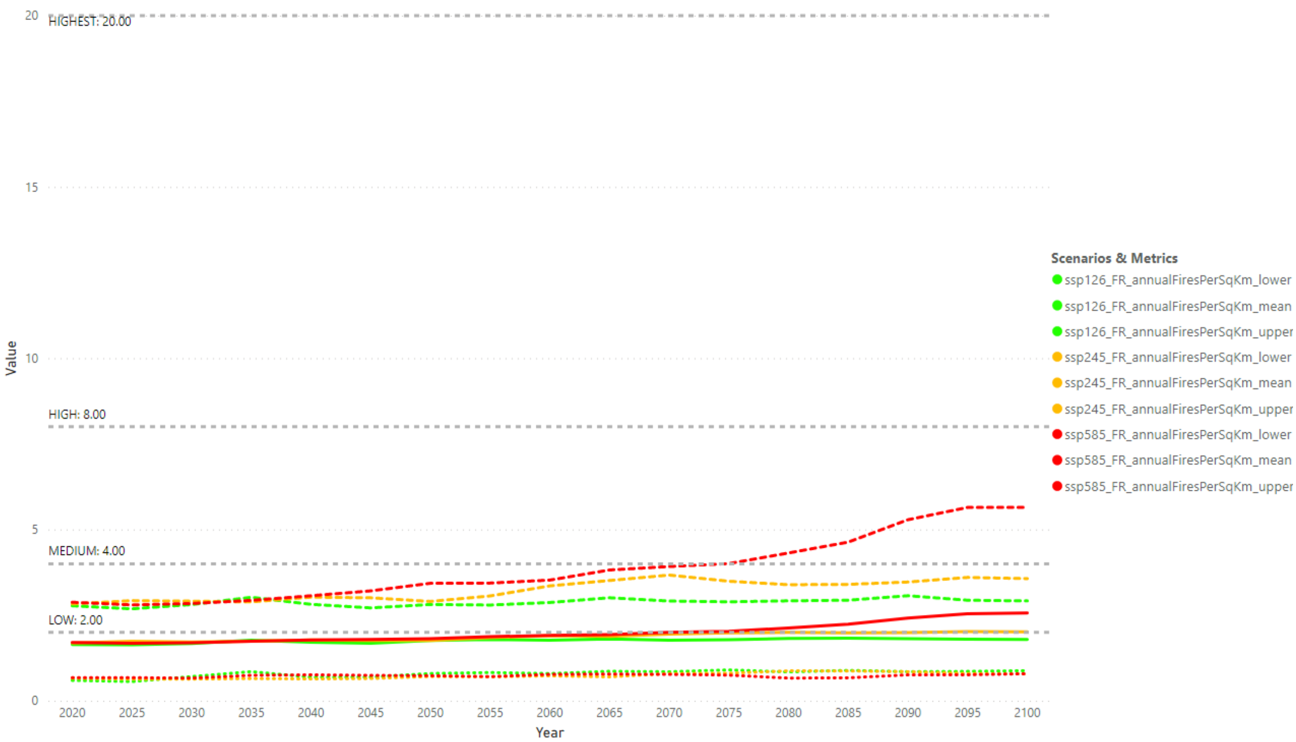

Figure 12: Wildfires (the maximum value, found across all months, of the probability of a wildfire occurring at some point in an individual month within 100km of the location, based on the means of several parameters from GCMs).

15.3.2 Assessment of Sensitivity, Adaptative Capacity and Vulnerability

15.3.2.1 Sensitivity

For each hazard, the Sensitivity was qualitatively characterized based on a set of indicators, selected according to the characteristics of the Project potentially exposed to that hazard. The choice of the set of most relevant indicators for this assessment and the selection of Project information useful to support the assessment was made during an internal workshop including WSP experts.

The final step was to assign a class of Sensitivity (“High”, “Medium” or “Low”), entailing all information collected through the assessment process, also considering their relative importance, reliability and completeness. A conservative approach has been adopted assigning a higher Sensitivity class whenever the assessment was uncertain due to inconsistent indicators.

The Project Sensitivity towards each hazard is presented below with the main considerations that justify the assessment.

15.3.2.1.1 Sensitivity to Extreme Heat

The overall Sensitivity has been assigned as “**HIGH**”. This class was assigned due to the extensive list of potential issues related to extreme heat events that could occur, and to their nature (especially related to material/infrastructure damage and to people’s health and safety). Airport elements susceptible to extreme heat are identified as follows:

- Buildings and infrastructure made with the use of materials that could be susceptible to high temperatures, such as plastic (polymers breakdown), metal (corrosion speed up if humidity is also present), brick weathering (which can weaken the steel structure within a building’s concrete exterior).
- From land, roads are the only gateway to the airport and also from where goods and needed materials for operations will be transported. Extreme heat can particularly damage roads, creating traffic disruptions.
- During a heat wave, high temperatures make the air less dense, reducing aircraft engine performance (the wings cannot generate enough lift to safely lift the plane off the ground) and creating unsafe conditions for some planes to take off. In extreme cases, some airlines may have to delay take-offs, and offload passengers or cargo from smaller aircraft.
- High temperatures can negatively impact baggage handlers and other personnel, who might need to take more frequent breaks during heat waves.
- Ground support equipment (GSE):
  - high temperatures can have a great impact on hydraulic junctions. When these expand in extreme weather conditions, they start to leak and become weakened. This may lead to serious GSE failure in the long run.
  - GSE transmissions can be impaired when operating aircraft ground support equipment during very hot weather.
  - High temperatures can break down lubricants faster and lead to boiling coolant and overheating engines, especially in gas or diesel-powered aircraft pushback tugs.
  - The intense heat draws moisture out of the soil, creating dust and loose dirt. These particles can permeate the ground support equipment, while moisture drawn from joints and seals allows dirt to enter the towing equipment systems.
- Airfield ground lighting system:

    - Airfield ground lighting system components installed within the pavement may result in their maximum operating temperature being exceeded.
    - Airfield ground lighting system components installed within asphalt pavement may be moved due to softening of asphalt pavement materials and aircraft undercarriage.
- Jet fuel: In hot weather, aircraft require more fuel to take-off.
- Runways, apron, taxiways:
    - Pavement materials are expected to be designed to accommodate a range of temperatures; however, long periods of high temperatures can increase the risk of failures, particularly at certain points on the runway, taxiway and apron.
    - Pavement markings materials are expected to be designed to accommodate a range of temperatures; however, the selection of certain materials could be more susceptible to high temperatures.
- Electrical infrastructure:
    - Installed airport electrical infrastructure equipment is capable to withstand high external temperatures. Extreme temperatures however, if overcoming the limits, could lead to disruptions. Extreme temperatures could also lead to failure in the National GRID causing potential blackout.
- Air conditioning/ventilation system: Increasing summer temperatures may affect/reduce the output of the cooling system in the airport in case temperatures exceed current external temperature design criteria.
    - Reduced cooling system capacity may result in people discomfort within terminal buildings.
    - Performance of the equipment depending on the cooling systems may be affected.
    - Cooling equipment is likely to require more maintenance and may fail if it is frequently working at maximum duties.

15.3.2.1.2 Sensitivity to Drought

The overall Sensitivity has been assigned as "**MEDIUM**". Although the airport requires large amounts of water to function properly, the risks of damage to airport infrastructure and materials in a water shortage scenario are not considering to be alarming. Furthermore, the risk to human life was not identified as being high. Airport elements susceptible to drought are identified as follows:

- Airports consume substantial volumes of water to maintain their infrastructure and operations, generally for non-potable purposes such as water-cooling systems (for air conditioning), cleaning and washing of vehicles, runways and aircrafts, public uses (WC, food service) and maintenance activities. This could put the water supply system under pressure in the case of a drought event.
- During operations, the airport will rely on the local availability of water for its own activities: water will be supplied from the existing Cabinda Water Supply Network, which operates by surface water intake from the Chiloango River. Groundwater is also planned to be used, from a water well to be built in the water technical area.
- Runways, apron, taxiways:
    - Severe or prolonged drought can affect the pavement structure and its subgrade. Drying out clay soils that can cause voids.

15.3.2.1.3 Sensitivity to Severe Storms

The overall Sensitivity has been assigned as “**HIGH**”. This class was assigned due to the nature of issues related to severe storms events that could occur, such as serious structural and material damages, including electrical hazards, and also posing great risks to people’s health and safety. Airport elements susceptible to severe storms are identified as follows:

- The occurrence of severe storms with very strong crosswinds can jeopardize the normal operation of the airport, with interruption of landings and take-offs.
- Severe storms may affect buildings’ components, causing structural damage to roofs, windows, doors, exterior equipment (such as cooling systems, communications equipment, and electrical components).
- The airport has some taller infrastructure that could be more severely impacted in the case of strong winds: the Air Traffic Control (ATC) Tower; and the watch tower in the Fire Station building.
- Weather events are a major source of disruptions to electrical power grids. Severe weather may impact the local electrical grid that will supply the airport, causing power disruptions to the operations.
- Airport Electrical Substation: lightning strikes can ignite combustible materials, such as oil, gas, or insulation materials that may cause substation fires and power cuts.
- In the occurrence of dense fogs, the airport runway visibility can be affected, impacting taxiing, take-off, and landing operations.
- Thunderstorms and especially lightning pose a safety risk to airline and airport personnel that work outdoors servicing gate-side parked aircraft and maintaining airport grounds. Lightning strikes are particularly hazardous to ramp operations at airports, and all aspects of the airport operations (landside, terminal, and airside) are impacted when there is a ramp closure.

15.3.2.1.4 Sensitivity to Extreme Precipitation

The overall Sensitivity has been assigned as “**HIGH**”. This class was assigned due to the nature of issues related to extreme precipitation events that could occur, such as serious structural and material damages, including electrical hazards, and also posing great risks to people’s health and safety. Airport elements susceptible to extreme precipitation are identified as follows:

- Heavy rains may cause building flooding. In addition, the storm penetrating the building could catapult dangerous debris (such as glass and bricks) around, severely injuring or even killing the occupants.
- Airport buildings and aboveground infrastructure could be sensitive to structural damages if gutters are not well designed, or if materials used are not adequate to withstand heavy rain.
- Since the Project is located in a large flat area, it could be susceptible to floods in case of extreme precipitation. Some impacts of flooding in the airport are: runway flooding, damage to the airport infrastructure such as landing lights, radar and navigation installations and communications networks; flooding of the Passenger Terminal, and of the inter-terminal transport routes; flooding of airport access roads and transport networks surrounding the airport; impact on any underground structure (cables, pipes, underground fuel hydrants); potential impacts on electrical infrastructures, HVAC and Terminal Data System
- Runways, apron, taxiways:
    - Heavy rain may increase the depth of water to the surface of the runway increasing the risk of the aircraft aquaplaning when braking. There may be increased risk where smooth asphalt materials or tire rubber deposits are present.

15.3.2.1.5 Sensitivity to Wildfires

The overall Sensitivity has been assigned as "**HIGH**". This class was assigned due to the nature of issues related to wildfires events that could occur, such as serious structural and material damages, and also posing great risks to people's health and safety. The list of potential fire hazards in the Airport, which could be triggered by wildfires are identified as follows:

- The Project is located in a greenfield, predominantly vegetated with herbaceous vegetation and shrubland. The close surroundings are vegetated by a mix of evergreen and semi-deciduous forests, with some patches of open forest and herbaceous wetlands.
- Airports are susceptible to fire hazards due to the high number of people, machines, and combustible materials.
- Flight catering area of 570 m^2 for onsite meal preparation, which will contain electrical appliances, heated fats, stove, etc.
- Fuel Farm with storage tanks for 1000 m^3 fuel storage capacity: although it is not known when the fuel farm will be operative, it has been considered here since highly flammable, combustible materials are involved, where fires and explosions can happen.
- Ground support equipment (GSE) can serve as potential high-risk elements for fire at an airport. The fluids used to keep the GSE vehicles running are highly flammable and can cause a fire if they come in contact with hot surfaces. Engine fires put human life, property, and machinery at risk. GSE fires can destroy an aircraft and put passengers and crew at risk. Even a minor fire can result in weeks of downtime, disrupting day-to-day operations.
- The presence of several electrical equipment and electronics such as computers and air conditioning units. Short circuits, overloaded electrical points, and faulty or frayed wiring pose substantial fire hazards.
- The presence of combustible materials, such as cardboard boxes, paper, and plastic, can easily ignite in the presence of heat or flame.
- The presence of hazardous chemicals, such as solvents and cleaning agents, can be ignited by a spark or heat source.

15.3.2.2 Adaptative Capacity

Like Sensitivity, the Adaptive Capacity was qualitatively assessed through a participatory process involving WSP Project experts. The final step was to assign a class of Adaptive Capacity ("High", "Medium" or "Low"), entailing all information collected through the assessment process, also considering their relative importance, reliability and completeness. A conservative approach has been adopted assigning a lower Adaptive Capacity class whenever the assessment was uncertain due to inconsistent indicators.

The following are considerations that apply to all hazards; their evaluation helped with an overall identification of the Adaptive Capacity versus climate change-related events in the Project region:

- In 2022, Angola adopted a Country Climate and Development Report[21]. The report identifies pathways to achieving climate-resilient growth. A robust analysis of the impact of climate science was undertaken, followed by an in-depth analysis of the macroeconomic and sectoral implications of climate impacts on

[21] Source of the document: World Bank website, https://openknowledge.worldbank.org/entities/publication/f5d0bae7-8230-5d41-8466-b5031de9741e

Angola's future development prospects. The report was developed by the World Bank, the IFC and Multilateral Investment Guarantee Agency, in partnership with the Government of Angola.

- The Government of Angola launched in 2017 the National Strategy for Climate Change 2018-2030[22], prepared by the Ministry of the Environment with support from the United Nations Development Program (UNDP), which identifies and defines a set of strategic options of mitigation and adaptation for different economic sectors.
- The Project is located in a region covered by the Adaptation Plan to Climate Change in the Coastal Zone of Angola[23], a document created in 2019 by the government. It aims to alert and guide decision-makers and policy makers, as well as relevant institutions in different sectors, to the need for and importance of taking preventive and adaptive measures in each sector in the face of the effects of climate change.
- NAIC will be equipped with an Aircraft Rescue and Fire Fighting (ARFF) Building. It comprises amenities such as: a watch room tower, a medical room & storage, gear wash/drying room, hose drying facilities, hose store, work area, fire extinguisher room, complementary agent storage, foam storage & related pump room. One ambulance operator is also foreseen.
- An independent electrical switch & transformer station will be built for the proper functioning of the Airport, meeting its demand for energy. The station will be sufficiently sized to cater for the anticipated demand for the Project first phase (next 15 years – until 2036). Ample space will be reserved in the airport layout plan to accommodate future expansion of this facility.
- A 100% standby power will be provided via 4 x 2500 kVA prime rated diesel generators.
- Energy efficiency: in order to reduce energy consumption, all lighting will be specified based on energy efficient LED lamps. Lighting in offices, stores, toilets. etc. will be controlled via local switches or occupancy sensors. Large spaces will be controlled by lighting contactors installed in the lighting panels.

15.3.2.2.1 Adaptive Capacity to Extreme Heat

Due to the lack of specific Project information related to the use of technologies or actions that could be helpful to mitigate a possible extreme heat event, a conservative approach has been taken and the overall Adaptive Capacity to extreme heat has been assigned as "**LOW**". The only information received relevant to this topic is:

- Ventilation and air conditioning systems (HVAC) will be installed in the buildings.

15.3.2.2.2 Adaptive Capacity to Drought

Although the Project presents a diversification of water sources, it is not known whether measures to reduce water consumption during the NAIC operational phase are existent. Therefore, the overall Adaptive Capacity to Drought has been identified as "**MEDIUM**" considering the Project characteristics available:

- For water supply diversification, the Project will have two sources of water:

1) the newly built Cabinda Water Supply Network, whose pipes pass through the Sassa-Zau road, very close to the Project site. This network is supplied by surface water intake from the Chiloango River, which is perennial and the main river in the province of Cabinda.

2) an artesian well, which will be located inside the administrative yard, in the Water technical area.

[22] Source of the document: undp.org, https://info.undp.org/docs/pdc/Documents/AGO/ENAC%202018-2030_14082017.pdf

[23] Source of the document: undp.org, https://info.undp.org/docs/pdc/Documents/AGO/Get2C_ProdutoIV.1%20-%20Final%20Draft.pdf

- The airport will have a Water Treatment Plant, which will be sufficiently sized to cater for the anticipated demand for the Project first phase (130 m³/d) (until the year of 2036). Ample space will be reserved in the airport layout plan to accommodate future expansion of this facility, for the flow of 300 m³/d at the ultimate phase (after 2036, possibly into 2050 and beyond).

15.3.2.2.3 Adaptive Capacity to Severe Storms

Although the Project presents a robust storm water drainage system to prevent against floods, it is not known whether measures to mitigate other events related to severe storms (such as lightning, heavy winds, dense fog, dust storm, etc) will be in place during operations. Therefore, the overall Adaptive Capacity to severe storms has been identified as "**LOW**".

15.3.2.2.4 Adaptive Capacity to Extreme Precipitation

Due to the robust storm water drainage system that will be built for the Project, the overall Adaptive Capacity to extreme precipitation has been identified as "**HIGH**".

The storm water drainage system for the airport will cover both the land-side and the air-side of the airport. The storm water network foresees a collection system of slot drains, pipes and channels along with cross drainage structures like culverts. The system will avoid water accumulation within the airport limits or in the surroundings. Collection network from air-side and land-side shall convey the stormwater to main storm collectors for final discharge into natural ponds, resulted from land depressions. These ponds shall be emptied within 2 days after the storm event. The storm water drainage system also includes a storm water pipe along the NAIC access road.

15.3.2.2.5 Adaptive Capacity to Wildfires

Although the Project will be equipped with an Aircraft Rescue and Fire Fighting (ARFF) building as described in section 15.3.2.2 above, at this stage it is not known whether other important fire safety measures will be taken (for example the use of fire suppression technologies and fire alarm systems, the management of flammable materials, protection of electrical appliances, preventative inspections, among several others). Therefore, the overall Adaptive Capacity to Drought has been identified as "**MEDIUM**".

15.3.2.3 Vulnerability

The magnitude of potential effects and consequences were assessed for each hazard, combining the Sensitivity and the Adaptive Capacity. A qualitative approach has been used, applying the matrix shown in Figure 13:

VULNERABILITY			
	SENSITIVITY		
ADAPTIVE CAPACITY	Low	Medium	High
High	Lowest	Low	Medium
Medium	Low	Medium	High
Low	Low	High	Highest

Figure 13: Vulnerability matrix.

The Vulnerability of the Project resulted higher for Extreme Heat and Severe Storms. The level of Vulnerability for these hazards is "highest", meaning that the Project could experience severe damages and consequences in case of any of these extreme events related to climate change. The Vulnerability is also relevant for Wildfires as it has been assessed as "high".

The Project resulted less vulnerable to Drought and Extreme precipitations.

Table 4 shows the details of Vulnerability assessment for all hazards.

Table 4: Vulnerability assessment.

Hazard	Sensitivity	Adaptive Capacity	Vulnerability
EXTREME HEAT	High	Low	Highest
DROUGHT	Medium	Medium	Medium
SEVERE STORMS	High	Low	Highest
EXTREME PRECIPITATIONS	High	High	Medium
WILDFIRES	High	Medium	High

15.3.3 Physical Risk Assessment

The Climate Change Risk has been assessed combining Vulnerability and Hazard levels, according to qualitative considerations based on the following matrix:

RISK					
	VULNERABILITY				
HAZARDS	Lowest	Low	Medium	High	Highest
Lowest	Lowest	Lowest	Low	Low	Medium
Low	Low	Low	Low	Medium	Medium
Medium	Low	Medium	Medium	High	High
High	Low	Medium	High	High	Highest
Highest	Medium	High	High	Highest	Highest

Figure 14: Risk matrix.

All three emission scenarios were considered for a time spanof 5 years starting from 2020 up to 2100, consistently with temporal scope of the hazards' characterization. It is noted that all risks are elevant for all emission scenarios, at present and in the future, although significant differences can be highlighted among all different hazards and temporal scope. A summary of the outcomes is presented in the following graphs (Figure 15 to Figure 19).

In addition, from these outcomes, four (4) time horizons for each emission scenario, have been identified, from 2020 to 2050, allowing a better view of the criticality per risk during the Project lifecycle until 2050:

- 2020 (existing and starting data);
- Short-term (2030);
- Mid-term (2040); and
- Long-term (2050).

Such division in time-horizon has been considered thinking to the development stages of NAIC (the initial stage until 2036 and the final stage, possibly into 2050 and beyond).

In the following chapters the results for all risks are presented. The order they are presented reflects the level of criticality, from the most critical to the less critical ones.

15.3.3.1 Extreme Heat Risk

This is one of the most critical risks because already relevant at present due to high temperatures, high sensitivity, and lack of specific measures to adapt. For both the optimistic and intermediate scenario, the level of risk is "medium" at present, but expected to escalate to "high" in 2030. The risk further increases in the future, due to predicted increasing temperatures, reaching the "highest" Risk level in 2060. For the pessimistic scenario, the Risk trend is even more critical, with the "highest" level reached already in 2040.

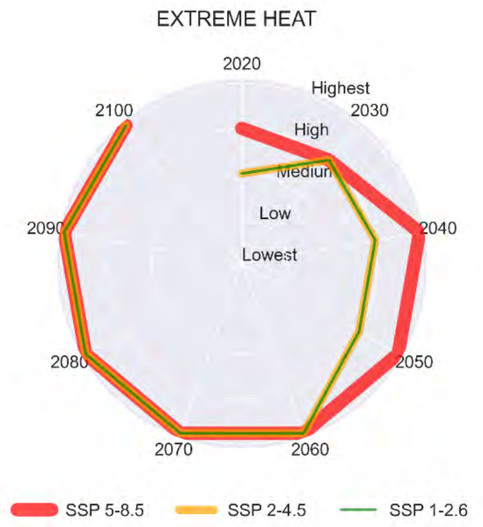

Figure 15: Extreme Heat Risk.

According to Figure 15, the following table shows the levels of risk for extreme heat identified for each defined time horizon, in each emission scenario:

Table 5: Risk level for Extreme Heat for each defined time-horizon.

Time horizon	Risk Level – Extreme Heat		
	Optimistic Scenario	Intermediate Scenario	Pessimistic Scenario
2020	Medium	Medium	High
Short-term (2030)	High	High	High
Mid-term (2040)	High	High	Highest
Long-term (2050)	High	High	Highest

15.3.3.2 Extreme Precipitations Risk

Extreme precipitation is another quite critical risk. This is due the fact that despite the remarkable adaptation level, the sensitivity to this climatic hazard is high, and the future projections show a tendency to further extreme precipitation increase with the respect to an already critical situation at present.

The trend is similar for all scenarios, with a "high" risk level at present which is expected to remain like that till the end of the century.

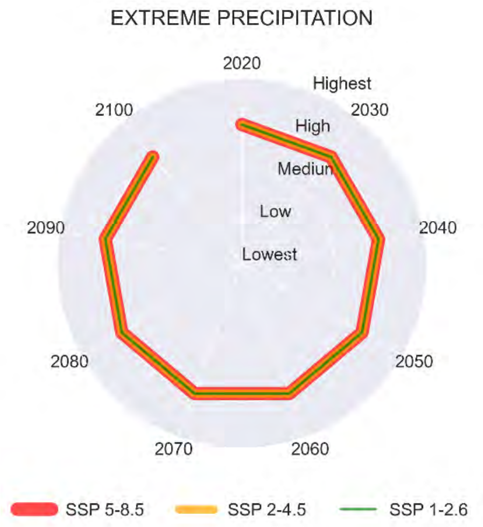

Figure 16: Extreme Precipitations Risk.

According to , the following table shows the levels of risk for extreme precipitations identified for each defined time horizon, in each emission scenario:

Table 6: Risk level for Extreme Precipitation for each defined time-horizon.

Time horizon	Risk Level – Extreme Precipitations		
	Optimistic Scenario	Intermediate Scenario	Pessimistic Scenario
2020	High	High	High
Short-term (2030)	High	High	High
Mid-term (2040)	High	High	High
Long-term (2050)	High	High	High

15.3.3.3 Severe Storms Risk

Severe storms resulted a significant risk. However, the risk is expected to reach “high” level only for the pessimistic scenario.

For the optimistic and intermediate scenarios, the trend for the future shows stability. The level of the risk is “medium” at present and remain stable for the rest of the century. On the contrary, for the pessimistic scenarios the level of this risk escalates to “high” level yet in 2030. Then the risk remains at the same level for the rest of the century.

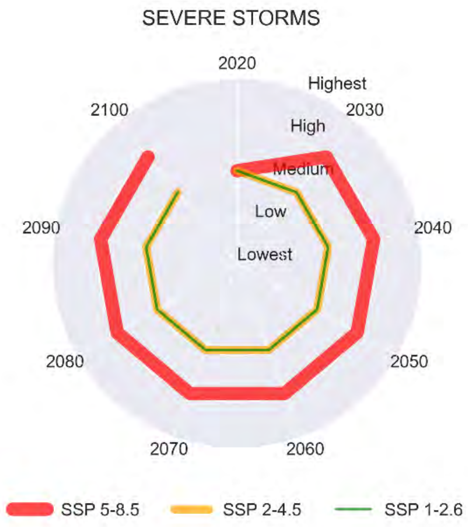

Figure 17: Severe Storms Risk.

According to , the following table shows the levels of risk for severe storms identified for each defined time horizon, in each emission scenario:

Table 7: Risk level for Severe Storms for each defined time-horizon.

Time horizon	Risk Level – Severe Storms		
	Optimistic Scenario	Intermediate Scenario	Pessimistic Scenario
2020	Medium	Medium	Medium
Short-term (2030)	Medium	Medium	High
Mid-term (2040)	Medium	Medium	High
Long-term (2050)	Medium	Medium	High

15.3.3.4 Drought Risk

According to the outcomes of this CCRA, drought resulted a critical risk as well. The risk level shows an increasing trend in all scenarios. This is due to the combination of a “medium” vulnerability with and increasing trend of drought events which are expected to happen in the future. For the optimistic scenario, the risk level is “medium” for the entire century and reaches the “high” level only late in 2090. For the intermediate, the increase is faster, with the “high” level reached in 2070. Finally, for the pessimistic scenario, the increase the worsening of the Risk is expected to happen even earlier, already in 2050.

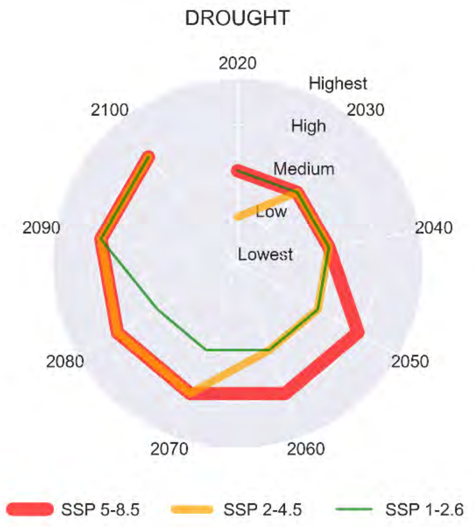

Figure 18: Drought Risk.

According to Figure 18, the following table shows the levels of risk for drought identified for each defined time horizon, in each emission scenario:

Table 8: Risk level for Drought for each defined time-horizon.

Time horizon	Risk Level – Drought		
	Optimistic Scenario	Intermediate Scenario	Pessimistic Scenario
2020	Medium	Low	Medium
Short-term (2030)	Medium	Medium	Medium
Mid-term (2040)	Medium	Medium	Medium
Long-term (2050)	Medium	Medium	High

15.3.3.5 Wildfires Risk

Wildfire risk does not seem a critical risk for the airport. In fact, despite a high vulnerability, the predicted number of wildfires remain low thus contributing to a generally “low” risk level. Only for the pessimistic scenario the risk reaches the “medium” level, but late in the century, after 2080.

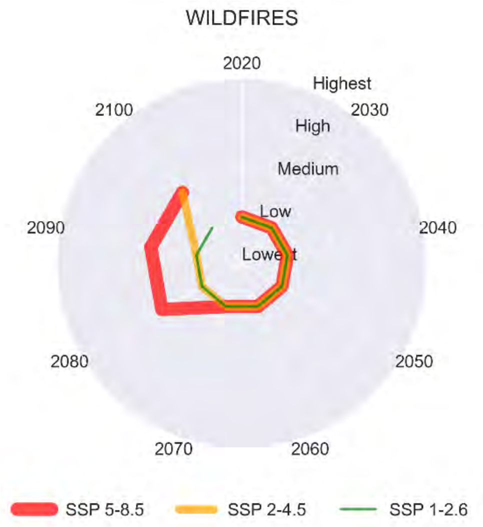

Figure 19: Wildfires Risk.

According to Figure 19, the following table shows the levels of risk for wildfires identified for each defined time horizon, in each emission scenario:

Table 9: Risk level for Wildfires for each defined time-horizon.

Time horizon	Risk Level – Wildfires		
	Optimistic Scenario	Intermediate Scenario	Pessimistic Scenario
2020	Low	Low	Low
Short-term (2030)	Low	Low	Low
Mid-term (2040)	Low	Low	Low
Long-term (2050)	Low	Low	Low

15.3.4 Risk Mitigation Actions and Conclusions

The Climate Change Physical Risk Assessment helped to identify the most critical climate-related risks associated to the consequence of climate change according to different emission scenarios and during the lifetime of the Project.

Overall, the current status of the Project does not allow a full risk assessment because of the early stage of the design phase. Further considerations will be needed during the Project development once the Ministry of Transportation will define the approach for the management of the new airport and will set up strategy and costs related to the functioning and maintenance. The preparation of a Climate Adaptation plan is strongly recommended to be developed by MoT or SGA before any operation starts. The Adaptation Plan will be a living document to be periodically reviewed, whose actions for reducing and adapting to risks will have to be organized according to short, medium, and longer-term timescales, covering the period up to 2050. As the plan is intended to be a combination of actions needed to reach the low carbon strategy, the consideration of the transitional risks will have to be also included. As a guidance reference, the ICAO Climate Resilient Airport toolkit may provide some good foods for thoughts.

A few measures are proposed below to reduce the climate risks for the hazards considered in the assessment. These measures have been inspired by ICAO standards and WSP expertise on Climate Change Risk Assessments for similar projects.

Actions could be prioritized based on the risks level, the timeframe expected to reach results and the coordination with Government policies. However, according to the nature of the measures, these could be implemented in the short or mid-term. For long-term measures it is recommended to undertake a monitoring programme of climatic data at Cabinda region. The responsibility for implementing them should be taken by the Ministry of Transportation and SGA.

The list of measures identified below does not have to be considered binding or exhaustive. However, they should be taken into consideration as potential actions to reduce the Vulnerability of the NAIC towards climate-related hazards.

The validity of these adaptation measures should be revised once Operation phase approaches. They could also represent a solid basis for the preparation of a more comprehensive Climate Change Adaptation Plan.

First, measures that could be beneficial for all risks are presented. Then risk-specific measures are listed, starting from the most critical risks, Extreme Heat and Extreme Precipitations, followed by Severe Storms and Drought which resulted also relevant. Finally, few measures are mentioned for Wildfires, considering that levels for this risk resulted negligible.

<u>All Risks</u>

- As part of the Emergency Preparedness and Response Plan (EPRP) required within the Project’s Environmental & Social Management System (ESMS), a detailed focus and integration on the control of all hazards is needed.
- Conduct further research to improve understanding of how the weather could change due to climate change especially in the wet season and the impacts on the procedures to be considered in the Cabinda airport.
- During airport operations, an Airport Emergency Plan compliant with ICAO standards must be in place. General guidelines for the preparation of the airport emergency plan are found in the *ICAO Annex 14 — Aerodromes, Volume I — Aerodrome Design and Operations, Chapter 9*. The Airport Emergency Plan shall support the coordination of the actions to be taken in an emergency occurring at the airport or in its vicinity. Examples of emergencies include the ones related to natural disasters and building fires. The plan will set forth the procedures for coordinating the response of different aerodrome agencies (or services) and of those agencies in the surrounding community that could be of assistance in responding to the emergency.
- Implementation of an Emergency Operations Center. ICAO recommends that an emergency operations center should be part of the aerodrome facilities and should be responsible for the overall coordination and general direction of the response to an emergency.
- Maintain all hazard-specific mitigation measure, according to regular interventions and checks, possibly based on dedicated maintenance programs.
- Implementation of an efficient communications and alarm system in the ARFF building. A full description of airport communication and alarm requirements is found in the ICAO Airport Services Manual (Doc 9137).
- Implement an early warning system and make provision for a direct connection with any existing early warning systems at local or regional level to guarantee information on potential extreme event are monitored and shared on a daily basis.

Risk of Extreme Heat

- Provide adequate and regular maintenance of cooling systems verifying that the adequacy is guaranteed in the face of the expected increase in temperatures and the frequency of conditions of thermal stress and heat waves.
- Consider using construction materials for buildings and other infrastructures with a lower capacity to absorb heat and higher capacity to maintain their main properties in case of extremely high temperatures.
- Provide proper and regular maintenance to buildings, infrastructures, and equipment to avoid increasing their sensitivity hot temperatures.
- Rescheduling working hours and provide more work breaks during extremely hot periods to ensure the safety and efficiency of staff working in outdoor areas of the airport.
- Provide for additional shades in public spaces, such as planting additional trees, and adding shades in parking lots.
- Consider the implementation of techniques to keep the moisture of the soils in the surroundings of the airport (such as water spraying), to avoid loose dirt to permeate ground equipment.
- Review capital projects in relation to airfield re-surfacing to check existing levels of tolerance to climate change. Make sure all future airfield resurfacing works consider the impacts of increasing temperatures, to protect the project / asset throughout its lifetime.
- As per the ICAO Climate Adaptation Synthesis Document, "*in areas where higher temperatures may be a challenge for aircraft take-offs, future temperature and aircraft runway length calculations may need to be reconsidered when determining the appropriate runway length*".

Risk of Extreme Precipitation

- Implement measures to protect the Airport infrastructure from infiltration due to intense precipitations, or disruption caused by strong wind.
- Keep regular maintenance of the storm water drainage system and keep drainage channels clean to avoid potential flooding in cases of heavy rain associated with intense precipitations.
- Carry out more in-depth geotechnical studies to better characterize the stability of the geological formation in the airport area and surroundings, particularly in the presence of exceptional amount of water, in case of intense precipitations.
- Review the design criteria of the existing rainwater system vs new data for the rainwater intensity.

Risk of Severe Storms

- Implementation of a Meteorological & Weather Management System at the airport for predicting and forecasting weather phenomena for flying activities throughout the region.
- Consider the implementation of a thunderstorm safety procedure.
- The airport would benefit from the implementation of a Lightning Detection Network (LDN) for detecting and monitor thunderstorm development, intensity, and movement over a selected area, and providing this information, in real-time, to pilots, aerodrome operators and air traffic units.
- Implementation of airport lightning protection components, such as lightning rods and wiring to direct the electrical current from a strike harmlessly into the ground.

- Verify that airport materials/structures potentially subject to displacement in the presence of strong gusts of wind are adequate to cope with more intense and more frequent storms.

Risk of Droughts

- Introduce water efficiency systems and technologies to reduce water consumption.
- Identify the potential effects of water shortages on NAIC operations and include mitigation measures and coordination actions in the Airport Emergency Plan.
- Identify the potential effects of water shortages on the increased risk of soil erosion around apron and runway. Consider the inclusion of mitigation measures and coordination actions in the Emergency Preparedness and Response Plan (EPRP).

Risk of Wildfires

- Include mitigation measures and coordination actions in the Emergency Preparedness and Response Plan (EPRP) regarding Wildfire risks, intended to reduce the risk of forest fires that may be triggered or spread by utility electrical equipment or installations.
- Review existing and planned fire response standard and procedures in order to verify their effectiveness to fight fires due not only to accidents within the airport but also wildfires originating outside of its boundary.

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