Climate Risk And Vulnerability Analysis

BELÉM, PARÁ

EXECUTIVE SUMMARY

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ICLEI Governos Locais pela Sustentabilidade

NBCITIES Nature-Based Cities

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DOCUMENT INTRODUCTION

This document provides a summary of the results obtained during the development of the Ecosystem Services Diagnosis for Belém, as part of the Nature-Based Cities: Biodiversity and Climate Resilience for Urban Development (NBCities) project, implemented by ICLEI South America and funded by the Global Ecosystem-based Adaptation (EbA) Fund.

Located within the Amazon Rainforest and one of Brazil's most important capitals, the city was selected to host the World Climate Conference, COP30, in 2025. Through an Ecosystem-based Adaptation approach, the NBCities project, which started in June 2023, aimed to support evidence-based planning to integrate the climate and biodiversity agendas in the city.

ICLEI – Local Governments for Sustainability

A global network of more than 2,500 local and regional governments committed to sustainable urban development. Active in over 125 countries, ICLEI's network in South America connects members from eight countries in the region to this global movement. We influence sustainability policies and drive local action for low-carbon, nature-based, equitable, resilient, and circular development.

Municipality of Belém

The project was carried out in collaboration with the technical team of the Municipality of Belém, with notable support from the Secretariat of General Coordination of Planning and Management, the Municipal Secretariat for the Environment, the Municipal Forum on Climate Change, and the Civil Defense. It also benefited from the collaboration of municipal partners such as the HF Profa. Normélia Vasconcelos Herbarium of the Federal University of Pará (UFPA), the Federal Rural University of the Amazon (UFRA), the Emílio Goeldi Museum of Pará, and the UN Refugee Agency (UNHCR).

Global EbA Fund

The Global EbA Fund is a catalytic funding mechanism for supporting innovative approaches to EbA to create enabling environments for its mainstreaming and scaling up. The fund is financed by International Climate Initiative (IKI) of the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) and co-managed by the International Union for Conservation of Nature (IUCN) and partners. Learn more about the Fund and apply for a grant through the website: https://globalebafund.org/

BELÉM CITY HALL

Belém, the capital of the state of Pará, embodies both tradition and modernity. It preserves a rich cultural and historical heritage. Now known as the "Capital of the Amazon," the city stands out for its colonial architecture, with landmarks such as the Ver-o-Peso Market and the Theatro da Paz, symbols of the peak of the rubber boom that now blend into a cosmopolitan landscape. The local culture is vibrant, centered especially around the Círio de Nazaré, the world's largest religious celebration, held on the second Sunday of October. Belém's gastronomy is recognized worldwide, bearing the title "Belém Creative City of Gastronomy" granted by UNESCO (only four cities hold this title), a testament to its unique cuisine highlighted by dishes such as açaí, tacacá, and pato no tucupi. The city also preserves its natural charms, with areas like the Utinga State Park, the Guajará Bay waterfront, and the Rodrigues Alves Amazon Botanical Garden offering refuge for the region's fauna, flora, and citizens amidst the bustle of urban life.

Belém is the Brazilian city that has received the most public investment in recent years and, in November 2025, will host the 30th United Nations Climate Change Conference (COP-30), one of the world's leading events on the subject. The city is undergoing a moment of transformation, combining its rich cultural and natural heritage with a hub of development, economic growth, and policies of innovation and sustainability, such as the "Green City" project, which aims to plant 10,000 seedlings per year over the next four years to expand the city's urban green areas. Hosting COP-30 in 2025 highlights Belém's global role in the climate change debate and in shaping a sustainable future for the Amazon.

Igor Wander Centeno Normando
Mayor of Belém

ICLEI SOUTH AMERICA

Belém joined ICLEI in 2022 with the goal of promoting low-carbon urban development, adapted to climate change and aligned with sustainability, urban biodiversity, and the inclusion of vulnerable populations. The city is further distinguished on the international agenda after being named the host of COP30, which underscores the importance of a sustainable development agenda.

This document presents a summary of the results obtained from the Climate Risk and Vulnerability Analysis (CRVA) of Belém, conducted as part of the Nature-Based Cities: Biodiversity and Climate Resilience for Urban Development (NBCities) Project. The project, implemented by ICLEI South America and funded by the Global Ecosystem-based Adaptation (EbA) Fund, aimed to strengthen evidence-based planning for the integration of climate and biodiversity issues into Belém's urban development.

Developed in collaboration with the City Hall and partners, Belém's CRVA focused on three priority climate risks for the city: floods, coastal erosion, and urban heat island phenomena. It considered the population and infrastructure exposure, as well as future threats resulting from climate change. The results of this analysis will help inform the formulation of public policies to enhance resilience and promote a sustainable future for Belém. This process also reinforces the city's commitment to climate action, especially in light of the upcoming COP30 in 2025.

Enjoy your reading!

Rodrigo Perpétuo
Executive Secretary, ICLEI South America

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1 Introduction

Climate change is one of the most complex challenges of this century. The sixth report of the Intergovernmental Panel on Climate Change (AR6 - IPCC, 2021) points out that human action has a major contribution to global warming, through activities that emit Greenhouse Gases (GHG).

The current model of urban development has generated several pressures on the Earth's ecosystems, accelerating the biodiversity loss crisis, which is intertwined with the current context of climate emergency.

The climate imbalance scenario causes an increase in the frequency and intensity of climate events considered extreme, such as pluvial and river floods, coastal erosion, long periods of drought, heat waves, in addition to warming and rising average sea levels. These and other events impact territories in different ways in each region of the planet.

In countries in the Global South such as Brazil, high levels of social inequality and poverty increase vulnerability to climate change, given the population's reduced ability to adapt to extreme weather events. Pará, a vast and richly biodiverse state in northern Brazil, faces significant climate change-related challenges associated with biodiversity loss. Accelerated deforestation and other land use changes compromise its tropical forests, which are vital to global climate regulation. Faced with this scenario, the state has been seeking actions to escape the status of one of the largest emitters of CO^2 of Brazil, to position itself at the forefront of climate action.

On a municipal scale, the impact of climate events varies according not only to environmental factors, but also to the city's infrastructure and land use and occupation. There is an urgency to develop institutional action mechanisms for **adaptation of urban environments** (AR5 - IPCC, 2015), positioning the theme of adaptation and resilience of urban territories as a priority. In this sense, the city of Belém has also been adopting its own measures to advance the climate agenda at the local level.

The city joined ICLEI in 2022, in order to advance the promotion of public policies and actions for sustainable, socially inclusive development, in harmony with nature and resilient to climate change. Belém has sought to strengthen a collective strategy for sustainability and support climate compliance, having carried out its first Greenhouse Gas Emissions Inventory with ICLEI in 2023.

In the same year, the NBCities - Nature-based Cities project was started, with one of its pillars being capacity building and data-based planning. Developed within the scope of NBCities, the Climate Risk and Vulnerability Analysis (CRVA) identifies the main climate threats, the level of exposure of the population and infrastructures, in addition to the vulnerability of the territory, thus indicating the current and future climate risk. In addition, CRVA also analyzes local climate governance using the Scorecard tool developed by the Making Cities Resilient 2030 Initiative (MCR2030).

There are many risks related to climate change. Each territory, depending on its different conditions, is impacted in a specific way. To address the issues observed and most discussed in the city of Belém, together with the City Hall, a set of three climate risks were defined for analysis:

At the conclusion of the process, results on climate risks in the city of Belém were obtained, which, along with the recommendations presented, structure a robust document to support the formulation of public policies for urban adaptation and increased resilience capacity. municipal. . From this perspective, this CRVA was used by Belém to carry out its Climate Action Plan in a way that, immediately, constitutes a diagnostic instrument that is already being used to plan risk reduction actions. That said, we add that, in the Actions listed in the PLAC, added to the risks mapped here is the importance of planning the city for the risk of Arbovirus, which in the future, when mapped, must be the object of recognition along with the risks already recognized, as well as its overlap in the observation of what we call here as "Critical Risk".

2 Belém: an overview of the territory

Belém is located in the western Brazilian Amazon northeastern Pará (Figure 3). As the state capital, it is one of the most important cities in the Amazon and forms the Metropolitan Region of Belém (RMB), along with seven other municipalities. The city has 1,059.458 km^2 of territorial extension (around 0.08% of the state's territory).

The city is divided into 72 neighborhoods, organized into eight administrative districts:

- Belém (DABEL)
- Benguí (DABEN)
- Entroncamento (DAENT)
- Guamá (DAGUA)
- Icoaraci (DAICO)
- Mosqueiro (DAMOS)
- Outeiro (DAOUT)
- Sacramenta (DASAC)

The municipality is divided between a continental portion and an island portion. The continental portion accounts for 34.36% (17,378.63 ha) of the total area, while the island portion is made up of 39 islands and corresponds to 65.64% (33,203.67 ha) of the city's total area. Most of these islands are densely forested with low population density. However, Mosqueiro, Caratateua (Outeiro), and Cotijuba are exceptions, featuring urbanized areas and a larger population. In general, the islands play a fundamental role in the city's landscape, reflecting its ribeirinho character crisscrossed by rivers, streams, igarapés, and tide channels.

2.1 Environmental characterization

Located on a flat plain, its lowlands lie just 4 meters above sea level, while the highest portions reach 16 meters (Cardoso et al., 2023). With a rainy tropical climate, the city receives an average annual precipitation of 3,308 mm. During the summer months, from January to March, the monthly average exceeds 390 mm, while August and September are the months with the lowest levels of precipitation, with a monthly average below 130 mm (INMET, 2022).

Figure 1 - Location of Belém and its Metropolitan Region, Pará

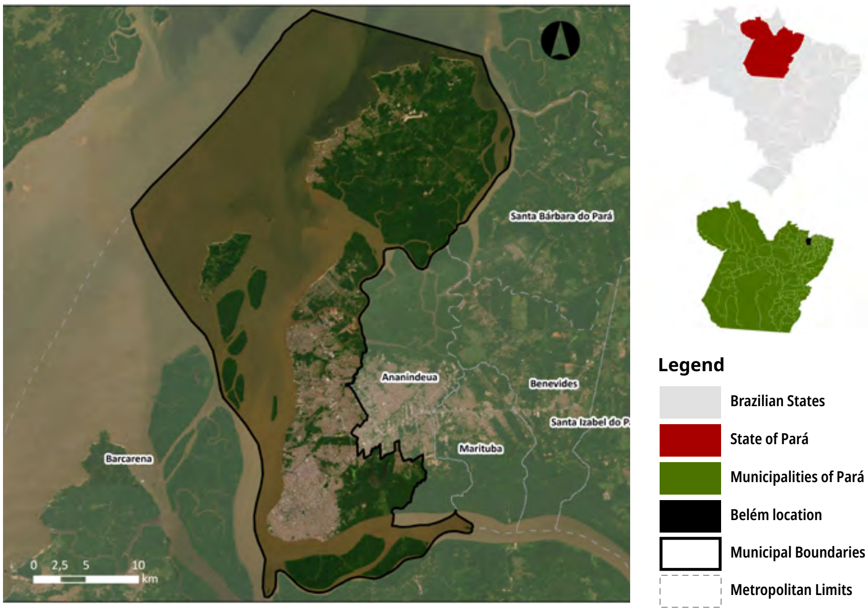
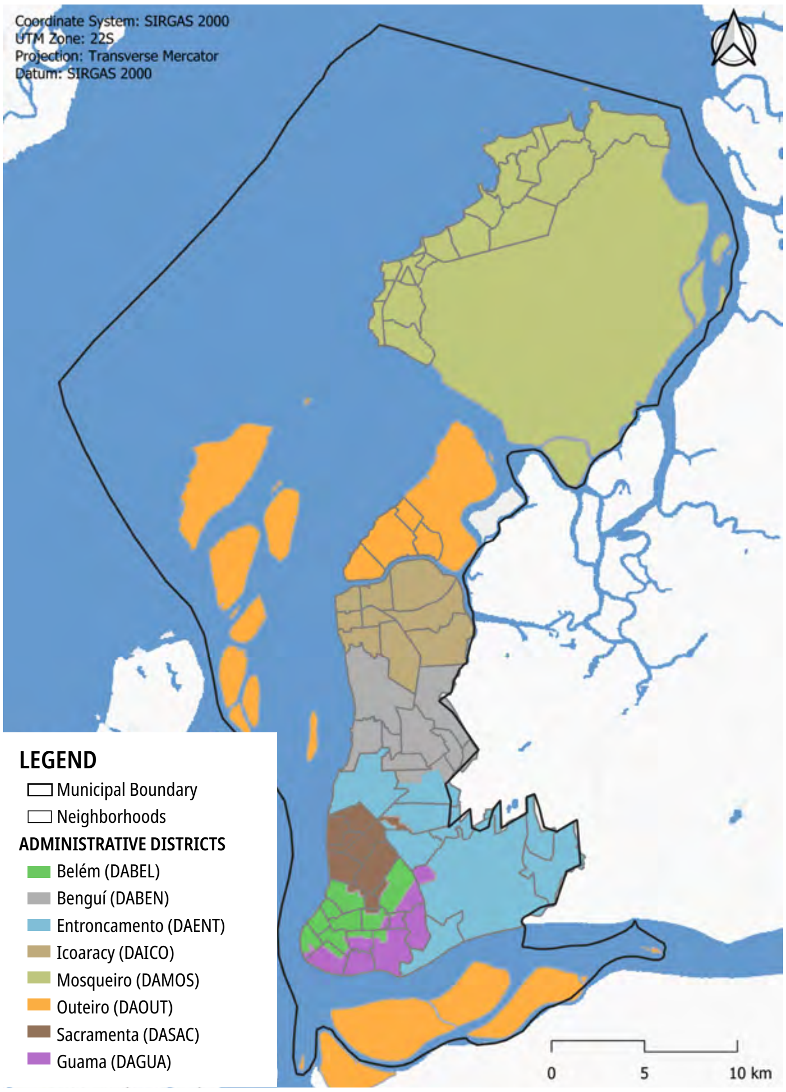


Figure 2 - Administrative division of Belém, PA



Situated at the confluence of the Guamá River and the Guajará Bay, which is part of the Marajoara Gulf, the city is subject to daily ocean tides and is crisscrossed by numerous watercourses and their associated floodplains (Gonçalves, 2016). Among the most significant rivers in the region are the Maguari, Aurá, Guamá, Murubira, and Pratiquara, in addition to several streams that meet the main watercourses. Additionally, the bays of Marajó, Santo Antônio, and Sol hold considerable importance (Mercês, 1997 as cited in Catete, 2010).

Figure 3 - Some of the main water bodies in Belém, PA

Belém's natural vegetation fragments are characterized as dryland forests and floodplain forests, both part of dense Ombrophilous vegetation types (Tavares, 2019). The capital of Pará is located within the Belém Endemism Center (CEB), one of the richest regions of the Amazon in terms of biodiversity. At the same time, it is also one of the regions facing the greatest challenges in terms of ecosystem protection and restoration, as it is the area where human settlement in the Amazon began and is now the most densely populated.

2.2 Characterization of land use and land cover

At the moment, the proportion of land use and coverage in Belém is distributed as follows: 31% forest formation, 28% floodplain forest, 27% urbanized areas, 9% grassland mosaic, 3% mangrove, 2% flooded fields and swampy areas (Figure 7). There are no significant traces of agriculture (MapBiomas, 2020), which aligns with the relatively small size of the municipality's rural area — approximately 6,000 hectares (Instituto Escolhas, 2022)

Figure 4 - Change in Land Use and Occupation (2020)

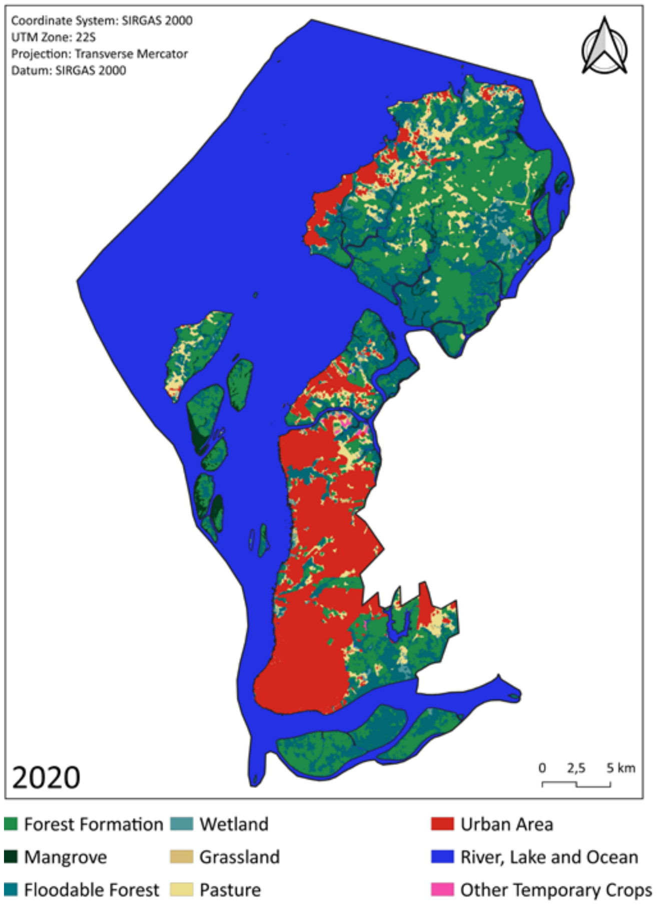
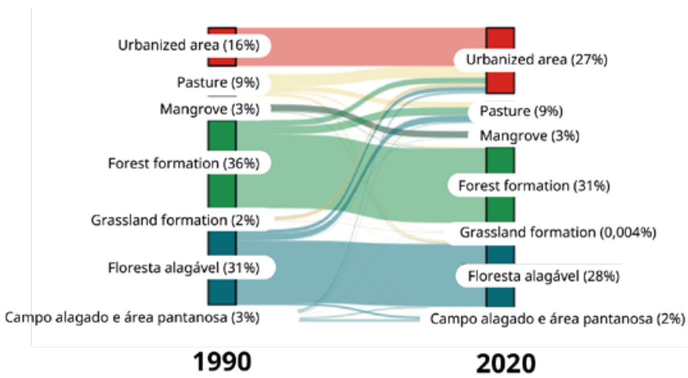


Figure 5 - Sankey Chart - Land use conversion



Source: Adapted from MapBiomas (2020)

A phenomenon common to most large Brazilian cities, the urban expansion over time is evident, as well as the reduction of natural classes of land use and cover. Natural attributes have played a crucial role in the formation and configuration of the city since it was in dialogue and conflict with the forests and, even more significantly, with rivers and bodies of water. As a result, the city's expansion has sometimes occurred at the expense of these attributes and sometimes in adaptation to them, shaping the current territorial, cultural, and socioeconomic characteristics of Belém.

2.3 Socioeconomic characterization

The total population of Belém was estimated at 1,303,403 inhabitants (IBGE, 2022). According to the Statistical Yearbook of the Municipality of Belém 2020, although most of the municipality's total area is classified as a rural area (258.11 km²), nearly the entire population (99%, according to the 2010 Census) resides in the urban area (250.20 km²), primarily located in the continental portion. This highlights the importance of addressing the urban perspective of the Amazon in the debate on sustainable development and urban planning integrated with nature.

In 2021, the city's GDP reached R$33.4 billion, representing 12.7% of the state's GDP. On the other hand, the Gini index, which measures the degree of income concentration in a given group, has indicated an increase in inequality in Belém. While 0 corresponds to complete equality and 1 represents complete inequality, the city's Gini index value increased from 0.44 in 2003 to 0.61 in 2010. The service sector alone accounted for 53% of the city's economy, tourism being a particularly important activity (FAPESPA, 2021). In addition to religious tourism, with emphasis on the Círio de Nazaré procession, ecotourism has grown, driven by natural resources, including river tourism.

2.4 Characterization on the occurrence of disasters

There are two main factors that contribute to Belém's heightened susceptibility to hydrological disasters: the climatic profile characterized by intense rainfall and high humidity throughout the year, and the geographic profile, with large low-lying areas and proximity to rivers and canals. According to the Digital Atlas of Disasters in Brazil, between 2018 and 2023, 34 disaster events were recorded in the municipality of Belém, of which 8 were classified as flooding. During this period, 23 fatalities and a total of 100,820 people affected were reported, with approximately 456 displaced persons and a public loss estimated at 21.82 million reais (MIDR, 2024). Additionally, the mapping of geological risk areas, conducted through a partnership between Belém's Civil Defense Commission and the Geological Survey of Brazil (CPRM), identified 125 risk areas, of which 76 correspond to flood-prone zones and 49 to areas at risk of coastal erosion (CPRM, 2021).

Climate change has the potential to significantly alter and intensify the disaster scenario in Belém, impacting the frequency, intensity, and extent of adverse events that already affect the city. In light of this, it is crucial to understand both current and future climate risks to inform investments in climate adaptation solutions. The climate change scenario is particularly concerning from the perspective of the exacerbation of social inequalities, as the poorest populations—often residing in higher-risk areas (near rivers or on vulnerable land)—are the most exposed to disasters. With the intensification of extreme weather events, these communities may face greater displacement as well as more severe economic and health losses, further underscoring the importance of applying a climate justice lens in risk analyses.

CLIMATE JUSTICE IN CLIMATE ANALYSIS

The concept of climate justice is crucial for understanding how climate change exacerbates social inequalities and vulnerabilities. Although the climate crisis affects the entire society, its impacts are unequally distributed, disproportionately affecting specific vulnerable social groups. The effects of the climate crisis compound poverty, limited access to education, inadequate infrastructure, and non-economic issues related to gender, race and ethnicity, age, mobility, and more. When overlapped, they result in profound inequality, further hindering the capability to adapt to the effects of climate change (Gender & Climate and Climate Observatory, 2022).

Therefore, from a climate justice lens, every climate mitigation or adaptation action must consider the inequalities in the conditions countries and people find to defend themselves from the impacts of climate change. Climate assessments work as relevant inputs for the design of public policies. However, they must consider different social markers that relate to various vulnerabilities.

That is why integrating exposure and sensitivity dimensions is so relevant. This process allows the consideration of the specific contexts and capacities in the face of the mentioned threats from the beginning of the risk analysis, thus providing an understanding of the climate risks that offer greater potential for advancing climate justice, by prioritizing areas of greater vulnerability.

3 The methodology of the Climate Risk and Vulnerability Analysis (CRVA)

The Climate Risk and Vulnerability Analysis (CRVA) methodological process is based on international and national guidelines and regulations, including the latest reports from the Intergovernmental Panel on Climate Change (IPCC, 2015; IPCC, 2023), the Vulnerability Sourcebook from the German development agency GIZ (2014; 2017) and the Disaster Resilience Scorecard for Cities from the Making Cities Resilient (MCR2030) initiative, led by United Nations Office for Disaster Risk Reduction (UNDRR), in addition to recent scientific research ((Mello, 2021; Buchala, 2022)) and studies by the Brazilian Federal Government (MMA, 2018).

Thereby, ARVC's methodological process is divided into three steps. The first is training and raising awareness of stakeholders; the second involves gathering information and analyzing georeferenced data; the final stage corresponds to preparing the report featuring the results.

3.1 Composition of the models

CRVA is a strategic territorial study that focuses on analyzing the phenomena of possible disaster from its components. This approach simultaneously considers multiple indicators: the set of **threats** related to climate events; the **exposure** to environmental and socioeconomic systems, in addition to the local infrastructure; and, finally, the territorial **vulnerability** of cities or regions, which is the degree of **sensitivity** or local susceptibility to **adaptive capacity** to address climate threats.

A **threat** is the probability of a natural or physically human-induced event, as well as the physical impact or its tendency that may cause loss and damage — such as flooding, coastal erosion, heat waves, droughts, rising sea levels, and others.

Exposure corresponds to the presence of infrastructure and operations that may be adversely affected, including the concentration of people and the existence of ecosystems and agricultural areas that could be negatively affected by climate change.

In turn, **vulnerability** encompasses a variety of elements and works as a balance between **sensitivity** (or susceptibility of the region to damage) and its **adaptive capacity** to deal with, respond to, and prepare for climate change.

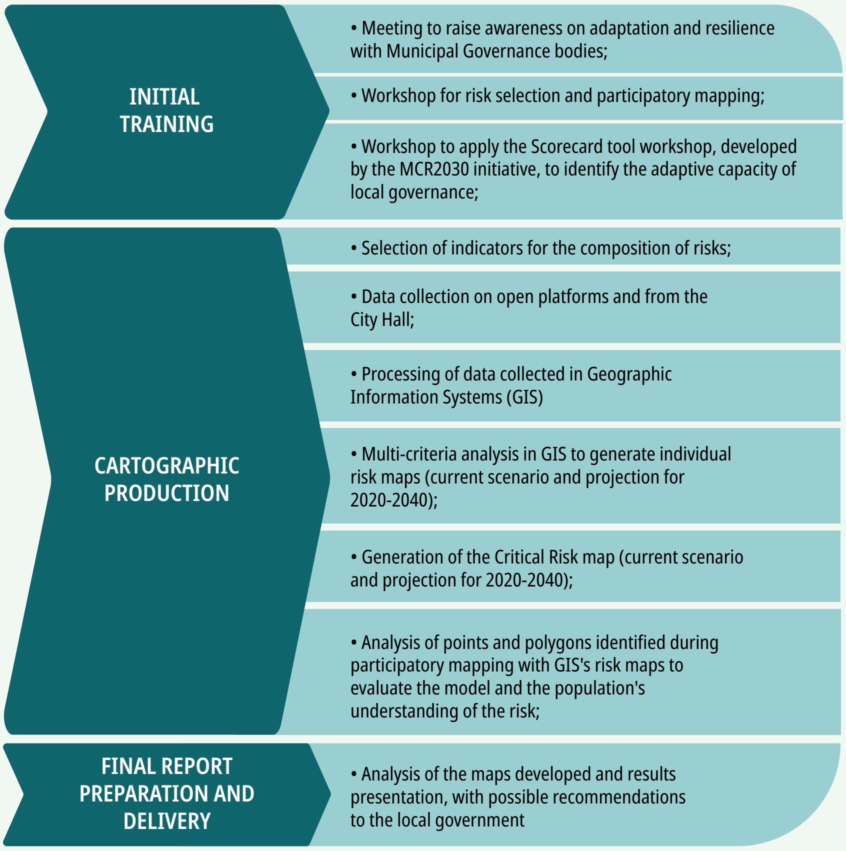
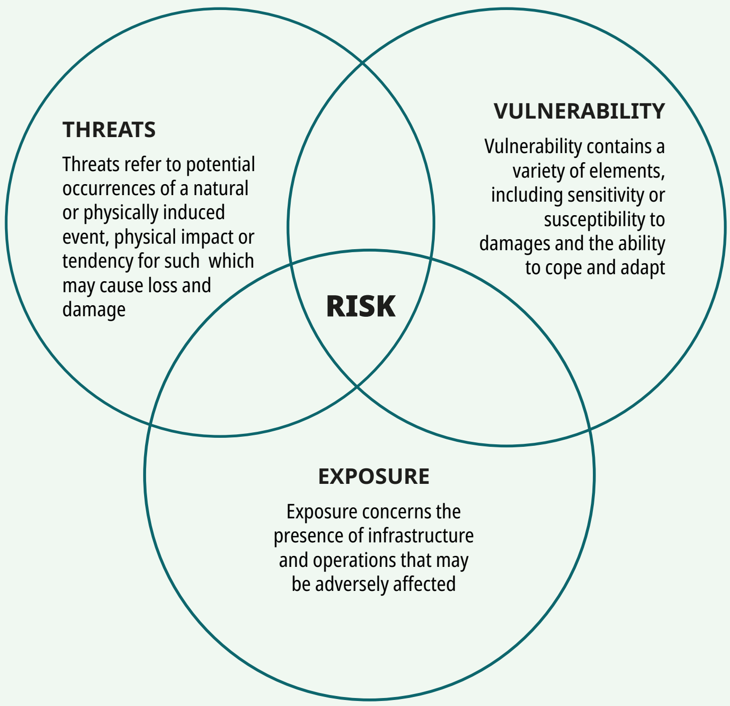


Figure 6 - Composition of climate risk according to the IPCC methodology



Source: Adapted from IPCC, 2015

Figure 7 - Illustration of climate risk and the interaction between its components

Source: Adapted from IPCC, 2015

3.2 Data processing

Preparing the risk maps requires the collection of a dataset to gather climatic, physical-morphological, social, environmental, and local infrastructure information. Open-access state, national, and international portals provided part of this information, including lithology, hydrography, census data, and land use and coverage. Conversely, strictly local information—such as containment infrastructure and the locations of public facilities—was requested from the municipal government of Belém.

The collected data varies in structure and nature, encompassing tables, indexes, images, and vectors. All of this information was spatially represented within the territory and adapted to the same geographic projection system. All data was normalized according to the same criteria to become standardized indicators. This data processing methodology allows different information such as precipitation, demographic density, and the presence of urban infrastructure to be crossed and translated into a unified index. Subsequently, these indicators were allocated to the risk component logic.

Threat Component

The threats mentioned here arise from climate causes. Temperature increase, precipitation decrease or increase, strong gusts of wind, among others, are factors understood as climate threats since they have atmospheric origins and potentially harm people and damage infrastructures. Threats constitute a risk when extreme events associated with high exposure and vulnerability occur.

Exposure Component

In the CRVA, exposure indicators concern the location or presence of people, natural systems, services and resources, infrastructures, or economic, social, cultural, or environmental assets that may be harmed by climate change (IPCC, 2015). This component encompasses a variety of indicators, including population density, income, concentration of services, businesses, industries, and public facilities.

Vulnerability Component

Vulnerability deepens the understanding of exposure factors and is assessed based on sensitivity and adaptation capacity factors. These factors represent the location development, indicating the degree of the territory's vulnerability to climate phenomena since the combination of high sensitivity and low adaptive capacity results in greater vulnerability.

Sensitivity refers to the degree to which a system can be (positively or negatively) affected by climate variation or change (MMA, 2018). For example, terrain concavity (flood-prone areas) can be used as an indicator to assess a location's sensitivity to floods. Similarly, for heat islands, the orientation of slopes (higher or lower solar incidence) serves as a sensitivity indicator.

Adaptive capacity, on the other hand, represents how a system can cope with potential damage associated with climate change. Indicators of adaptive capacity for sensitivity to floods and heat islands include soil permeability and the presence of tree vegetation, respectively.

Critical Climate Risk

Once individual risks are modeled, the next step is to proceed to an integrated analysis of the territory. At this stage, the goal is to understand the simultaneous occurrence of risks, which is done by crossing maps and finding the index average in a GIS environment. The process is carried out to model the current situation of the municipalities as well as possible future scenarios.

This step does not diminish the importance of the analysis of specific risks, but rather strengthens the Climate Risk and Vulnerability Analysis by enabling a broader understanding of the areas of the territory affected by a combination of different climate risks, and therefore indicating a greater need for intervention.

3.3 Building the Climate Risk and Vulnerability Analysis (CRVA) of Belém

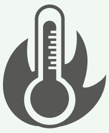
The first steps in developing the Climate Risk and Vulnerability Analysis (CRVA) of Belém were general data collection about the territory and contextualizing risks observed in the municipality. The city's CRVA analyzed three climate risks: flooding, coastal erosion, and the phenomenon of heat islands — all selected in agreement with the city and the participatory mapping workshop.

FLOODING

According to hydrological regime variations, the banks of rivers and streams may present natural flood scenarios, with water overflowing floodplain areas in different magnitudes (BENATTI, 2016). However, floods also occur in urban drainage due to the effect of soil impermeabilization, drainage obstructions, or drainage channeling (TUCCI, 2005). This study considers both possibilities.

COASTAL EROSION

Coastal erosion is the natural process of wearing down and removing sediments (such as sand, soil, and rocks) from coastal areas due to natural forces, such as tides and winds (Souza et al., 2005). However, human actions can influence and accelerate the erosion process, depending on the usage and forms of land occupation in coastal areas.



HEAT ISLANDS

Heat islands are an anthropic phenomenon related to the temperature difference observed between areas with varying densification and urbanization patterns (Oke et al., 2017). The heat accumulated during sun exposure — and amplified by human activities—is retained on surfaces and fails to disperse at night. This phenomenon occurs, for example, when excessive asphalt coverage coincides with a lack of trees. Heat waves are a large-scale meteorological phenomenon that intensifies the impacts of extreme temperatures when associated with heat islands. Although heat waves are natural occurrences, their frequency, intensity, and duration have increased due to climate change.

As previously mentioned, climate risks are analyzed based on **threat**, **exposure**, and **vulnerability components**, each featuring its analysis indicators. Therefore, understanding climate risk analysis implies also grasping the elements involved and how they relate to each risk. Please find the list of indicators, their definition, and sources in each risk-specific section.

Results analysis focused on high- and very-high-risk areas, defined based on neighborhood population density and climatic exposure. The primary criterion for delimiting both areas is that higher population density concentrates more people exposed to risks, thus becoming priority regions for interventions and impact mitigation. The indicators of such areas were also evaluated, further understanding the specific factors contributing to their vulnerability. The main objective of this analysis is to pinpoint regions with potentially greater severity, establishing a set of priority areas for local governance. However, this approach recognizes the importance of considering risks across the Municipality.

Various stakeholders participated in technical and participatory activities to develop the ARCV of Belém, including the Working Group (Grupo de Trabalho) — an executive governance body composed of representatives from the city's institutions and departments — and the Municipal Climate Change Forum of Belém (*Fórum Municipal de Mudanças Climáticas de Belém, FMMCB*), a network of expanded social participation, composed of representatives from the private sector and the civil society. This **Climate Governance** arrangement was established by Municipal Decree No. 1,163 of March 15, 2024.

SUMMARY OF THE METHODOLOGICAL STEPS APPLIED IN BELÉM:

- VIRTUAL MEETING with the **Working Group** to raise awareness;
- SURVEY AND COLLECTION OF DATA alongside the **City Hall** and in international and national databases;
- TECHNICAL VISITS to locations that present high vulnerability to the occurrence of climate risks and disasters;
- IN-PERSON WORKSHOP with **Belém City Hall and the Municipal Climate Change Forum** (FMMCB) for participatory mapping of the city's climate risks and disasters;
- IN-PERSON WORKSHOP with **Belém City Hall** and the **Municipal Climate Change Forum** (FMMCB) for preliminary results presentation and validation;
- IN-PERSON WORKSHOP with **Belém City Hall** and the **Municipal Climate Change Forum** (FMMCB) to discuss the city's adaptation actions and to apply the Scorecard tool from the MCR2030 initiative led by UNDRR;
- GIS TREATMENT AND GEOPROCESSING of collected data;
- DEVELOPMENT OF SCENARIO ASSESSMENT, identifying future possibilities for the year 2040;
- FINAL ANALYSIS OF THE GENERATED DATA;
- FINAL REPORT PREPARATION AND DELIVERY

The **participatory mapping** was designed during a workshop attended by representatives from various city departments and FMMCB members from civil society. In this workshop, participants were supposed to indicate points of occurrence of climate risks and disasters in available maps. This dynamic aimed to understand the community's perception of the risks that impact the territory.

The workshop also proposed analyzing **future possible scenarios** and identifying the extent to which the risks of extreme weather events will increase if adaptation measures are not implemented to improve the city's resilience.

3.4 Applying the Scorecard tool

In addition to the activities related to the CRVA, the Scorecard tool was also applied as a complementary measure. The Scorecard is part of the Making Cities Resilient 2030 (MCR2030) initiative and consists of a self-assessment of local governance for resilience to disasters at the local level. It was developed under the framework of the MCR2030 initiative, led by the United Nations Office for Disaster Risk Reduction (UNDRR), and co-coordinated by ICLEI globally and in Latin America.

In Belém, the Scorecard application happened during an in-person workshop organized by UNDRR and ICLEI held between March 11th and 13th, 2024, at the Management and Operational Center for the Amazon Protection System (Centro Gestor e Operacional do Sistema de Proteção da Amazônia, CENSIPAM). The event also included training modules conducted by UNDRR, ICLEI, and partners — such as UNICEF and CENSIPAM — to raise awareness and enhance the technical capabilities of municipal officials and civil society representatives, including members of the FMCCB. The training focused on integrated planning and implementing resilience, risk reduction, and climate adaptation actions.

Seventy-four people participated in the workshop **over three days**. The group featured representatives from eight municipal departments and bodies, agents of the Pará state government, the National Secretariat for Civil Protection and Defense (representing the federal government), community leaders from risk areas in Belém, civil society organizations, universities and scientific institutions, and one UNICEF spokesperson in Brazil.

The analysis of climate risks in Belém combined with governance evaluation offers a solid and comprehensive — current and future — understanding of the climate challenges in the city, in addition to providing valuable insights to increase climate resilience.

4 Main results

This section demonstrates the results obtained during the CRVA in Belém. Each risk analyzed by the study — flooding, coastal erosion, and heat islands — is conceptualized alongside its respective map, followed by the critical risk subchapter. The end of the results section presents the 2040 future scenario.

More than a predictive instrument, the primary purpose of the CRVA is to serve as a guiding tool for developing public policies, including determining priority areas that require new data collection. Like all modeling efforts, studies of this nature face limitations arising from uncertainties inherent in climate systems and intensified by the ongoing crisis. It is recommended to establish a culture of collecting and interpreting climate data so that the municipality remains prepared for extreme events. This includes permanent monitoring of policies and actions on a detailed scale, such as those actions related to the Civil Defense and Protection System, that should involve not only the Civil Defense department but also other departments or secretariats associated with the risk and disaster management system.

4.1 Flooding

Table 1 features the indicators used to model the risk of Flooding in Belém do Pará. Figure 8 presents the current risk map according to the historical threat, exposure, and vulnerability dataset. Figure 9 illustrates the 2040 risk possibility scenario based on a precipitation projection.

The maps show significant areas of high - or very-high- flooding risk in the south of the municipality — more precisely, at the DASAC, DABEL, and DÁGUA administrative districts. The highest levels of risk occur when climate threat, exposure, and vulnerability indicators overlap, including altimetry, soil permeability, presence of favelas, and concentration of public facilities. Although the model indicates risk in other areas, the analysis in this document was restricted to the regions initially mentioned due to their higher population density and consequential greater risk to life. Secondary risk areas are located in neighborhoods such as Cidade Velha, Jurunas, Guamá, Condor, Terra Firme, Telégrafo, Sacramenta, and Barreiro.

In general, **threat** indicators of flooding in these areas point to critical precipitation levels and the recurrence of extreme events. These high levels are also present across the city, aggravating the risk of frequent flooding. There is an expansion of risk areas between the current scenario and the 2040 prediction map due to the expected increase in precipitation and inherent annual mm accumulation, according to the used model (EC-Earth3-Veg, RCP 8.5 scenario).

Regarding **exposure**, the risk of flooding is significantly high in neighborhoods such as Cidade Velha, Jurunas, Guamá, Condor, and Terra Firme. High population density increases the number of people directly exposed to the effects of floods. Furthermore, the presence of favelas in these neighborhoods and the concentration of public facilities increase the severity of potential impacts. Income variation also indicates possible inequalities in the face of the effects of floods.

Concerning **sensitivity**, these regions highly concentrate impermeable surfaces. Additionally, they present floodplain areas that are often at risk of flooding. This overlap increases local vulnerability, highlighting these regions' potential to suffer direct impacts from extreme precipitation events.

The city's **adaptive capacity** regarding flooding risk presents severe limitations due to the low proportion of permeable surfaces in the most vulnerable neighborhoods. Neighborhoods such as Cidade Velha, Jurunas, Guamá, and Condor have reduced vegetation coverage and little availability of permeable soil, features that restrict water absorption and the natural capacity to mitigate flooding. There was no information on Belém's drainage infrastructure to add to the georeferenced model.

In short, the analysis indicates the combination of high precipitation, extreme rain events, and consecutive periods of rain — primarily affecting densely urbanized areas. High exposure driven by high population density, the presence of favelas, and the concentration of essential facilities aggravate the impacts of flooding. Cidade Velha, Jurunas, Guamá, Condor, and Terra Firme are the most affected districts. Additionally, the vast presence of impermeable and low-lying areas associated with low coverage of drainage infrastructures also intensifies sensitivity to this risk

TABLE 1: STRUCTURE OF FLOODING RISK MODELING IN BELÉM, PA

COMPONENTS		INDICATORS	DEFINITION	SOURCE
THREAT		Annual Precipitation/ Projected for 2040	Annual accumulated precipitation - global climatological standard normals/ EC-Earth3-Veg climate model	WordClim
		R95p	Extreme precipitation climate index	INMET
		CWD	Consecutive rainy days index	INMET
EXPOSURE		Population density	Census areas with the highest number of inhabitants per km²	IBGE
		Income	Income stratification by census areas	IBGE
		Favelas and Social Interest Housing	Areas of villages, favelas or social interest housing	IBGE, Belém City Hall
		Facilities concentration	Density of education, leisure, and health facilities. Education, leisure, and density of health equipment	Belém City Hall
		Traditional Communities	Location and concentration of Indigenous refugee communities in an urban context	ACNUR
VULNERABILITY	SENSITIVITY	Flooding areas	Estimated areas susceptible to flooding based on proximity to the coast, topography, and historical records	ESA, Belém City Hall, CPRM
		Impermeable surface	Estimated Impermeable surface areas according to the NDBI (Normalized Difference Built-up Index	LANDSAT-8
		Floodable areas (i≤5%)	Estimated areas susceptible to flooding based on terrain slope or concavity associated with mapped previous occurrences	ESA, CPRM
	ADAPTIVE CAPACITY	Permeable surface	Estimated permeable surface areas according to the NDVI (Normalized Difference Vegetation Index).	LANDSAT-8

Source: ICLEI, 2024

FLOOD RISK

These mapas are the results of the Climate Risk and Vulnerability Analysis of Belém. For a deeper comprehension, both in terms of modeling and interpretation, it is suggested to read the technical report. To estimate the 2040 scenario, the IPCC-verified EC-Earth3-Veg climate model was utilized.

CURRENT SCENARIO

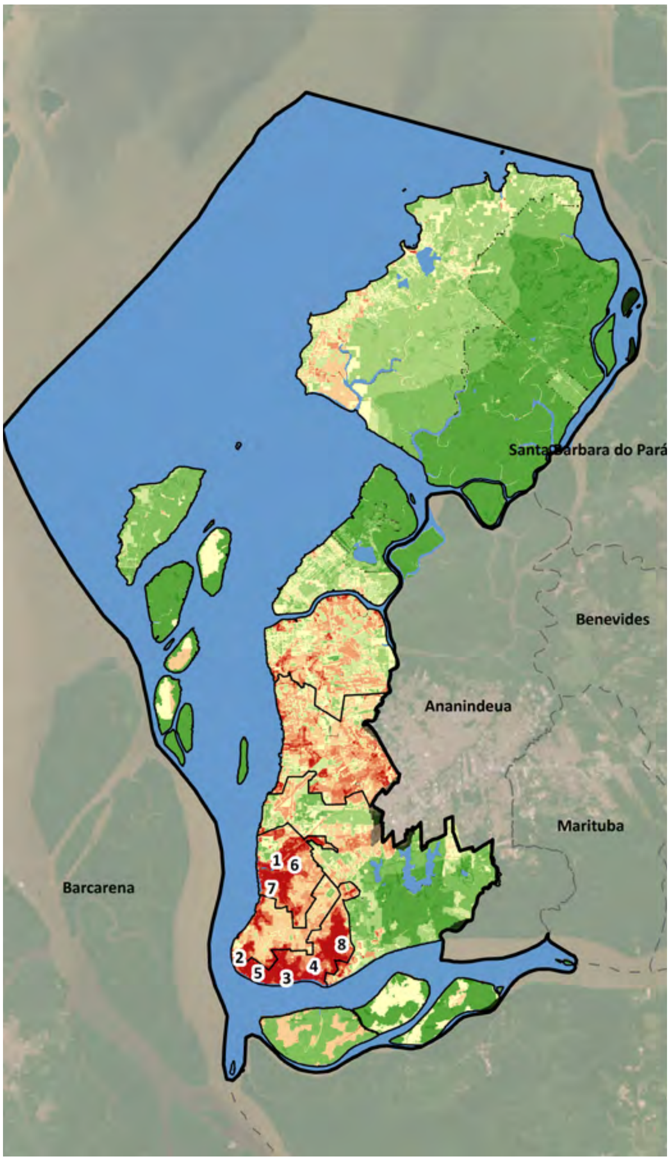


Figure 8 - Current flooding risk map in the municipality of Belém, PA

2040 SCENARIO

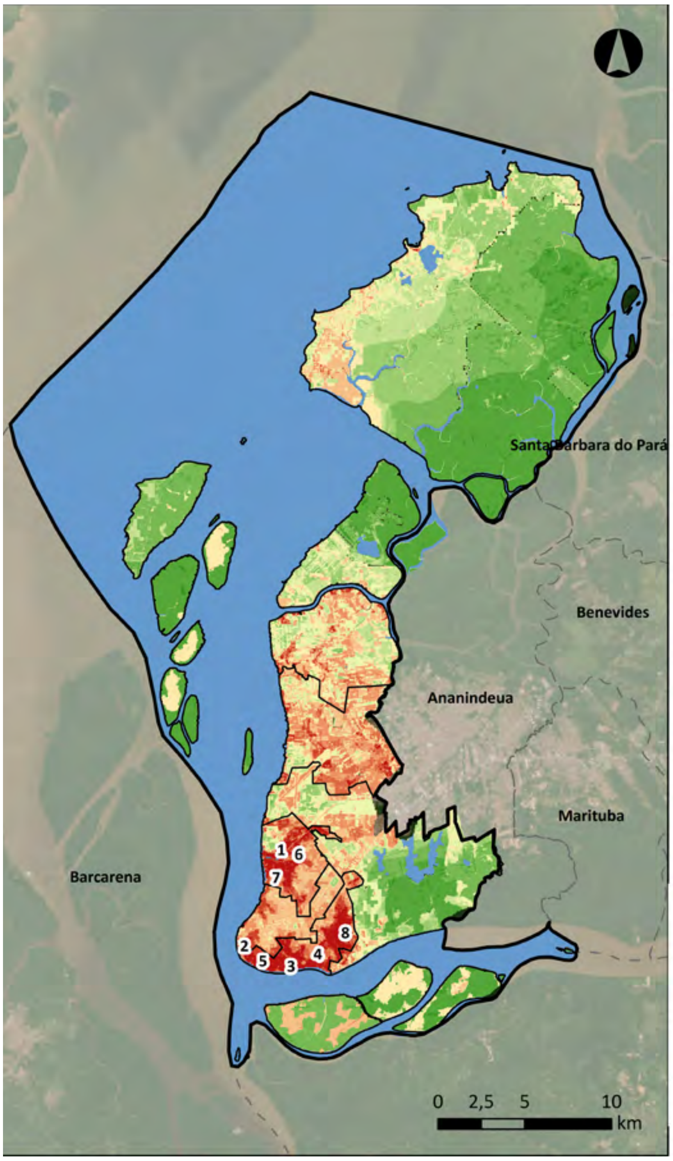


Figure 9 - Flooding risk scenario map for the year 2040 in the municipality of Belém, PA

Neighborhoods mentioned

1. Barreiro
2. Cidade Velha
3. Condor
4. Guamá
5. Jurunas
6. Sacramenta
7. Telégrafo
8. Terra firme

Legend

Neighboring Municip.

Belém Boundaries

Districts

Water Bodies

Flood Risk

High risk

Low risk

1:280:000
Sources: IBGE, Google Earth
SIRGAS 2000 UTM ZONE 22S
Transverser Mercator

4.2 Coastal erosion

Table 2 features the indicators used to model the risk of Coastal Erosion in Belém do Pará. Figure 10 presents the current risk map according to the historical threat, exposure, and vulnerability dataset. Figure 11 illustrates the 2040 risk possibility scenario based on a precipitation projection.

Unlike the other phenomena analyzed, high- or very-high- coastal erosion risk areas are concentrated on the edges of the city and its islands due to the nature of this risk. Some regions stand out due to the overlapping of risks, such as types of land usage and coverage and concentration of public facilities. Identified risk areas present similar characteristics, allowing broader, conjoint analysis in this study.

As previously mentioned, regarding **threat** indicators in Belém, the city features high levels of precipitation associated with the concentration of extreme rain — especially in the south of the municipality. Although extreme events are naturally not restricted to the coast, the constant presence of rain is a factor of pressure on such geographically vulnerable areas. The risk tends to rise following the increased rainfall scenario for 2040.

The indicators used to analyze **exposure** to coastal erosion in Belém were the same as those applied when analyzing flooding risk. However, the coast was the focus this time around, favoring the understanding of socioeconomically exposed areas within this perspective. On Mosqueiro island, the Maracajá neighborhood features the highest demographic density on the coast, followed by the islands of Caratateua, São João do Outeiro, and Maracacuera. To the south of the City, the Tapanã and Telégrafo neighborhoods are the most exposed to this risk. Villages and favelas are pretty notable in Belém, so neighborhoods such as Brasília, Jurunas, Condor, and Guamá stand out as risk-exposure hotspots. Often, these areas coincide with regions of lower average income.

Although featuring a high potential for impact on the coast, the extensive river area of the city expands Belém's **sensitivity**, especially along the coastline of neighborhoods such as Campina, Cidade Velha, Jurunas, and Condor. Additionally, constructions on the banks of the Guamá River and Guajará Bay, as well as land usage and coverage inconsistent with the vegetation that could stabilize the coast, are factors that increase sensitivity in the mainland part of the city.

Belém's **adaptive capacity** was assessed based on the existence of coastal vegetation. This approach was chosen since no data were obtained on retaining structures, although the field visits punctually identified a few infrastructures. The low presence of vegetation is a critical factor in neighborhoods such as Campina, Condor, and Guamá. On the other hand, Mangal das Garças is essential to the Cidade Velha neighborhood.

To summarize, the analysis of coastal erosion risk in Belém underlines the combination of high precipitation and extreme rain events with the coast's physical vulnerability and socioeconomic exposure. The concentration of favelas and buildings along the coastline aggravates the city's vulnerability. River flood-prone areas intensify sensitivity, while limited vegetation coverage constrains the city's adaptive capacity. These factors primarily affect neighborhoods such as Farol, Praia Grande, and Vila on Mosqueiro Island, Itaiteua on Caratateua Island, and much of the southern coastline of the territory. The other islands did not present high risks based on the available data.

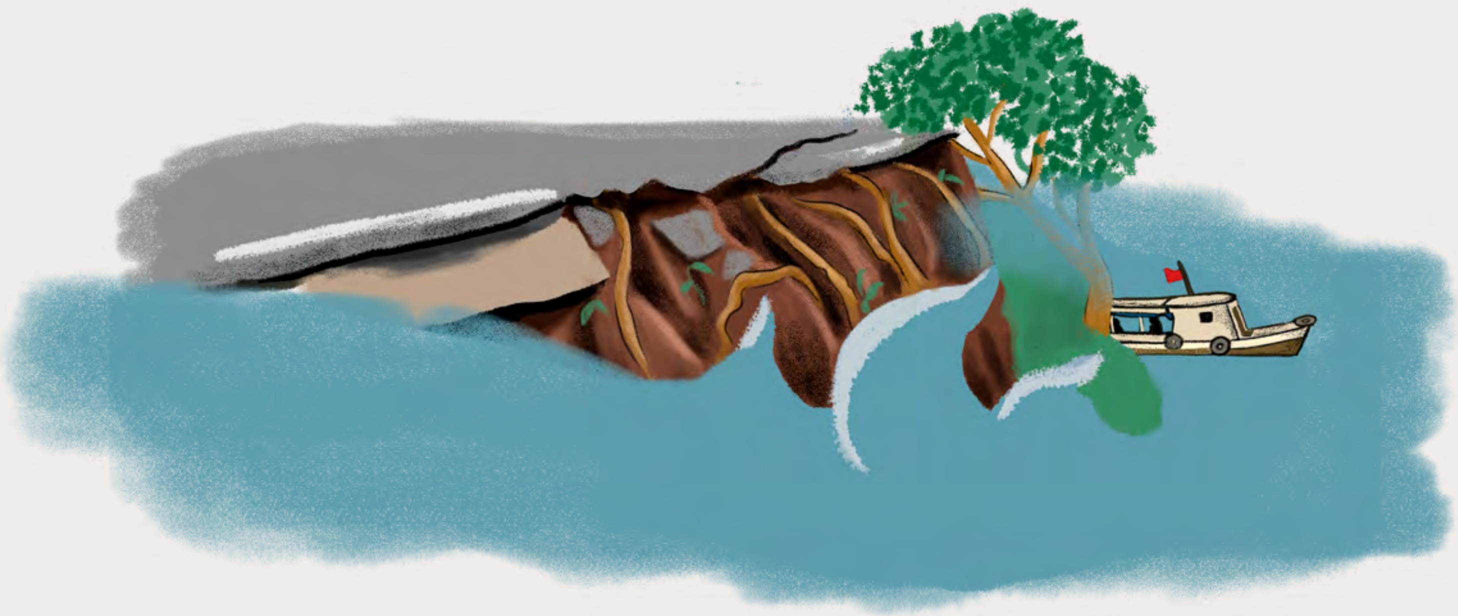


TABLE 2: STRUCTURE OF COASTAL EROSION RISK MODELING IN BELÉM, PA.

COMPONENTS		SERVIÇO ECOSSISTÊMICO	DEFINITION	SOURCE
THREAT		Annual Precipitation/ Projected for 2040	Annual accumulated precipitation - global climatological standard normals/ EC-Earth3-Veg climate model	WordClim
		R95p	Extreme precipitation climate index	INMET
		CWD	Consecutive rainy days index	INMET
EXPOSURE		Population density	Census areas with the highest number of inhabitants per km²	IBGE
		Income	Income stratification by census areas	IBGE
		Favelas and Social Interest Housing	Areas of villages, favelas or social interest housing	IBGE, Belém City Hall
		Facilities concentration	Density of education, leisure, and health facilities	Belém City Hall
		Traditional Communities	Location and concentration of Indigenous refugee communities in an urban context	UNHCR
VULNERABILITY	SENSITIVITY	Flooding areas	Estimated areas susceptible to flooding based on proximity to the coast, topography, and historical records	ESA, Belém City Hall, CPRM
		Slopes	Areas susceptible to erosion due to their inclination	ESA
		Coastal sensitivity	Estimated areas susceptible to erosion based on proximity to the coast and type of land usage and coverage	MapBiomas, Denner *et al*. (2015)
	ADAPTIVE CAPACITY	Presence of vegetation	Areas with vegetation either capable of stabilizing the coast or suggesting the erosion process	LANDSAT-8

Source: ICLEI, 2024

COASTAL EROSION RISK

Table 3 features the indicators used to model the risk of the Heat Islands phenomenon in Belém do Pará. Figure 12 presents the current risk map according to the historical threat, exposure, and vulnerability dataset. Figure 13 illustrates the 2040 risk possibility scenario based on a temperature projection.

CURRENT SCENARIO

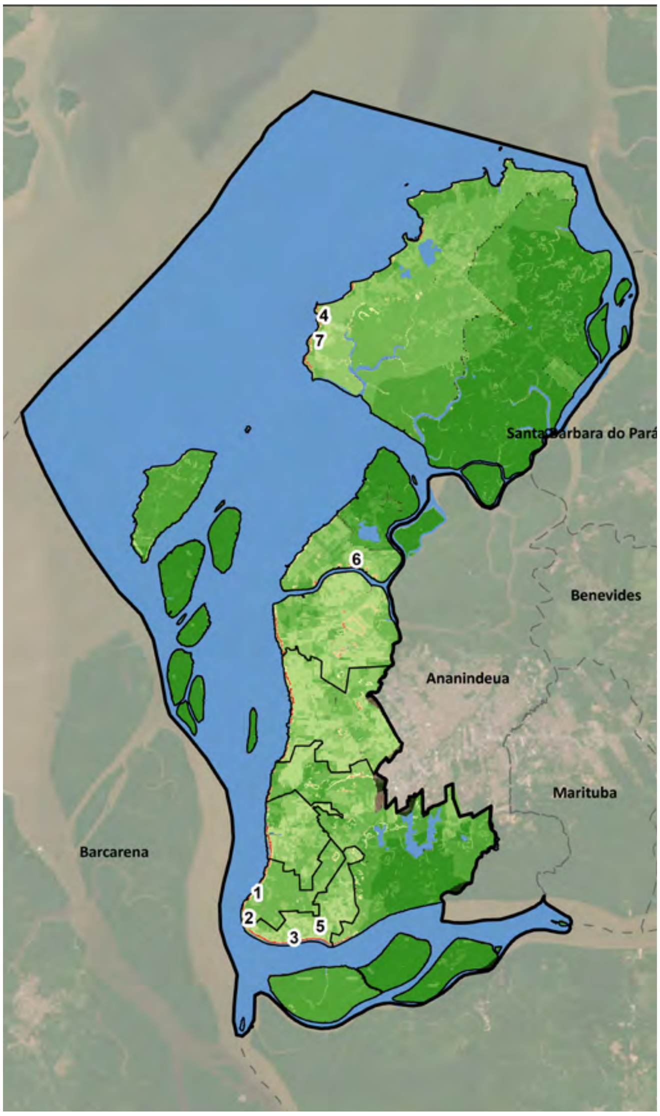


Figure 10 - Current coastal erosion risk map in the municipality of Belém, PA

2040 SCENARIO

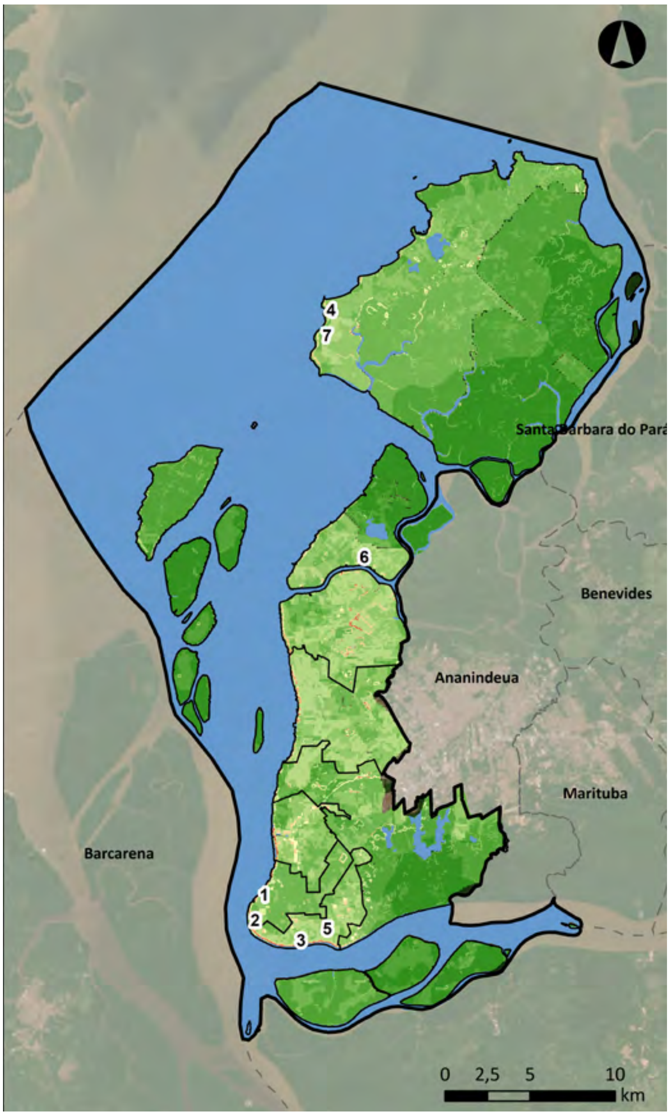


Figure 11 - Coastal erosion risk scenario map for the year 2040 in the municipality of Belém, PA

Neighborhoods mentioned

1. Campina
2. Cidade Velha
3. Condor
4. Farol
5. Guamá
6. Ataiteua
7. Praia Grande

Legend

Neighboring Municip.
Belém Boundaries
Districts
Water Bodies

Coastal Erosion Risk

High risk
Low risk

1:280:000
Sources: IBGE, Google Earth
SIRGAS 2000 UTM ZONE 22S
Transverser Mercator

4.3 Heat islands

Table 3 features the indicators used to model the risk of the Heat Islands phenomenon in Belém do Pará. Figure 12 presents the current risk map according to the historical threat, exposure, and vulnerability dataset. Figure 13 illustrates the 2040 risk possibility scenario based on a temperature projection.

In general, **threat** indicators in Belém reveal the prevalence of high maximum temperatures. The number of days with extreme temperatures is significantly high. Although prolonged periods of consecutive days without rain are unusual, the constant precipitation increases air humidity, thus enhancing thermal discomfort. The average maximum air temperature varies less than 0.5ºC between climatological normals and the forecast model for 2040. However, the increase in precipitation and relative humidity deserves attention. This phenomenon occurs because heat intensifies under humid conditions, and the body has difficulty cooling itself naturally. This study did not include humidity data due to the absence of open-access climate models available for consultation.

Compared to other risks, the heat island phenomenon occurs across the urban area rather than in specific locations. Regarding exposure, the main objective is identifying overlapping social markers that can pose a special danger to particular regions. Condor, Fátima, Telégrafo, Sacramenta, Val-de-Cans, Tapanã, Brasília, and Mangueiras are some of the neighborhoods featuring a complex overlap of factors indicating exposure.

Sensitivity-wise, Belém features urban typologies that favor heat accumulation across the southern part of the city — including dense constructions, high rates of soil impermeabilization, and low proportion of vegetation. There is a significant variation regarding surface temperature. Some neighborhoods present high values, indicating areas of more substantial thermal load accumulation. This distribution largely coincides with landscape typology patterns marked by high building density and areas with insufficient vegetation.

The city's adaptive capacity suggests limited conditions throughout the city. Neighborhoods in the most densely urbanized region of the city, such as Umarizal and Reduto, feature the worst rates. The area lacks sufficient vegetation to help dissipate heat, which compromises adaptive capacity. Local examples of microclimate regulation are Mangal das Garças, the Emílio Goeldi Zoobotanical Park, and the Mata da Marambaia.

In short, the analysis of **heat islands** in Belém indicates that the most at-risk areas combine high air temperatures, insufficient vegetation coverage, and limited cooling capacity, primarily affecting dense urban areas and socioeconomically disadvantaged populations. Most affected neighborhoods include Miramar, Barreiro, Maracangalha, Sacramenta, Pedreira, Fátima, Marco, Nazaré, São Brás, Canudos, Umarizal, and Reduto. These interconnected factors highlight the severity of heat island impacts in this region, facing restricted thermal regulation and increased exposure to extreme heat.

TABLE 3: STRUCTURE OF HEAT ISLAND RISK MODELING IN BELÉM, PA

COMPONENTS		SERVIÇO ECOSSISTÊMICO	INDICATORS	SOURCE
THREAT		Air Temperature	Average maximum temperature - global climatological standard normals/ EC-Earth3-Veg climate mode	WordClim
		TX90p	Extreme heat events index	INMET
		CDD	Consecutive days without rain index	INMET
EXPOSURE		Population density	Census sectors with the highest number of inhabitants per km²	IBGE
		Income	Income stratification by census sector	IBGE
		Sensitive Age	Sectors with the highest concentration of children (≤10 years old) and elderly people (≥60 years old)	IBGE
		Favelas and Social Interest Housing	Areas of villages, favelas or social interest housing	IBGE, Belém City Hall
		Traditional Communities	Location and concentration of Indigenous refugee communities in an urban context	ACNUR
VULNERABILITY	SENSITIVITY	LCZ	Classification of urban and natural landscape typologies based on characteristics that influence the microclimate	WUDAPT
		Vegetation Proportion	Existence and vigor of vegetation per pixel (0-1)	LANDSAT-8
		Surface temperatures	Thermal range in a stable atmosphere	LANDSAT-8
	ADAPTIVE CAPACITY	Cooling Potential	Areas with vegetation capable of regulating the microclimate	LANDSAT-8

Source: ICLEI, 2024

HEAT ISLANDS

Estes mapas são resultado da Análise de Riscos e Vulnerabilidade de Belém, PA. Para uma compreensão maior dos mapas, tanto em termos de elaboração quanto de interpretação, sugere-se a leitura do relatório técnico. Foi utilizado como entrada para o mapa de 2040 o modelo climático EC-Earth 3-Veg.

CURRENT SCENARIO

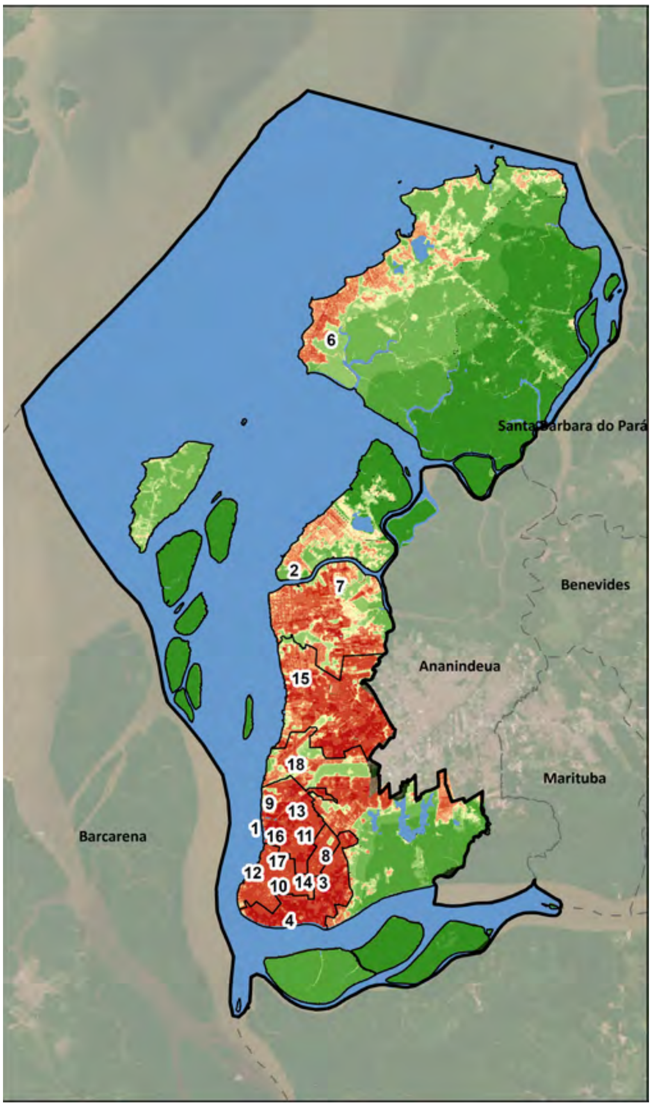


Figure 12 - Current heat island risk map in the municipality of Belém, PA

2040 SCENARIO

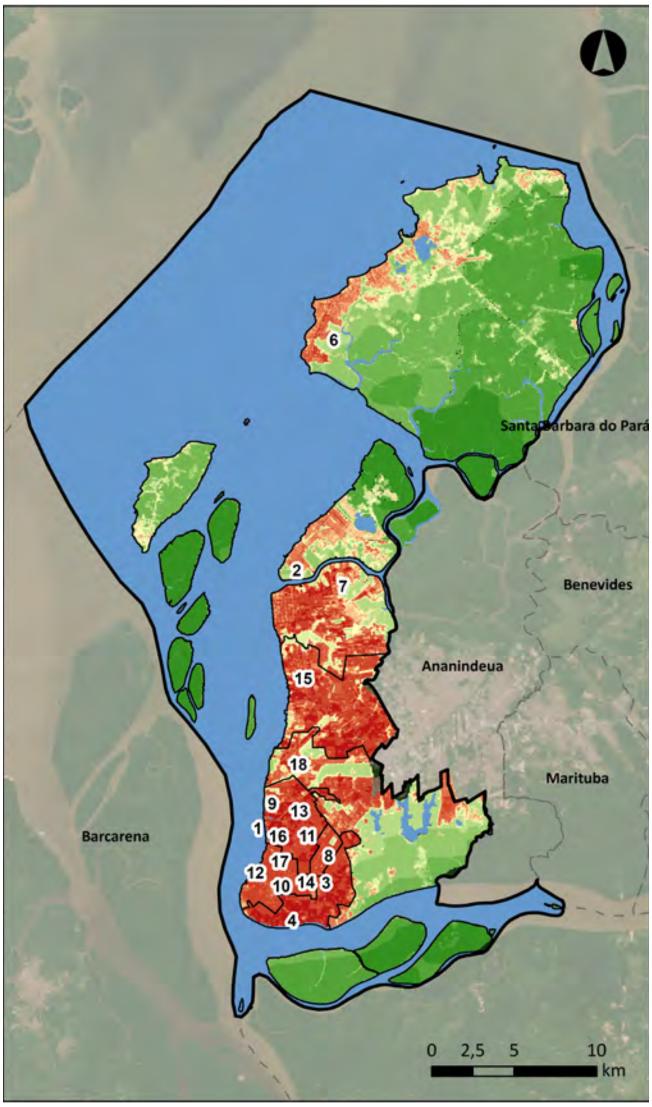


Figure 13 -Heat island risk scenario map for the year 2040 in the municipality of Belém, PA

Neighborhoods cited in the analysis

1. Barreiro
2. Brasília
3. Canudos
4. Condor
5. Fátima
6. Mangueiras
7. Maracacuera
8. Marco
9. Miramar
10. Nazaré
11. Pedreira
12. Reduto
13. Sacramenta
14. São Brás
15. Tapanã
16. Telégrafo
17. Umarizal
18. Val-de-Cans

Legend

Neighboring municipalities

Municipal limits

Districts

Hydrography

Heat Islands Risk

High risk

Low risk

1:280:000
Source: IBGE, Google Earth
SIRGAS 2000 UTM ZONE 22S
Transverser Mercator

4.4 Critical risk

The critical risk map overlaps the previously analyzed risk maps for flooding, coastal erosion, and heat islands. Therefore, the “very-high-risk” category in the critical risk map combines two or more “very-high-risk” for flooding, coastal erosion, and heat islands, indicating areas with less resilience to possible damages associated with climate change. The difference between the models consists of overlapping previously presented risk maps. The current critical risk scenario results from the sum of historical risk models, while the scenario for 2040 overlaps future possibility models.

This analysis identifies which areas could benefit from priority intervention and supports decision-making processes and strategic actions. In the regions where risk impacts overlap, integrated solutions for possible risk response become an even greater necessity to avoid responding to one risk in a way that would amplify the negative consequences of another (e.g., gray infrastructures designed to mitigate floods can increase heat islands). Specific urban intervention models for each type of risk should be observed, in addition to considering the areas indicated here, to ensure the accuracy of municipal adaptation actions.

Future projections suggest that risk levels may increase in areas of Belém that are currently non-urbanized, particularly on Mosqueiro Island, due to emerging climate dynamics. This potential trend highlights concerns regarding unplanned territorial expansion, which could advance over native vegetation. Moreover, the existing urban area might experience an intensification of risk exposure, especially in areas associated with flood risk, which also suffer from intense heat islands. Coastal areas within these zones could face a heightened risk of erosive processes. Collectively, these scenarios indicate a possible escalation in overlapping climate-related risks in Belém over the medium term, underscoring the necessity to expand adaptation measures within the municipality.

CURRENT SCENARIO

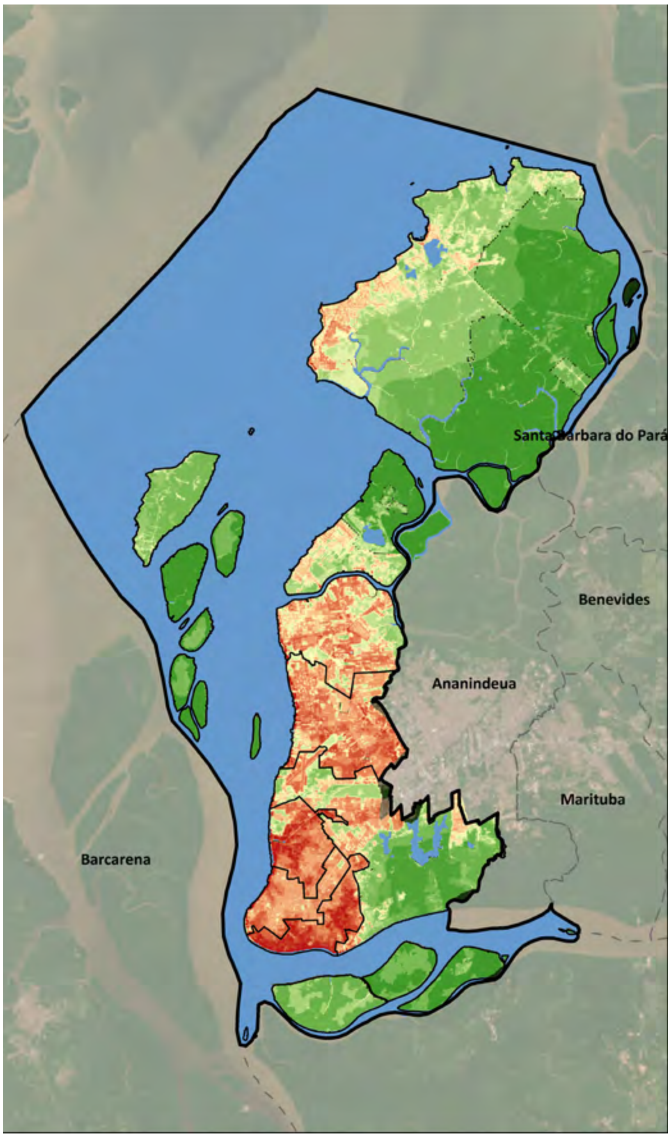


Figure 14 - Critical Risk Map in the municipality of Belém, PA

2040 SCENARIO

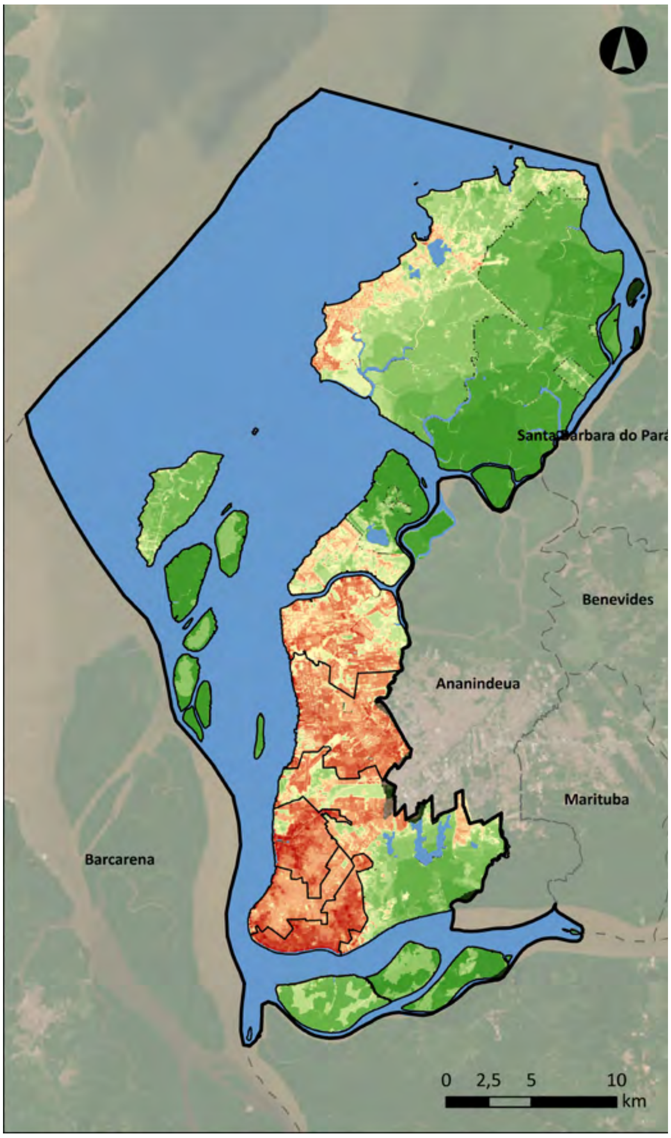


Figure 15 - Critical Risk scenario map for the year 2040 in the municipality of Belém, PA

5 Scorecard tool: Local governance conditions for resilience in the face of disasters

The Disaster Resilience Scorecard for Cities developed by the Making Cities Resilient (MCR2030) initiative supports local governments in developing resilience strategies. The tool provides a comprehensive and participatory assessment of the municipality's management and planning capabilities regarding risk reduction and climate adaptation. Repeated use of the tool allows for monitoring and analyzing progress in **implementing the Sendai Framework** — the main guiding instrument for disaster risk reduction (DRR), adopted by member countries of the United Nations (UNDRR, 2015).

The tool employs indicators structured around the Ten Principles of UNDRR for Making Cities Resilient.

The 10 MCR2030 Principles for making cities resilient can be grouped into three themes. **Principles 1 to 3** evaluate the **city governance agenda** regarding disaster risk reduction and constitute the basis of any municipal resilience agenda — which needs clear organization, a regulatory framework, shared responsibilities, and defined operational plans (Principle 1). Risk governance must also be evidence-based, allow risk-informed decision-making (Principle 2), and have the financial capacity to implement those decisions (Principle 3). Lower scores on these principles are the most critical as they threaten the very existence of the municipal resilience agenda.

Principles 4 to 8 analyze **mitigation, adaptation, and preparation** in the face of disasters. This thematic group addresses the municipal resilience agenda in an integrated manner, diagnosing urban planning actions (Principle 4) ecosystems (Principle 5) and infrastructures (Principle 8) protection, and development of institutional (Principle 6) and social (Principle 7) capabilities. Lower scores on these principles are critical as the Sendai Framework asks governments to prioritize preventative risk management, focused on building resilience to disasters and climate change, without leaving anyone behind.

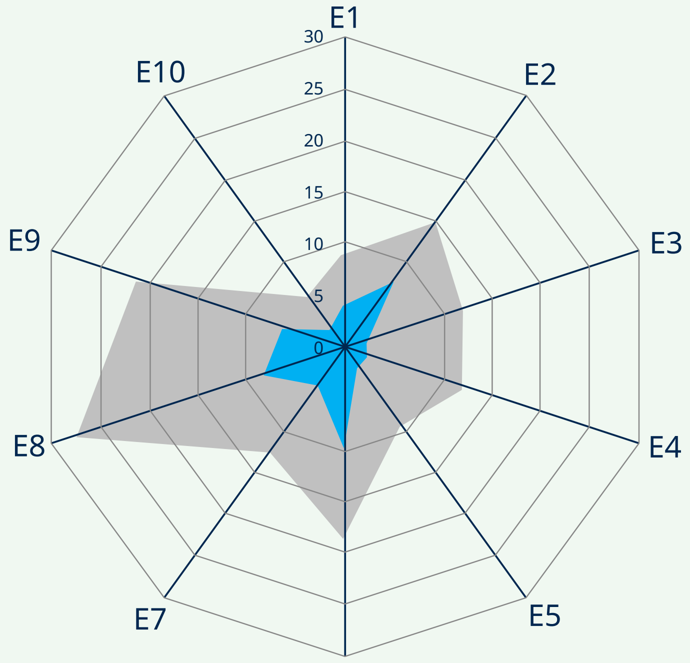
Essentials 9 and 10 themes address the **response and recovery of the city's emergency system.** This dimension assesses the municipality's risk monitoring, early warning, and correct response capabilities to disasters (Principle 9) and emphasizes "building better" as an absolute necessity for post-disaster recovery (Principle 10).

After the participatory application of the Disaster Resilience Scorecard for Cities, Belém's result, in a preliminary version, was **47 out of 141 or 33% of the total possible score** (Figure 16)

THE 10 PRINCIPLES FOR MAKING CITIES RESILIENT

LOCAL SELF-ASSESSMENT TOOL

Result
47/141



LEGEND

E = Essential Aspects or Principles.

FIGURE 16 - General result of the Scorecard evaluation (preliminary version)

TABLE 4 - MAIN STRENGTHS AND GAPS IDENTIFIED IN THE SCORECARD ASSESSMENT

GOVERNANCE

PRINCIPLES 1 TO 3

Strengths	Gaps
Public employees recognize the benefits and importance of resilience among them and partner organizations	The Master Plan makes no direct mention of disaster risk reduction
They have access to scientific data and updated maps of risk areas and understand the most common threats — including flooding due to rain and tides, geological risk, and overflow	The city does not have a resilience strategy or preventive risk management action plan
There are partnerships with scientific institutions, universities, and international organizations to collect and analyze data and information about risks	Information on climate hazards in the city is sporadic and often outdated regarding less frequent (like fires) or slowly growing risks (such as coastal erosion and food insecurity)
Only occasional initiatives encourage different societal sectors to support the construction of resilience	There is a need to strengthen the integration and sharing of information about risks between secretariats and sectors of society
	Funding for disaster resilience projects is periodic and limited. There is no specific financing plan nor link to the Multi-Year Plan (PPA)
	There is little knowledge of external funding sources available for resilience actions

MITIGATION, ADAPTATION AND PREPARATION

PRINCIPLES 4 TO 8

Strengths

There are national and city construction codes and standards. There is soil use zoning, which is currently being updated alongside the Master Plan

The Master Plan update offers an opportunity to integrate a vision of disaster resilience into the city's main urban planning instruments

The city adopted policies to value, recover, and protect native ecosystems, including measures to create green parks

Lorem ipsum dolor sit amet, consectetuer

A Municipal Afforestation Plan is currently in the implementation phase and could benefit from more significant societal involvement

The local government has developed some actions aimed at safeguarding green spaces

Some channels and campaigns disseminate information about risks (WhatsApp groups and Instagram accounts from the city hall and secretariats)

Different sectors have data on risks, albeit in isolation

There is planning of actions to develop resilient infrastructure, although on a sectoral basis (water, energy, waste)

Gaps

Os principais instrumentos de planejamento urbano são desatualizados, como o Plano de Desenvolvimento Urbano - PDU (2008), o Código de Posturas (1977) e a Lei Complementar de Controle Urbanístico - LCCU (1999)

The PDU has guidelines for environmental sustainability and land use suitability but does not directly mention disaster risk reduction goals

There are limited capabilities for technical compliance analysis of new constructions and inspection processes

There are serious gaps in raising public awareness of ecosystem services and the importance of preserving the city's natural capital

There is a need to expand environmental education programs, including risk reduction topics and focusing on solid waste management

A metropolitan integration of solid waste management, mobility, and basic sanitation is needed

In addition to raising awareness, there is a need for technical training of employees to implement concrete actions for disaster resilience

The city does not have institutional mechanisms for integrated and multisectoral resilience management. This absence can generate gaps in coordination between teams and with society

There is a need to strengthen the integration and sharing of data on risks between departments and sectors of society

RESPONSE AND RECOVERY

PRINCIPLES 9 TO 10

Strengths

Coordination among secretariats and departments to respond to emergencies lacks formal mechanisms or planning

The existing tools for communicating alerts are not accessible to the population

Regarding security, an integrated command from the Municipal Guard integrates the other operating bodies, including SEMOB and the Civil Defense

Some programs support recovery processes, including Programa Recomeçar, Cheque Moradia, and Aluguel Social

An Integrated Municipal Security Center for crisis management is being formed, with the participation of multiple departments

Gaps

There is a need to structure the Municipal Civil Protection and Defense System. Currently, the department is incapable of responding to emergencies. Coordinating with other bodies and civil society is sporadic and reactive (a task force is created with several bodies to respond)

There is no disaster response planning and pre-established protocols

The municipality does not have a Contingency Plan. There is no emergency management planning, and most actions are reactive

There are no mechanisms to integrate lessons learned during emergency management to adapt protocols

Source: MCR2030 Initiative and ICLEI, 2024.

STRENGTHS

- Good understanding of risks;
- Good institutional capabilities;
- Varied actions being implemented;
- Updating the Master Plan as an opportunity to include a climate lens

SENSITIVITIES

- Low financial capabilities;
- Lack of integration in urban development planning and between departments;
- Need for more conservation and valorization of ecosystem services for resilience;
- Need to structure the Civil Protection and Defense System

In addition to the Scorecard tool, the study also applied the addendum for urban resilience and the Annex for the Inclusion of Persons with Disabilities, included in the specific report on the Scorecard developed by UNDRR.

After carrying out the workshop to analyze Belém's climate and disaster resilience capabilities and the inclusion of persons with disabilities, it is imperative to formalize an Action Plan for Disaster Risk Reduction and Resilience for Belém. This process began with this assessment of resilience capabilities and now demands concrete actions with goals, follow-up indicators, deadlines, and designated responsible parties to face the identified challenges.

6 ILLUSTRATED SUMMARY MAP

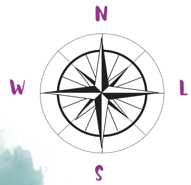
In addition to the technical maps, an illustrated map summarizes the Belém ARVC's central results. The map focuses on the critical climate risk while also providing, through the infographic, an understanding of individual risks — flooding, coastal erosion, and heat island phenomenon.

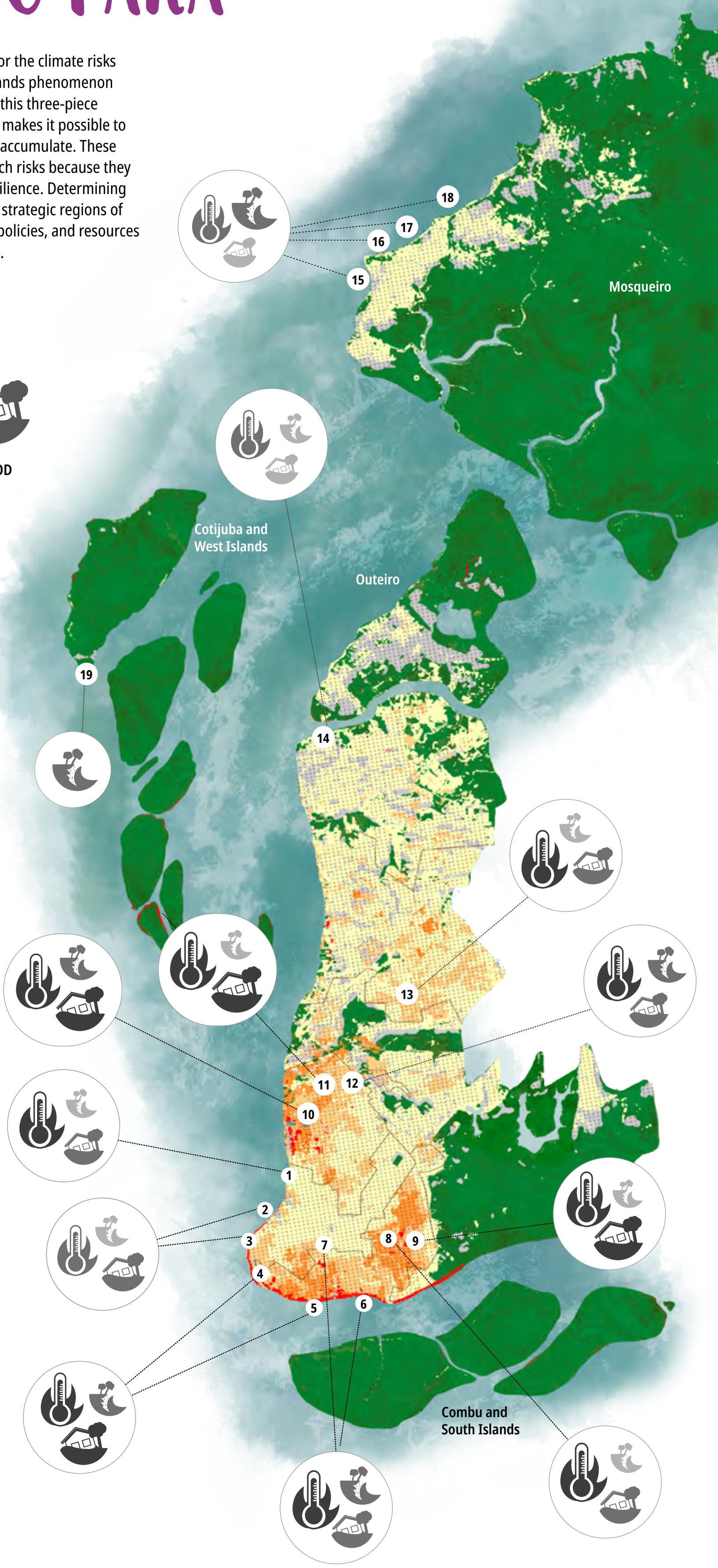
Thus, the map allows the understanding of the most crucial climate risks and vulnerabilities in the municipality, working as an instrument to raise awareness among municipal managers and society about climate change and vulnerability issues in the city. Figure 17 provides an overview of the map; to access a higher-resolution version, see ICLEI (2024).

Climate Risk and Vulnerability Analysis

CLIMATE RISK MAP FROM
BELÉM DO PARÁ

This map summarizes the risks analysis for the climate risks of flooding, coastal erosion, and heat islands phenomenon in Belém. The overlap and integration of this three-piece information indicate a critical risk, which makes it possible to identify areas where the impacts of risks accumulate. These places are seen as more vulnerable to such risks because they have less capacity for adaptation and resilience. Determining these areas broadens the perspective on strategic regions of the municipality for allocating research, policies, and resources for climate and urban adaptation actions.





MAPPED RISKS

EROSION HEAT ISLANDS FLOOD

CRITICAL RISK LEVEL

Observe the city's critical risk areas, where overlapping climate risks have been identified. The color bar indicates the risk level considering this overlap.

LOW MEDIUM HIGH VERY HIGH

PREDOMINANCE OF EACH RISK IN THE NEIGHBORHOOD

LOW MEDIUM HIGH

NEIGHBORHOODS

DABEL - Administrative district of Belém:
1. Reduto; 2. Campina; 3. Cidade Velha;

DAGUA - Administrative district of Guamá:
4. Jurunas; 5. Condor; 6.Guamá; 7. Cremação; 8. Canudos; 9. Terra Firme (Montese)

DASAC - Administrative district of Sacramenta:10. Telegráfo, 11. Barreiro; 12. Sacramenta

DABEN - Administrative district of Benguí:
13. Benguí

DAICO - Administrative district of Icoaraci:
14. Ponta Grossa

DAMOS - Administrative district of Mosqueiro:
15. Vila; 16. Praia Grande; 17. Farol; 18. Porto Arthur

19. Ilha de Cotijuba

LEGEND

Administrative limits

Hydrography

Vegetation

Urban area

How it happens and the most affected neighborhoods

EROSION

Coastal erosion is the natural process of wearing away and removing sediments (such as sand, soil, and rocks) from coastal areas. It happens due to natural forces such as rain, waves, tides, and winds. This process intensifies when these forces are constantly present and when the slopes lack adequate vegetation or soil containment infrastructure, being unprotected. Erosion can also be influenced by human actions, depending on the forms of land occupation in coastal areas. In Belém, although the erosion risk does not cover large areas in length, it is a significant risk for the city's coastal areas, such as the Cidade Velha neighborhood in the Historic Center, and Porto Arthur and Farol in Mosqueiro.

HEAT ISLANDS

It is a phenomenon that occurs primarily due to urbanization patterns in densely populated areas in urban centers that did not consider the climate in their planning. These regions have a significantly higher temperature when compared to other surrounding areas, especially natural and rural areas, as they have difficulty cooling the local temperature. In Belém, neighborhoods such as Condor, Cabanagem, and Telégrafo presented a higher proportion of high and very high risk.

FLOOD

Similar to other large urban centers, Belém grew around and over bodies of water, often occupying areas naturally prone to transient floods. Now, it is known that this form of urbanization has significant consequences for the local population's lives and the city's dynamics. Climate change worsens this scenario with more frequent floods. In Belém, the neighborhoods with the highest proportion of areas at high and very high risk for flooding were Barreiro, Jurunas, and Terra Firme, which are frequently affected during the rainy season.

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7 Conclusion: scenarios and windows of opportunity

This report presents the results of the Climate Risk and Vulnerability Analysis of Belém, one of the technical products of the NBCities project - Nature-Based Cities: Biodiversity and Climate Resilience on Urban Development. NBCities integrates a set of strategic actions implemented by ICLEI South America with the support of different partners on the development of Belém's Climate Compliance, which culminates in the city's Local Climate Action Plan (PLAC).

CRVA sought to advance the understanding of climate risks in the city, thus providing data for more assertive risk management and working as an input for the PLAC's development. In Belém, the study analyzes the climate risks of flooding, coastal erosion, and heat islands. This method emphasizes the multifactorial aspect comprising each mapped climate risk, reinforcing the importance of understanding the factors affecting most at-risk areas.

Bodies of water crisscross Belém's territory, and the city's urbanization patterns greatly influence the risks observed. Belém features flat and lowland areas and an agglomerated occupation on the coast. These characteristics currently leave the city extremely vulnerable to **coastal flooding and erosion risks**, with a high potential for infrastructure and material loss, as well as risk to life. Fluctuation levels of the Guamá and Guajará rivers can severely impact neighborhoods such as Guamá and Umarizal.

The analysis indicates that high exposure — driven by high population density, the presence of favelas, and the concentration of essential facilities — aggravates the impacts of flooding, particularly in neighborhoods such as Cidade Velha, Jurunas, Guamá, Condor, and Terra Firme. Additionally, the extensive presence of impermeable surfaces and low-lying areas coupled with insufficient drainage infrastructures amplifies sensitivity. These interconnected factors underline the complexity and severity of flood risk in Belém, primarily challenging to socially disadvantaged populations.

Consequently, the extensive presence of river flooding areas intensifies sensitivity to coastal erosion risk, while low vegetation cover limits the adaptive capacity. These issues mainly affect neighborhoods such as Farol, Praia Grande, and Vila em Mosqueiro; Itaiteua, on Caratateua Island; and most of the southern coastline of the territory. These regions tend to become even more vulnerable when considering extreme events. Developing and implementing coastal protection strategies regarding urbanization and soil usage is crucial when facing such significant vulnerability, thus mitigating risks and protecting vulnerable coastal areas.

Since the municipality is located in the Amazon and at a latitude close to the Equator, high air temperature and humidity levels are also characteristics of Belém. Thus, extreme heat events are a constant threat to the territory. These extreme events accentuate the phenomenon of heat islands, already observed in a large part of the city's urban area. The most predisposed regions to risk are those in which less vegetated and permeable areas coincide with greater construction density. The Guamá, Jurunas, Tapanã, and Miramar neighborhoods are the most vulnerable locations featuring such characteristics.

It is crucial to adopt strategies that promote thermal relief in urban areas, reducing the effects of heat islands in Belém. Afforestation programs must be implemented, in addition to planting trees and creating green spaces —such as parks and gardens — which help reduce the ambient temperature through shade and evapotranspiration. Furthermore, using climate-appropriate construction materials, such as green roofs and permeable pavements, can lower surface temperatures.

Integrating these measures into urban policies and development plans will help reduce the impacts of high-temperature phenomena and improve the quality of life of the city's inhabitants. Therefore, the risk of heat islands significantly reinforces the need to increase intra-urban vegetation, integrating green and gray infrastructure (conventional engineering solutions) towards the city's climate adaptation.

Critical risk analysis, which consists of risk overlap, reinforces the importance of analyzing the synergetic effects between risks. Through climate models, it was possible to obtain risk evolution indicators until 2040. The tendency for increased precipitation in the 2040 horizon warns of the potential increase of extreme events and the need to act on adaptive interventions in the urban fabric.

Regarding air temperature, no significant change was observed in Belém over the medium-term horizon (2040). However, heat islands' future scenario deserves attention since heat waves are already a threat in the city, but also because the applied model lacks an entire comprehension of influencing factors, such as urban expansion trends and changes in construction patterns associated with verticalization and paving. This directly relates to how Belém will conduct urban development in the coming decades.

Although it is necessary to recognize that the modeled scenarios involve a certain degree of uncertainty inherent to climate systems, they are helpful as a guidance tool for public policies. Considering possible changes, these scenarios' reinforce that current actions must adopt an anticipatory and preventive approach to combat climate change's various dimensions, further strengthening the need to promote integrated strategies.

In this context, this report highlights neighborhoods that require specific attention while identifying potential opportunities. Restoring, expanding, and improving urban systems and services essential for the population's well-being must be a priority. However, this action must avoid vegetation loss, soil paving increase, and the occupation of sensitive regions — such as floodplain forest areas, which historically contributed to the city's current risk profile.

Therefore, it is necessary to enhance social and environmental services simultaneously to promote inclusive urban development. These efforts are essential for making resilient and equitable cities. The climate agenda increasingly requires **integrated strategies** that position climate change as a shared issue in public management, highlighting the potential of multidimensional approaches such as **Ecosystem-Based Adaptation**.

Strengthening Ecosystem-Based Adaptation in Belém:

Opportunities for Climate Disaster Risk Management through Nature-Based Solutions

Nature-based solutions (NbS) provide a transformative approach to making resilient cities founded on justice, equity, and human rights principles. This framework focuses on working with natural systems rather than trying to control them.

The growing adoption of SbN in urban planning reflects a global shift towards recognizing nature as the basis for long-term sustainable solutions that Belém can incorporate.

Strategies such as urban forests, constructed wetlands, green roofs, rainwater harvesting, public green spaces, and soil bioengineering are gaining attention for their **potential to improve urban well-being**.

NbS also offers a sustainable and cost-effective approach to **managing climate disaster risks**, leveraging the functions of natural ecosystems to protect communities, increase resilience, and mitigate climate impacts, including

REDUCING EXPOSURE TO RISKS

Coastal Protection — Mangroves act as natural buffers against storms and coastal erosion

Flooding Management — Swamps and floodplain areas store excess water during heavy rains, reducing the risk of flooding downstream

VULNERABILITY MITIGATION

Urban Green Spaces — Parks and green roofs reduce urban heat, lowering the impact of heat waves

Forest Restoration — healthy forests stabilize slopes and prevent coastal erosion during torrential rains

IMPROVING RESILIENCE

Agroforestry Systems — Diversified crops with integrated tree systems improve soil health and water retention, reducing drought impacts

Reforestation — Planting native trees mitigates flooding risks and improves local microclimates

As climate challenges become more urgent, integrating the enhancement of adaptive capacities into green and blue infrastructure projects is vital. Failure to do so risks exacerbating social conflicts, accelerating urban degradation, and reducing opportunities to ensure safety, health, and well-being, especially for vulnerable groups such as children, the elderly, women, and typically marginalized communities. In the context of Belém, this includes quilombolas (Afro-Brazilian rural communities), riverine populations, indigenous people in urban settings, refugees and migrants, and other racialized communities.

Recommendations to strengthen Ecosystem-based Adaptation (EbA) in Belém:

Intersectoral Collaboration:	Strengthen coordination between the various municipal departments and other levels of government, and promote partnerships with NGOs, civil society movements, and the private sector
Capacity Building, Research, and Innovation	Train communities and stakeholders in the implementation and maintenance of Nature-based Solutions (NbS).
Political Incentives	Introduce subsidies or tax benefits to encourage the adoption of climate adaptation strategies, projects, and technologies that incorporate NbS
Research and Innovation	Support studies to quantify the economic and ecological benefits of NbS, valuing locally produced knowledge
Leverage existing infrastructures and social systems	Effective land management and settlement strategies are essential to prevent undesirable outcomes, such as the creation of new risk-prone areas. At the same time, making use of established social systems, such as housing and cultivation methods adapted to Belém's floodplain areas, can create opportunities for more harmonious project implementation
Strengthen social ties within urban structures	Not only does this increase community resilience, but it also enhances the city's ability to respond effectively to acute crises and ongoing pressures by diversifying efforts towards inclusion while promoting local entrepreneurship. These benefits can be amplified through participatory programs that engage residents in the management and funding of various urban initiatives, fostering inclusion and long-term success

The points highlighted here arise from a general assessment of the Climate Risk and Vulnerability Analysis of Belém. These indicators helped develop the city's Climate Action Plan. They can also support other municipal planning tools, thus contributing to the progressive alignment of various instruments that guide the city's territorial management toward more sustainable urban planning. This diagnosis should work as the foundation for designing more specific and adequate actions for Belém's territory, aiming to transform it into a more resilient city capable of addressing the effects of climate change.

Establishing a continuous climate risk monitoring program in Belém is recommended to ensure this study remains relevant and aligned with local reality. Strategic actions should include installing monitoring stations along river and coastal areas to track the combined behavior of flows and tides, particularly during extreme weather events, and expanding the analysis of the historical dataset by integrating them with climate forecasting systems. Additionally, efforts should focus on securing funding and technical support for scientific and technological research that explores climate adaptation solutions for river-sea interface areas and urban contexts in the Amazon. Such follow-up research should focus on warning and alarm systems, as well as on risk communication for the population, especially the most vulnerable.

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9 Key concepts

Climate adaptation: The process by which human society adjusts to climate change and its effects, whether current or anticipated. It is promoted through strategies and measures that can occur at structural, institutional, ecological, and/or behavioral levels..

Climate threats: A natural or human-induced physical event that can cause harm or impact health, infrastructure, material property, livelihoods, the provision of public and private services, ecosystems, and natural resources. In this report, the term “threat” generally refers to extreme climate-related events (floods, landslides, heatwaves, droughts, sea level rise, etc.).

Adaptive capacity: The extent to which living organisms, systems, and institutions have the ability and resources to anticipate and transform physically or behaviorally to adjust to potential damage, take advantage of opportunities, or respond to the effects of climate change, whether current or anticipated.

Climate: The habitual succession of weather types over a particular location on the Earth’s surface, described through studies and statistical parameters.

Exposure: Refers to the presence of factors (people; livelihoods; species or ecosystems; ecosystem functions, services, and resources; infrastructure; or economic, social, or cultural assets) in places and settings that may be adversely affected by threats.

Climate impacts: Positive or negative effects of climate events on natural and human systems, also referred to as consequences and outcomes. They result from the interaction between dangerous climate events or threats occurring within a specific period and the vulnerability of a society or system exposed to a certain hazard.

Climate change: Refers to changes in the state of the climate that can be identified by shifts in its average and/or variability of its characteristics, with these changes persisting for at least a few decades. While climate changes can occur through natural internal processes, such as variations in solar cycles and volcanic eruptions, there is scientific consensus that the climate change observed in recent decades is predominantly caused by constant human interference with atmospheric composition or land use, as evidenced in the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC).

Resilience: The capacity of interconnected social, economic, and ecological systems to deal with a dangerous event, trend, or disturbance by responding or reorganizing in ways that maintain their essential functions, identity, and structure.

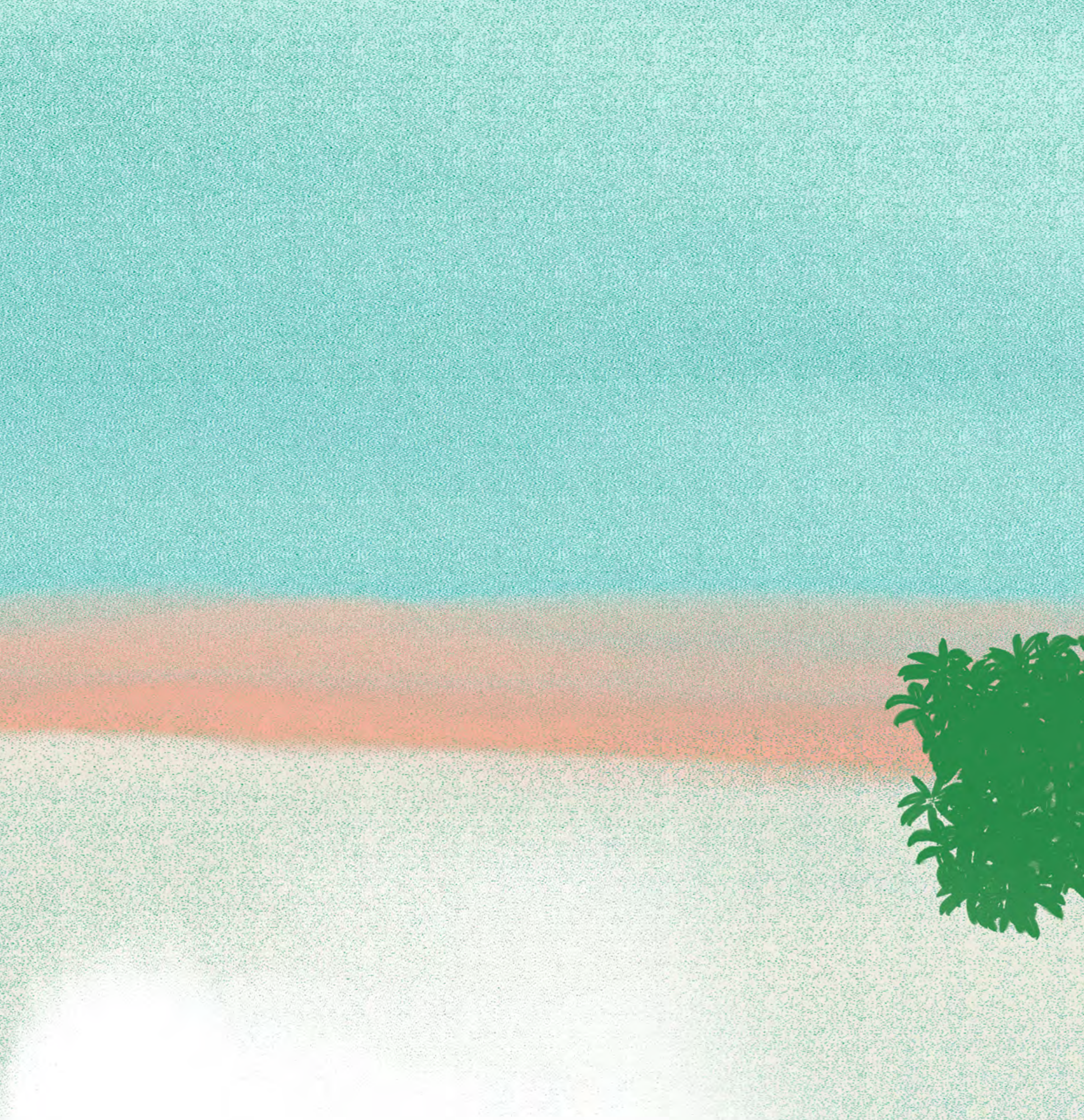
Climate risk: The possibility of negative consequences for human and natural systems resulting from climate events. Risk can arise from both the potential impacts of climate change and human responses to these changes. It is composed of “risk factors,” which are the threat, exposure, and vulnerability.

Sensitivity: Refers to the degree to which a human or natural system, at any scale from individual to population level, is affected by the positive or negative impacts of climate change. It is also called “susceptibility.”

Vulnerability: The tendency or predisposition to be adversely affected by the impacts of climate change, encompassing a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to respond or adapt. The level of vulnerability can vary depending on the concepts and elements considered.

10 List of acronyms

UNHCR - United Nations Refugee Agency
APA - Environmental Protection Area
APP - Permanent Preservation Area
CRVA - Climate Risk and Vulnerability Analysis
GHG - Greenhouse Gases
GEX - Executive Group
GIZ - Deutsche Gesellschaft für Internationale Zusammenarbeit
IBGE - Brazilian Institute of Geography and Statistics
SDI - Spatial Data Infrastructure
IDHM - Municipal Human Development Index
INPE - National Institute for Space Research
IPCC - Intergovernmental Panel on Climate Change
IPEA - Institute for Applied Economic Research
IPTU - Tax on urban and territorial property
LPUOS - Land Parceling, Use, and Occupation Law
MCR - Making Cities Resilient
MIDR - Ministry of Integration and Regional Development
MMA - Ministry of the Environment
SDG - Sustainable Development Goal
NGO - Non-Governmental Organization
UN - United Nations
PDUI - Integrated Urban Development Plan
GDP - Gross Domestic Product
PLAC - Local Climate Action Plan
PMB - Belém City Hall
UNDP - United Nations Development Program
PPA - Multi-Year Plan
RCP - Representative Concentration Pathway
RMB - Metropolitan Region of Belém
RPPN - Private Natural Heritage Reserve
NbS - Nature-Based Solution
ES - Ecosystem Services
GIS - Geographic Information System
UC - Conservation Unit
UNDRR - United Nations Office for Disaster Risk Reduction
UNICEF - United Nations Children's Fund
GVA - Gross Value Added
WEF - World Economic Forum
WRI - World Resources Institute



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