Ministry of the Environment and Climate Change
Ministry of Science, Technology and Innovation
Office of the President's Chief of Staff

CLIMATE PLAN

Adaptation

National Adaptation Strategy

FEDERATIVE REPUBLIC OF BRAZIL

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Climate Adaptation Plan
National Adaptation Strategy

Brasília/DF (Federal District)
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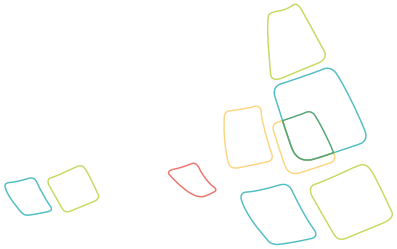


List of Figures

List of Tables

List of Abbreviations and Acronyms

CBD	Convention on Biological Diversity
CDD	Consecutive Dry Days
CEMADEN	National Center for Monitoring and Early Warnings of Natural Disasters (Centro Nacional de Monitoramento e Alerta de Desastres Naturais)
CGE	Computable General Equilibrium
CIM	Interministerial Committee on Climate Change (Comitê Interministerial sobre Mudança do Clima)
CO_2	Carbon Dioxide
COP	Conference of the Parties
EAR	Stored Energy
EARmax	Maximum Stored Energy
EbA	Ecosystem-based Adaptation
EEZ	Ecological-Economic Zoning
ENA	National Adaptation Strategy (Estratégia Nacional de Adaptação)
ENSO	El Niño Southern Oscillation
ETF	Enhanced Transparency Framework
FBMC	Brazilian Forum on Climate Change (Fórum Brasileiro de Mudança do Clima)
FIDE	Disaster Information Form (Formulário de Informações do Desastre)
GDP	Gross Domestic Product
GGA	Global Goal on Adaptation
GVP	Gross Value of Production
IAM	Integrated Assessment Model
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Intertropical Convergence Zone
LDO	Budget Guidelines Law (Lei de Diretrizes Orçamentárias)
LOA	Annual Budget Law (Lei Orçamentária Anual)
MCS	Mesoscale Convective Systems
MCTI	Ministry of Science, Technology and Innovation (Ministério da Ciência, Tecnologia e Inovação)

MMA	Ministry of the Environment and Climate Change (Ministério do Meio Ambiente e Mudança do Clima)
NAP	National Adaptation Plan
NbS	Nature-based Solutions
NDC	Nationally Determined Contribution
PCD	People with Disabilities (Pessoas com Deficiência)
PCTs	Traditional peoples and communities (Povos e Comunidades Tradicionais)
PD	Master Plan (Plano diretor)
PDUI	Integrated Urban Development Plan (Plano de Desenvolvimento Urbano Integrado)
PNMC	National Policy on Climate Change (Política Nacional sobre Mudança do Clima)
PNOT	National Land Use Planning Policy (Política Nacional de Ordenamento Territorial)
PNPDEC	National Policy on Protection and Civil Defense (Política Nacional de Proteção e Defesa Civil)
PPA	Multi-Year Plan (Plano Plurianual)
Q90	Expected minimum flow rate in 90% of the time
Rede Clima	Brazilian Research Network on Global Climate Change (Rede Brasileira de Pesquisas sobre Mudanças Climáticas Globais)
RX5day	Highest 5-day Precipitation Amount (Highest volume of precipitation in 5 consecutive days)
SDGs	Sustainable Development Goals
SIN	Brazilian Interconnected System (Sistema Interligado Nacional)
SPEI	Standardized Precipitation Evapotranspiration Index
SST	Sea Surface Temperature
UN	United Nations Organization
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
WBGT	Wet-Bulb Globe Temperature
WSDI	Warm- Spell Duration Index

Foreword

Dear Sir or Madam,

Over the past three years of our administration in the Federal Government, significant results and deliverables have been achieved in the socio-environmental and economic spheres. This has been a government that stands with the Brazilian people in the effort to rebuild a country that suffered substantial losses during the 2019–2022 period. This is a time for unity, and as a further element to foster it, we present the new National Climate Change Plan (Plano Clima), with an implementation period from 2024 to 2035. The Plan was approved by the Interministerial Committee on Climate Change (CIM, in Portuguese) at its 4th Ordinary Meeting, held on December 15, 2025. The CIM is the main collegiate body of Brazil's climate governance and is chaired by the Chief of Staff of the Presidency of the Republic (Casa Civil), with the support of its Executive Subcommittee (SUBEX/CIM, in Portuguese), coordinated by the Ministry of the Environment and Climate Change (MMA, in Portuguese).

The approval of the Climate Plan, which comes 17 years after its first edition, marks a decisive moment in Brazilian climate policy, establishing a transparent, robust, and participatory pathway for the country to fully meet its commitments under the Paris Agreement, which celebrated its 10th anniversary in 2025. The new Climate Plan is therefore instituted at a historic moment, in the year Brazil hosted the 30th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 30) in Belém, in the state of Pará. Following this landmark moment of multilateralism under Brazilian leadership, the Government of Brazil, with the support of a wide range of sectors of society, delivers a Plan designed to guide the country on its path toward a net-zero greenhouse gas emissions economy by 2050, in line with sustainable development and the principle of common but differentiated responsibilities and respective capabilities, as well as a just transition and climate justice.

The new Climate Plan reflects Brazil's democratic strength and capacity for dialogue, coordinating climate actions across different sectors, organized under the pillars of Adaptation, Mitigation, and Cross-Cutting Strategies for Climate Action. In this context, it is worth highlighting that in 2025 the establishment of three CIM advisory chambers was consolidated: Social Participation, Scientific Advisory, and Interfederative Articulation.

The process of developing the Plan was participatory, inclusive, and transparent. It engaged more than 24,000 participants through plenary sessions and public consultations, generating thousands of contributions and incorporating proposals prioritized at the 5th National Environment Conference. In parallel with this social engagement, technical rigor was ensured through an unprecedented collaborative effort involving more than 25 ministries within the CIM technical working groups. This intersectoral and participatory effort, which included numerous workshops, negotiations, and technical meetings of the SUBEX/CIM and the CIM Plenary of Ministers, culminated in the consolidation of a strategic document validated at the highest executive decision-making level of Brazil's climate governance.

The Climate Plan 2024–2035 is therefore a milestone of consensus and commitment, guiding us to strengthen our low-carbon economy while preparing for the impacts of climate change.

We therefore call upon all levels of government, the private sector, and civil society to embrace this Plan and to join efforts in its implementation. Climate action requires shared responsibility to ensure a sustainable and prosperous future for all.

Sincerely,

Rui Costa
Chief of Staff of the Presidency of the Republic
Chair of the Interministerial Committee on Climate Change

The climate emergency is the greatest challenge of our time. In recent years, the world has experienced a succession of climate-related disasters. Unprecedented droughts, intense rainfall, and heat waves have become increasingly frequent and severe in people's daily lives. In Brazil, this has been no different. Torrential rains and prolonged droughts have caused large-scale disasters, with human losses and economic impacts across several regions of the country. Numerous cases have been widely reported, such as the landslides that occurred on the North Coast of the state of São Paulo in 2023 and the floods in Rio Grande do Sul and in several other cities in 2024. In those same years, severe droughts in the North and Central-West regions isolated communities, disrupted production, and triggered major wildfires in the Amazon, the Pantanal, and the Cerrado.

What we are witnessing, therefore, is extremely serious and requires us to act on two fronts simultaneously: addressing the consequences of the ongoing climate crisis and intensifying efforts to reduce greenhouse gas (GHG) emissions, seeking to limit the average increase in global temperature to 1.5°C, as set out in the Paris Agreement.

As humanity, we have a duty to promote the transition to an economic model that respects the planet's carrying capacity, helping to restore climate balance in an ethical manner, with the aim of overcoming a model that perpetuates historical socioeconomic inequalities.

It was in this spirit that the Brazilian government led the development of the National Plan on Climate Change. The Plan was built by many hands in a broad intersectoral and participatory process, within the scope of the Interministerial Committee on Climate Change (CIM), under the coordination of the Chief of Staff of the Presidency of the Republic (Casa Civil/PR), which chairs the Committee, and the Ministry of the Environment and Climate Change (MMA) through the National Secretariat on Climate Change (SMC), responsible for the technical and methodological guidance of the work, the latter carried out in conjunction with the Ministry of Science, Technology, and Innovation (MCTI).

The work of the CIM technical groups involved dozens of meetings, workshops, and seminars, with the unprecedented participation of 25 ministries, the Brazilian Forum on Climate Change (FBMC), and the Climate Network (Rede Clima), which brings together researchers from across the country, in addition to the engagement of civil society organizations and the private sector, as well as the direct participation of citizens. The Participatory Climate Plan (Plano Clima Participativo) mobilized more than 24,000 participants through plenary sessions and public consultations, generating thousands of contributions on the Brasil Participativo Platform. It also incorporated proposals from the 5th National Environment Conference, which engaged more than 71,000 people throughout its mobilization process.

The Climate Plan is a plan that reflects Brazil's identity, as it sought to align technical rigor —based on the best available science and evidence from a wide range of sectors—with active and qualified listening to the Brazilian population, which demonstrated a collective commitment to building a safer, more resilient, and sustainable future. In the pages of this Plan, we present a pathway for Brazil to address climate change while promoting sustainable development, job creation, and social inclusion. The Plan is organized around three complementary strategic pillars:

The **Climate Mitigation Plan** represents our commitment to reducing greenhouse gas (GHG) emissions that contribute to global warming. It comprises the National Mitigation Strategy and eight Sectoral Plans. Grounded in science, we have established clear and ambitious targets to reduce GHG emissions across multiple sectors, aiming to consolidate a low-carbon economy while leveraging Brazil's strengths in renewable energy and socio-biodiversity to generate new opportunities.

The **Climate Adaptation Plan**, in turn, consists of the National Adaptation Strategy and 16 Sectoral and Thematic Plans. It represents our effort to make our cities, rural areas, ecosystems—and, above all, our people—more resilient to the impacts that are already occurring. We will do so guided by the principle of climate justice, ensuring that care and protection reach vulnerable groups first.

Finally, the **Cross-Cutting Strategies for Climate Action** constitute the instruments that will enable the implementation of the Plan. This pillar establishes governance arrangements and means of implementation, investing in education, research, development, and innovation, and ensuring transparency in the management, monitoring, and evaluation of our actions, under the perspectives of a just transition, climate justice, and gender equality.

We invite everyone to learn about the documents of the Climate Plan 2024–2035 and to actively participate in its implementation, strengthening the collective commitment to building a fairer, more resilient, and sustainable Brazil, moving toward a new cycle of prosperity for present and future generations.

MARINA SILVA
Minister of State for the Environment and Climate Change

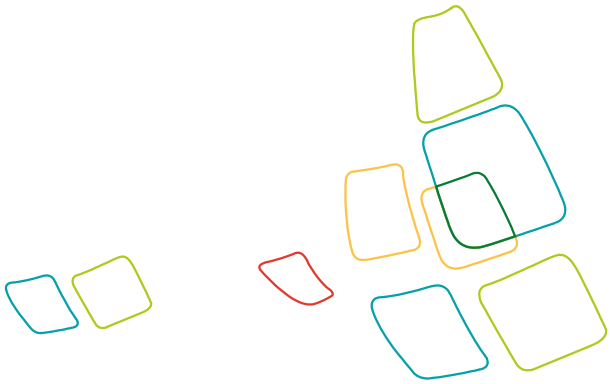


Table of Contents

1. Introduction

Adapting to climate change is the process of adjusting natural and human systems to current and future climate conditions and dealing with their effects. This process involves the implementation of actions and measures aimed at reducing or avoiding potential damage, as well as taking advantage of opportunities that may be beneficial (IPCC, 2022).

In Brazil, the **National Policy on Climate Change (PNMC, Política Nacional sobre a Mudança do Clima)** plays a key role in the climate planning system and has as one of its main instruments the National Plan on Climate Change (at national level called the Climate Plan), in which adaptation actions to reduce the adverse effects of climate change and the vulnerability of environmental, social and economic systems must be considered. In this respect, the Plan's update, which began in 2023, includes both mitigation and adaptation strategies, with the respective Sectoral and Thematic Plans, and updates **Brazil's National Adaptation Plan (NAP - 2016)**, changing its name to "Climate Adaptation Plan".

The Climate Adaptation Plan sought to incorporate the assumptions and lessons learned from the NAP launched in 2016, based on the results presented in the 2017 and 2021 monitoring and evaluation reports. Three of these lessons were especially important for the drafting of the Plan: (1) the need to ensure coordination at strategic levels of the federal government and the maturation of the governance structure, fostering integration among sectors and different federal levels; (2) the definition of responsibilities; and (3) the establishment of national adaptation targets, linked to indicators that can be monitored during the Plan's term and focused on the country's priorities (Brasil, 2021). Another important lesson is the increase of capacity-building actions associated with the generation and dissemination of evidence to address the new climate regime.

As a strategic driver of the **Climate Adaptation Plan**, the National Adaptation Strategy (Estratégia Nacional de Adaptação – ENA) is presented here as a key document in Brazil's climate action planning system. The National Strategy, which was developed simultaneously with the National Mitigation Strategy and based on the principles of co-production of evidence-based public policies, is the result of a broad debate involving government managers, scientists and representatives of civil society, indigenous peoples and traditional peoples and communities. The development of this Strategy relied on the gathering of the most up-to-date scientific production on the subject of adaptation, combined with traditional knowledge and technical knowledge generated by public agents and civil society working on the climate agenda.

The ENA is linked to a set of sixteen Sectoral and Thematic Plans, in addition to Cross-Cutting Strategies, which also make up the Climate Plan. The co-production of the climate plan involved 25 ministries, under the general coordination of the Ministry of the Environment and Climate Change (MMA) and the technical-scientific coordination of the Ministry of Science, Technology and Innovation (MCTI). Representatives of other federal government bodies and public managers at sub-national level were also involved.

The sixteen Sectoral and Thematic Plans adopted in the Climate Adaptation Plan are: Agriculture and Livestock; Family Farming; Biodiversity; Cities; Energy; Racial Equality and Combating Racism; Industry and Mining; Ocean and Coastal Zones; Traditional Peoples and Communities; Indigenous Peoples; Water Resources; Risk and Disaster Reduction and Management; Health; Food and Nutrition Security; Transport and Tourism. These sectors and themes were defined based on **CIM's – Interministerial Committee on Climate Change (Comitê Interministerial sobre Mudança do Clima) Resolution No. 3, of September 14, 2023**, also considering the priorities and urgencies in relation to the country's current vulnerabilities.

In a cross-cutting manner, the Climate Plan addresses five integrating axes between adaptation and mitigation, organized as Cross-Cutting Strategies for Climate Action that relate to and complement the Sectoral and Thematic Plans. These axes address: Just Transition and Climate Justice; Women and Climate; Means of Implementation; Education, Capacity-building, Research, Development, and Innovation; and Monitoring, Management, Evaluation, and Transparency.

The ENA represents the maturing of the climate adaptation agenda, which presents challenges related to coordination on multiple geographical and governmental levels. Global commitments and contributions from UNFCCC and IPCC documents have been incorporated into this document, as well as regional and local initiatives aimed at strengthening territorial resilience.

The interrelationship between mitigation and adaptation actions should be noted, in which the effectiveness of adaptation strategies is limited by the lack of ambitious mitigation actions on a global scale (IPCC AR6, 2022). In this context, it is clear that, in order for the actions proposed in the Climate Plan to be successful, it is necessary to make progress with regard to the collective commitments made by the countries under the Paris Agreement, especially with regard to limiting the increase in the global average temperature to well below 2 °C above pre-industrial levels, with efforts to restrict it to 1.5 °C.

This Strategy has been largely guided by the climate risk approach, considering the dimensions of climate-related hazards, exposure and vulnerability in an integrated manner. Other relevant references in the development of this document were the Global Goal on Adaptation, the Iterative Adaptation Cycle and Sustainable Development.

The text of the National Adaptation Strategy, divided into chapters, begins with background information on the climate agenda in Brazil and worldwide. In this section, references are made both to global policies agreed within the framework of the United Nations (UN) and to legal frameworks that regulate national climate action. Some of the regulations that guided the development of the Strategy are described, as well as information on the process of drafting the document and its connection with other legal instruments, with emphasis on the development of the Sectoral and Thematic Plans, which make up the Climate Adaptation Plan.

The third and largest chapter of the ENA, entitled "Impacts, vulnerabilities and adaptation", includes the technical concepts and methodological basis adopted in the process of developing the ENA and the Sectoral and Thematic Plans. Thus, evidence on climate change already observed and future trends are presented, considering the scenarios of compliance with the Paris Agreement, as well as data on observed impacts in different dimensions, such as disasters, health, food and energy security, among others. It is possible to identify different vulnerability factors found in the population and in systems, as well as the main climate risks at national level, both backed up by the best available science.

The fourth chapter covers the General Principles of the Climate Plan, based on the main institutional frameworks that make up the environmental agenda in Brazil and worldwide. Then, in the fifth chapter, the Guidelines, Vision and Goals that make up the ENA are presented. This section includes the nine National Adaptation Goals and the 12 National Adaptation Targets that will guide concrete initiatives to be implemented by federal bodies in conjunction with sub-national entities, as well as actors from society.

The sixth and final chapter deals with the management of the Climate Adaptation Plan, addressing issues such as means of implementation and aspects related to federal governance and the participation of civil society, the business sector and the scientific community. Finally, definitions of monitoring, evaluation and learning from the Plan are presented, as well as knowledge management and transparency.

In summary, the ENA presents the main regulatory and theoretical references of the Climate Adaptation Plan, seeking to represent the way in which the different documents of this Plan are connected in order to form a coherent planning system. The development of this Strategy was imbued both with the democratic aspect of broad social participation and by the scientific rigor that highlights the climate crisis. This crisis, which is unprecedented in history, is putting different ways of life at risk, exacerbating territorial inequalities and demanding increased efforts in favor of climate justice and the promotion of sustainable development.

2. National Circumstances

The adaptation agenda is essential to ensure human dignity and rights by boosting sustainable development, promoting protection and resilience to the impacts of climate change. Its relevance is growing given the increase in climate risks to ecosystems and human populations, especially those in situations of greater socio-economic and territorial vulnerability (IPCC, 2023). Adaptation is a cross-cutting agenda that acts as a basis for ensuring not only the implementation of international commitments, but also the principles of the 1988 Constitution (Brasil, 1988).

The global adaptation policy is guided by the United Nations Framework Convention on Climate Change (UNFCCC), an international treaty that is a key document in the international regime for tackling climate change. Negotiated and established during Rio-1992, the Convention recognizes that all countries have the right to sustainable development, including social, environmental and economic needs.

The UNFCCC follows the principle of common but differentiated responsibilities, recognizing that all countries have shared responsibilities in combating climate change, but with different capacities and levels of contribution to global warming. In this sense, the countries that have historically contributed the most to greenhouse gas emissions should take on greater responsibilities, while the most vulnerable countries, which face the most severe impacts, should receive support to adapt. This principle promotes global cooperation and considers that climate phenomena and their effects do not respect borders, affecting different regions of the world in an interconnected way and without being limited to a single country or region.

Among its duties, the UNFCCC Secretariat facilitates intergovernmental negotiations on climate change, supports the implementation of the Convention, the Kyoto Protocol and the Paris Agreement. It should be noted that the Conference of the Parties (COP) is the supreme decision-making body of the UNFCCC, which annually brings together the Party countries in world conferences. The decisions of a COP are made collectively and by consensus and can only be made if they are accepted by common agreement of the Parties, being sovereign and valid for all signatory countries.

Until the thirteenth Conference of the Parties (COP13), which was held in Bali in 2007, adaptation was secondary to mitigation. However, COP13 adopted the “Bali Action Plan” which, for the first time, pointed out that adaptation should be at the center of climate negotiations, just as much as mitigation. However, it wasn’t until the Cancun Adaptation Framework, established at the sixteenth session of the Conference of the Parties (COP16) in 2010, that the adaptation agenda became more relevant worldwide. On this occasion, the Adaptation Committee was established and the importance of developing National Adaptation Plans was formally recognized, as key instruments for strengthening countries’ response to climate change. Since this milestone, adaptation has played an increasingly greater role in multilateral climate negotiations.

Adaptation at the center of the agenda - The tendency to place adaptation at the center of climate negotiations was reinforced by the Paris Agreement signed in 2015 at COP 21, which established the Global Goal on Adaptation (GGA). In the national context, **Decree No. 9.073, of June 05, 2017**, which promulgates the Paris Agreement in Brazil, includes the GGA in its Article 7.1, with the following wording:

> The Parties establish the global goal on adaptation, which is to increase adaptive capacity, strengthen resilience and reduce vulnerability to climate change, contribute to sustainable development and ensure an adequate adaptation response in the context of the temperature target referred to in Article 2.

It is important to clarify that the temperature target mentioned in Article 2 aims to keep the global average temperature increase well below 2 °C above pre-industrial levels, with efforts to limit this increase to a maximum of 1.5 °C. There is a global scientific recognition that maintaining this level would significantly reduce the risks and impacts of climate change. Despite these global commitments and ongoing mitigation efforts, the latest scientific evidence indicates that we are continuing on a global warming path that exceeds the 1.5°C limit, which has already resulted in more frequent and intense climate impacts, with increasing risks to natural and human systems.

In this context, climate adaptation becomes even more urgent and must be guided by the needs, capacities and priorities of each country. The Paris Agreement itself recognizes this principle when it states that adaptation must be country-driven, i.e., driven or directed by the country, respecting its autonomy to define strategies that are consistent with its socio-economic, environmental and institutional contexts.

The Paris Agreement also recognizes the importance of engaging all levels of government and different actors; the integrity of all ecosystems, including the ocean; the protection of biodiversity; and climate justice in adopting measures to address climate change.

In order to monitor progress in the implementation of the Global Goal on Adaptation, the Glasgow-Sharm el-Sheikh Work Program (2021-2023) was established at COP26, with targets to be achieved by 2030. These adaptation goals, adopted at COP28 in Dubai, cover the following topics: (a) water; (b) food and nutrition security, and agricultural production; (c) health, biodiversity, and ecosystems; (d) infrastructure; (e) poverty eradication; and (f) protection of cultural heritage, traditional knowledge, indigenous knowledge, and local knowledge systems. Goals related to the phases of the Iterative Adaptation Cycle were also included: (a) impacts, vulnerabilities, and risks; (b) planning; (c) implementation; and (d) monitoring, evaluation, and learning.

This verification is an integral part of the Paris Agreement's Global Stocktake, a transparency mechanism that collectively assesses, every five years, the progress of signatory countries towards meeting greenhouse gas mitigation, climate adaptation, financing and technology transfer targets, and helps decision-makers strengthen their climate policies and commitments.

Although there is no requirement for additional reporting, the first Global Stocktake, released in 2023, invites countries to voluntarily include information on adaptation in Biennial Transparency Reports, National Adaptation Plans, and National Communications and Nationally Determined Contributions (UNFCCC, 2023).

First National Adaptation Plan – In the Brazilian legal framework, adaptation is included in the objectives, guidelines and instruments of Law **No. 12.187, of December 29, 2009**, which established the National Policy on Climate Change (PNMC, Política Nacional sobre Mudança do Clima) and determines the establishment of Sectoral Adaptation Plans. This was achieved through the first

National Adaptation Plan (NAP), issued by **MMA Ordinance No. 150, of May 10, 2016**. The plan was drawn up by the federal government in collaboration with civil society, the private sector and state governments and it covers 11 sectors and themes, with review cycles planned every four years.

This instrument was considered a milestone in Brazil's national climate policy, serving as the basis for the preparation of adaptation and climate action plans in some Brazilian states and municipalities. In addition, it has contributed to advancing knowledge about climate-related impacts, risks and vulnerabilities and to incorporating aspects of climate change into public management planning.

Priority government agenda – After a hiatus in the implementation of climate change adaptation policy and in the face of new disasters related to extreme events, the urgency of the issue was recognized in 2023. As a result, the climate agenda has been integrated into the structure of 19 of the Brazilian government's 37 ministries. In order to implement this priority, the Interministerial Committee on Climate Change (CIM) was restructured by **Decree No. 11.550, of June 05, 2023**, with the mission of proposing updates to the National Policy on Climate Change. Its duties include reviewing mitigation and adaptation strategies, as well as the Nationally Determined Contribution (NDC), covering targets, means of implementation and monitoring, reporting and verification mechanisms.

In that same year, the Committee approved the correction of Brazil's NDC, reinforcing its ambitions to achieve the goals of the Paris Agreement. It also published **CIM's Resolution No. 3, of September 14, 2023**, which provides for the review of the National Plan on Climate Change and establishes the Temporary Mitigation and Adaptation Working Groups, with the mission of drawing up the National Mitigation and Adaptation Strategies.

The Resolution outlined the basic elements that should be included in the National Adaptation Strategy and in Sectoral and Thematic Plans, namely: agriculture and livestock; family farming; biodiversity; cities; risk and disaster reduction and management; industry and mining; energy; transport; racial equality and combating racism; traditional peoples and communities; indigenous peoples; water resources; health; food and nutrition security; ocean and coastal zones; and tourism.

In June 2024, demonstrating the cross-cutting nature of the climate agenda, the CIM's membership was expanded to 25 government bodies by **Decree No. 12.040, of June 05, 2024**. This decree also established the Scientific Advisory Chamber, the Social Participation Chamber and the Federative Coordination Chamber as permanent structures of the Interministerial Committee.

With the reinforcement of **Law No. 14.904, of June 27, 2024**, which establishes guidelines for the preparation of climate change adaptation plans, Brazil, then, conducted the review of the NAP. Article 5 of this law states that:

> The measures provided for in the National Adaptation Plan, to be drawn up by the competent federal body, will be developed in conjunction with the 3 (three) branches of government and the socio-economic sectors, guaranteeing the social participation of those most vulnerable to the adverse effects of this change and representatives of the private sector, with a view to strengthening and encouraging the achievement of tangible adaptation results that guarantee the mitigation of the current and expected effects of climate change, making environmental protection compatible with economic development.

Article 2 of this Law establishes, as a guideline for climate change adaptation plans, the synergy between PNPDEC – National Policy on Protection and Civil Defense (Política Nacional de Proteção e Defesa Civil), established by Law No. 12,608, of April 10, 2012; the National Plan on Protection and Civil Defense; the state, district, and municipal plans on protection and civil defense; and the National Strategy for Critical Infrastructure Safety.

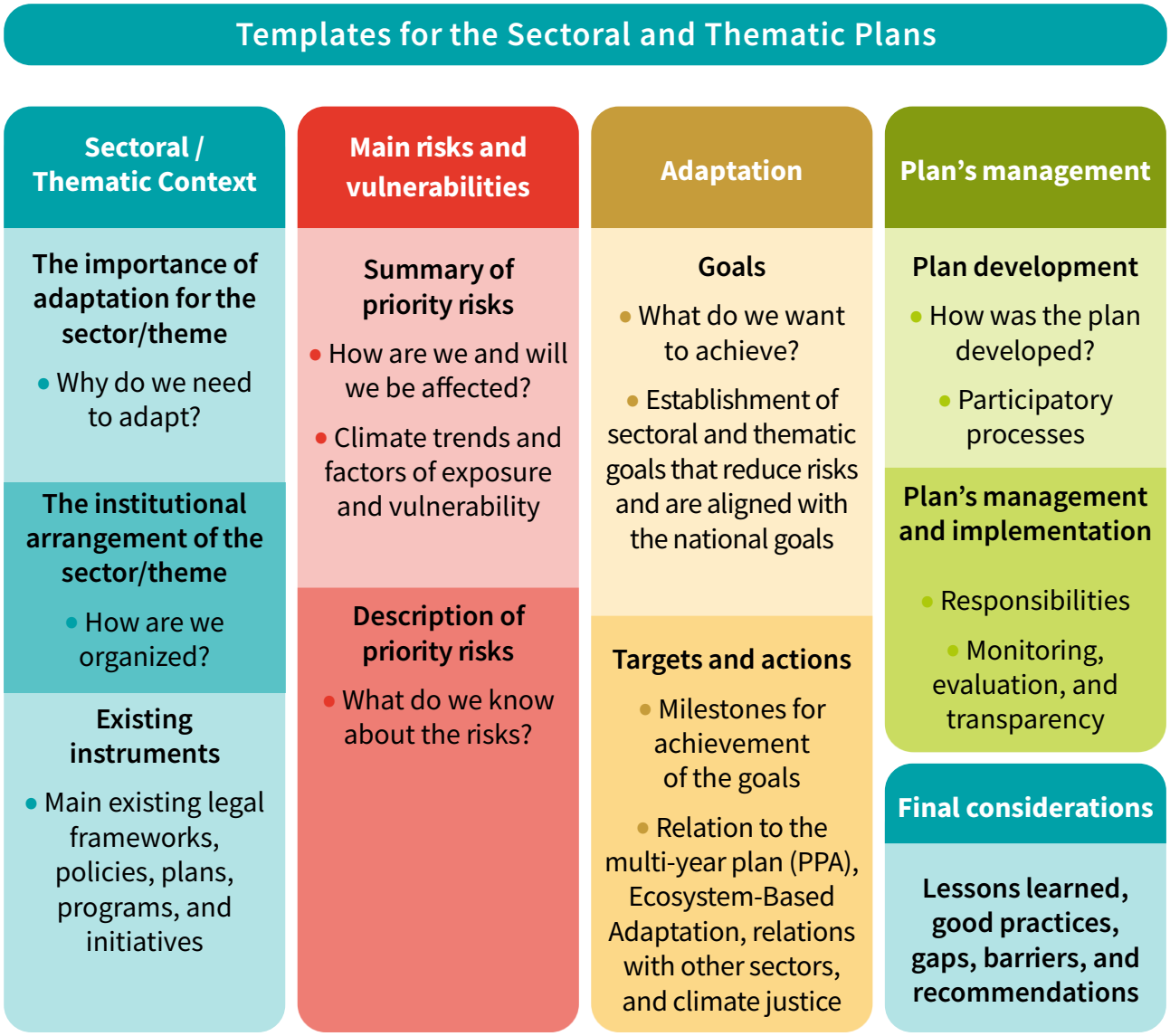
In addition, by means of **CIM/CC/PR Resolution No. 7 of July 03, 2024**, Brazil submitted its new NDC with the target of reducing net emissions by between 59% and 67% by 2035 (2005 base year) and achieving climate neutrality by 2050. This commitment incorporates principles of climate justice, with a focus on social equity, recognizing the importance of indigenous cultures and reducing inequalities, and adopts the Climate Plan as the basis for implementing mitigation and adaptation targets.

Climate Adaptation Plan – In this context, the Climate Adaptation Plan represents the review of the National Adaptation Plan, consolidated in the National Adaptation Strategy and its Sectoral and Thematic Plans. It was drawn up with the co-authorship of 25 ministries, under the coordination of the MMA and MCTI, as well as the participation of various societal actors. The new Plan incorporates lessons learned from the previous NAP, with a focus on governance, establishment of targets and indicators, strengthening of capacity-building and dissemination of knowledge about the climate crisis.

Sectoral and Thematic Plans – The co-authoring ministries were responsible for drawing up the Sectoral and Thematic Plans, ensuring that they played a leading role in defining the contents and priorities according to their governmental competencies, following the guidelines agreed for this Plan. In order to ensure the alignment, coordination and integration between those involved in the various ministries, awareness-raising, capacity-building and conceptual leveling actions were carried out on topics related to climate risks and vulnerabilities, such as Ecosystem-Based Adaptation (EbA), climate emergency, human mobility and climate justice. A series of 26 capacity-building events were held, including seminars, technical meetings, workshops and webinars, with the participation of more than 870 representatives of the sectors and themes, including managers and experts directly involved in the preparation of the content.

Templates were agreed upon between the governmental entities to ensure consistency between the Sectoral and Thematic Plans, as well as the monitoring of actions. Each plan has five chapters: I) Context, with a description of the importance of adaptation and the institutional arrangement of each sector/theme; (II) Summary of the main impacts, risks, and vulnerabilities; (III) The goals, targets, and actions linked to national adaptation goals, with identification of funding sources; (IV) Description of the preparation process, the actors involved, and the responsibilities for implementing the plan; and (V) Lessons learned, good practices, and barriers identified in the process, with recommendations for the implementation phase and the Plan's review cycles (Figure 1).

Figure 1 – Templates for the Sectoral and Thematic Plans



Source: Own elaboration.

The templates indicated the need to detail, for each planned action, the priority locations, the target audience and the timeframes for implementation, as well as other essential information for the implementation and monitoring of Sectoral and Thematic Plans. Throughout the process, the importance of applying the lenses of **climate justice and Ecosystem-based Adaptation (EbA)** was reinforced in order to guide the prioritization of the most vulnerable communities and the conservation and restoration of ecosystems as a fundamental part of adaptation strategies.

The effort made to organize and make available the technical-scientific knowledge that underpins the plan, based on the best available science, is noteworthy. This process, coordinated by the MCTI, included the collaboration of researchers from Rede CLIMA – Brazilian Research Network on Global Climate Change (Rede Brasileira de Pesquisas sobre Mudanças Climáticas Globais) and the National Institute for Space Research (INPE, Instituto Nacional de Pesquisas Espaciais), who gathered and analyzed a broad range of scientific references, including numerous bibliographical references and updated data from platforms such as AdaptaBrasil, in order to ensure the technical consistency of the information used by the different ministries.

Based on the considerations of technicians and government managers on the country's vulnerabilities to climate change and considering climate justice as the guiding principle, a set of goals, principles and strategic adaptation actions was proposed, which was submitted for discussions with society.

A plan that reflects Brazil

The Climate Plan was developed with broad social participation (Figure 2), driven by the Participatory Brazil Platform (Plataforma Brasil Participativo), which allowed citizens to contribute directly with proposals to the following question: "How can Brazil face climate change and reduce its impacts?". This digital stage was complemented by onsite meetings held in eight cities, with the aim of engaging civil society, answering any queries and publicizing the drafting stages of the Climate Adaptation Plan.

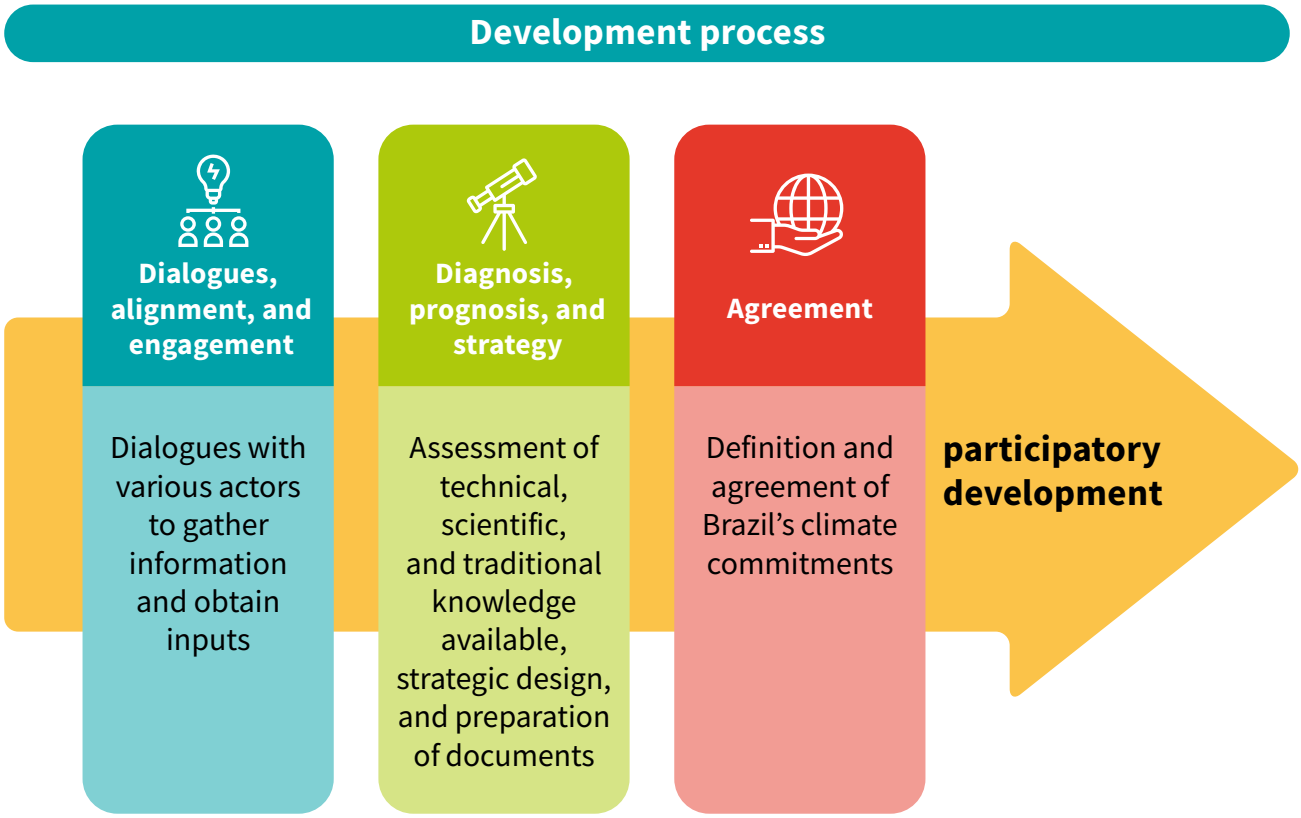
The period for submitting proposals to the Participatory Climate Plan ran from June 5 to September 17, 2024. During this period, the platform recorded 298,000 hits, 23,009 participants, 1,296 proposals, more than 47,000 votes and 2,000 comments. Seven onsite plenary sessions, organized by biome - Coastal-Marine System, Caatinga, Pantanal, Atlantic Forest, Cerrado, Amazon and Pampa - were held in the cities of Olinda (PE, Pernambuco State), Teresina (PI, Piauí State), Campo Grande (MS, Mato Grosso do Sul State), São Paulo (SP, São Paulo State), Imperatriz (MA, Maranhão State), Santarém (PA, Pará State) and Porto Alegre (RS, Rio Grande do Sul State), bringing together 4,161 participants. The YouTube broadcasts totaled 2,582 views.

During the drafting of the Climate Adaptation Plan, several opportunities were also provided for in-depth listening to key stakeholder groups. Six workshops were held with subnational governments, civil society, and the business sector; three regional seminars focusing on women and climate justice; five national preparatory workshops with representatives from the private sector and civil society; six intersectoral and thematic workshops; and six webinars providing guidance on the development of Sectoral and Thematic Plans. In total, these activities involved 871 participants, with the participation of 25 federal ministries.

Based on these contributions, the Climate Adaptation Plan has set ambitious targets, based on broad and participatory governance that involves local governments, the private sector and civil society, aimed at building a fairer, more democratic and sustainable country.

In addition, both the National Adaptation Strategy and the Sectoral and Thematic Plans underwent public consultations, reinforcing the participatory nature of the process. The ENA received more than 900 contributions between October 23 and November 13, 2024, while the 16 sectoral plans received 2,778 contributions between March 10 and May 09, 2025 - all collected through the Participatory Brazil Platform.

Figure 2 – Stages of the participatory process for drawing up the Climate Adaptation Plan



Source: Own elaboration.

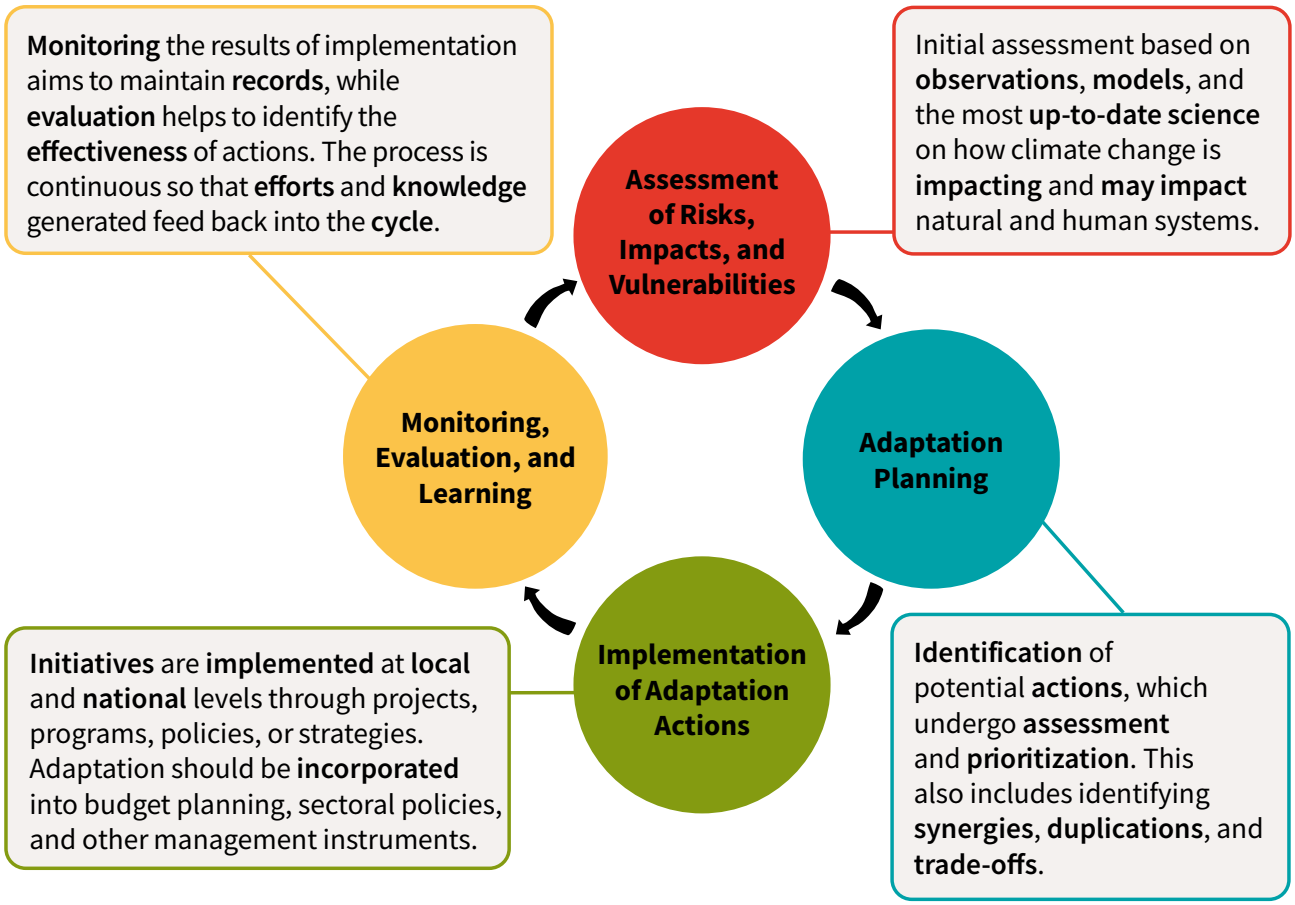
3. Impacts, Vulnerabilities and Adaptation

3.1. The iterative adaptation cycle in the context of climate risk

Climate (or climate-related) risks result from both climate elements, such as changes in temperature and precipitation patterns, and socio-economic factors. They evolve and interact over time, being dynamic and complex. Thus, the development and implementation of effective climate change adaptation strategies should be guided by a **continuous, progressive and iterative process** in several stages (Wise *et al.*, 2014; Simpson *et al.*, 2021; IPCC, 2022).

To guide the planning and implementation of adaptation in countries, the Adaptation Committee[1] (UNFCCC, 2019) represented the "**iterative adaptation cycle**" in four stages (Figure 3), which are included in various methodological guidelines to support adaptation planning (Stafford-Smith *et al.*, 2022). Iterative means that the process takes place in successive rounds, aiming for continuous improvement by updating information and evaluating the adaptation process.

Figure 3 – Stages of the iterative adaptation cycle



Source: Adapted from UNFCCC, 2019.

[1] The Adaptation Committee (AC) was established under the Cancun Adaptation Framework (2010) to promote the implementation of adaptation actions in a manner that is consistent with the United Nations Framework Convention on Climate Change and the Paris Agreement.

The Brazilian Climate Adaptation Plan was developed based on the stages described above. The starting point recommended by several sources (Stafford-Smith *et al.*, 2022) is to first create a "scope" that defines goals, principles and other guiding aspects, which will be presented in the following chapters. The Plan is a **long-term** planning instrument that is **flexible** in nature, i.e., it should include ongoing **reviews and improvements** to incorporate updates in the understanding of population and territorial contexts, barriers and opportunities, as well as the evaluation of the results achieved.

In addition to the Plan, Brazil should adopt policies aimed at **climate-resilient development**. To this end, governments (federal, state, district and municipal), civil society and the private sector need to make development choices **that are inclusive**, i.e., that prioritize risk reduction, promote equity and justice and integrate decision-making processes, funding and actions across levels of governance, sectors and time horizons.

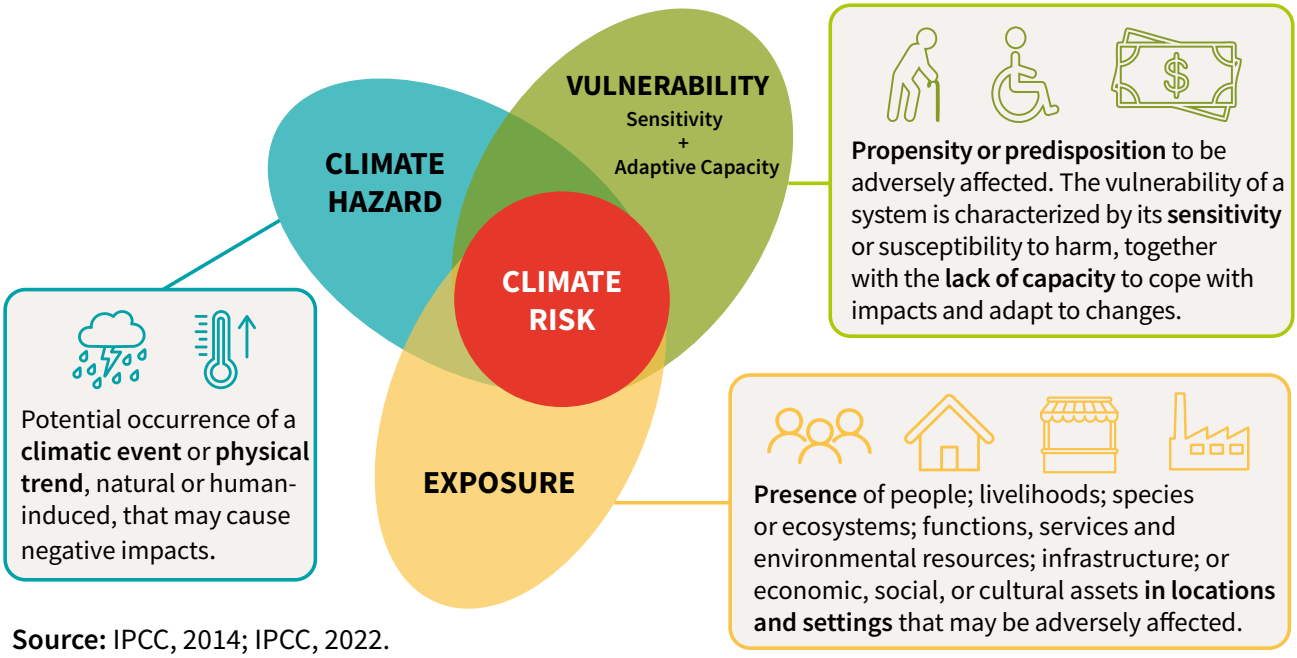
Main climate risk and adaptation concepts

Adaptation to climate change is the process of adjustment of natural and human systems to actual and future climate and its effects. It includes actions and measures to moderate or avoid potential harm or exploit beneficial opportunities (IPCC, 2022).

Adaptation to climate change must take into account the **risks and vulnerabilities in the present and in future scenarios**. Observational climate data, experiences with past climate events and their respective responses to the results obtained with coping actions and vulnerability analyses, especially on adaptive capacities, are examples of important elements for understanding climate-related risk levels. In addition, projections of climate risk, impacts and socio-economic pathways, among others, allow the creation of future scenarios that aid risk assessment and inform planning (UNFCCC 2020; UK/CCRA 2017; IPCC 2022).

The first stage of the iterative adaptation cycle involves carrying out a climate risk assessment. The IPCC (2014, 2022) proposes the adoption of a conceptual framework that integrates both climate and socioeconomic and biophysical information, due to the multi-causal nature of the risks (Figure 4).

Figure 4 – Risk analysis takes into account the combination of information on climate-related hazards, exposure, and vulnerability



Source: IPCC, 2014; IPCC, 2022.

Climate risk is the **potential for the occurrence of climate-related adverse consequences** (or impacts) to human or ecological systems. Climate risks result from dynamic interactions between climate-related hazards and the exposure and vulnerability of affected human or ecological systems (IPCC, 2022).

The **corresponding impacts are the climate-related consequences or effects** on natural and human systems. Impacts can be direct or indirect and generally refer to adverse effects (damages and losses) on lives, livelihoods, health and well-being, ecosystems and species, economic, social and cultural assets, services (including ecosystem services) and infrastructure (IPCC, 2022).

Experts and managers recommend that risk assessments take into account **climatic and non-climatic factors**, so that adaptation is planned on the basis of its effect on **overall risk reduction** and not just on the reduction of the additional risk posed by climate change. This perspective also considers that adaptation and development are intrinsically related and that adaptation focused only on incremental climate risks can lead to poorer results (O'Neill *et al.*, 2023; Jafino *et al.*, 2021; Reisinger *et al.*, 2020).

As a component of **vulnerability**, **sensitivity** is the degree to which a system or species is adversely or beneficially affected by climate change or variability. **Adaptive capacity**, on the other hand, is the ability of systems, institutions, people and other organisms to adjust to potential harm, take advantage of opportunities or respond to consequences (IPCC, 2022).

In ecological systems, living beings adapt to the environment through evolutionary processes. In human systems, adaptation can be **anticipatory or reactive**, as well as **incremental and/or transformational**. Incremental adaptation refers to small improvements, usually in the short term. Transformational adaptation alters the fundamental attributes of a system (social, ecological, economic, etc.) in anticipation of climate change and its impacts, and refers to broader and deeper adaptation needs, with a long-term perspective. It can also extend beyond political cycles to become part of the way communities operate (UNFCCC, 2019).

Adaptation plays a fundamental role in reducing exposure and vulnerability to climate change.

Adaptation planning can include a wide range of actions, with different approaches, such as **institutional and political, physical and technological, knowledge and communication, economic and financial, among others**. The combination of actions can contribute to more effective adaptation (IPCC, 2014; BRASIL, 2021). Furthermore, the success of adaptation depends on the active and sustained involvement of stakeholders, including local communities, national, regional, multilateral and international organizations, the public and private sectors, civil society and other relevant actors, as well as effective knowledge management.[2]

Currently, most of the adaptation implemented in the world is fragmented, small-scale, incremental, sector-specific, designed to respond to current impacts and risks in the short term, and more focused on planning than on implementation (IPCC, 2022). These characteristics, combined with the complexity of addressing climate change in different mitigation scenarios, multifaceted operational contexts and different social, economic and institutional capacities to respond to the demands caused by the climate crisis, can lead to maladaptation.

[2] Source: **https://unfccc.int/topics/adaptation-and-resilience/the-big-picture/introduction**.

Therefore, **maladaptation** refers to actions that, unintentionally, can lead to increased risks, vulnerabilities, inequalities and reduced well-being in the present or in the future. Inadequate adaptation responses may worsen existing inequalities, especially for indigenous peoples and marginalized groups, as well as decrease the resilience of ecosystems and biodiversity (IPCC, 2022). Governance issues and process fragilities also contribute to maladaptation, for example, the prioritization of projects that favor political interests to the detriment of areas with greater vulnerability, and low-quality projects (UNDP, 2015).

Although it can occur during the process of drawing up and implementing adaptation policies, science points to various tools and good practices that can help avoid and minimize maladaptation, such as flexible, multisectoral, inclusive and long-term planning (IPCC, 2022). Climate transparency is another mechanism that brings a number of benefits, by providing consistent information for decision-making, increasing political commitment to climate action, strengthening and maintaining technical capacity for the long-term development of monitoring policies, strengthening access by communities and organizations, and increasing public awareness, among others (UNFCCC, 2023).

Maladaptation adversely affects especially marginalized and vulnerable groups (IPCC, 2022).

Adaptation is subject to limits, i.e., when it is unable to ensure the goals of people or groups (or the needs of a system) in the face of changing situations and does not prevent additional impacts or risks. These limits can be **hard or soft**. At the hard limit, there is no way to avoid intolerable risks, and at the soft limit, there may be options for actions, but they are unavailable, and restrictions must be overcome (UNFCCC, 2022).

Once **adaptation limits** are exceeded, societies and ecosystems are subject to losses and damages. Losses occur when there is no possibility of recovery, while damages are losses that can still be recovered, albeit partially. These losses and damages can be economic and/or non-economic and originate from extreme weather events, such as floods and heat waves, or from gradual changes in climate patterns, such as rising sea levels or changes in drought and rainfall patterns (IPCC, 2022).

Non-economic losses and damages include loss of life, forced displacement, loss of culture, territory and impacts on ecosystems and biodiversity (UNFCCC, n.d.). In addition, there is damage to health, especially of the most vulnerable populations, worsening social inequalities, irreversible loss of biodiversity, impairment of culture and local ways of life, food insecurity, among other negative impacts (Brasil, 2021).

An effective adaptation strategy involves the planning and implementation of short, medium and long-term actions that are appropriate for the different social, economic and environmental contexts and degrees of vulnerability and risk. Among the possible ways of prioritizing actions in the short term, we can consider those that are of **low- or no-regret**, i.e., that are cost-effective and represent benefits considering the current climate variability; measures that require a long implementation period; and those with a longer useful life, such as decisions and infrastructure measures that limit future adjustments, also known as lock-ins (UK/CCRA, 2017).

In this sense, the long-term perspective should be incorporated, considering how the climate and other factors may change over the years (UNFCCC, 2019). As adaptation options usually have long implementation periods, **long-term planning and accelerated implementation**, particularly in this next decade, are important to address the gaps (IPCC, 2022).

Therefore, it should be noted that adaptation has the potential to reduce risks and, consequently, impacts over time, by minimizing the exposure of populations, communities, assets and sectors, and reducing their vulnerabilities, although it is not possible to eliminate them completely. Thus, it is imperative to **improve risk assessment and communication processes**, as well as the planning and implementation of adaptation measures in the country. Given its cross-cutting nature across other public policies and socio-economic development agendas, adaptation will be more effective when combined with complementary approaches, at different levels of governance and considering the synergies and conflicts of choice (*trade-offs*) between them.

The following are the approaches that guided the development of the Climate Adaptation Plan. The themes below are considered essential for reducing vulnerabilities and for adopting a systemic approach to adaptation in the various Sectoral and Thematic Plans.

Climate Justice

The term "climate justice" has gained prominence in international forums since COP13 in Bali, Indonesia, in 2007. The disparity between the responsibilities for generating the causes of climate change and the impacts caused by it results in injustices between and within countries. Not only are vulnerable territories and social groups strongly affected, but they also have less capacity to cope with severe weather events. **For the purposes of this Climate Adaptation Plan, climate justice is understood as the human-centered approach to addressing climate change, safeguarding the rights of people in situations of vulnerability and sharing the burdens and benefits of climate change and its impacts in an equitable and fair manner** (IPCC, 2022).

Climate justice addresses the climate crisis not only as an environmental issue, but also as a human rights and social justice issue, considering that climate change disproportionately affects vulnerable populations, who are often the ones who contribute the least to the problem. Furthermore, it argues that climate policies should consider and correct these inequalities through a transformational approach, ensuring that those most affected have a voice in decision-making processes and that actions to mitigate and adapt to climate change are fair and equitable.

Therefore, the climate agenda must be intersectional, i.e., consider that each person has different characteristics of race, ethnicity, social class, age, sexual orientation, religion, geographical origin, among many others, which reflect social inequalities and power structures. The more these characteristics intersect, the greater the potential for increased vulnerability. Climate change can be seen as another axis of exclusion in the light of intersectionality, since it disproportionately impacts specific groups and populations, especially black and indigenous women (Louback, 2022).

In Brazil, the climate crisis is a clear pressure factor for marginalized populations, that are historically vulnerable and with less access to opportunities and to infrastructure, such as basic sanitation. For example, gender inequality is accentuated by social and economic inequality, exacerbated by climate change (Pasquali, 2023). Included in this context are the populations of the slums and peripheral communities, the black population, the LGBTQIA+ community, indigenous peoples, family farmers, shellfish gatherers, coastal dwellers, riverine communities, babaçu coconut breakers, people that practice African-based

religions in Brazil, such as Candomblé and Umbanda, gypsies, as representatives of other traditional peoples and communities (PCTs – Traditional Peoples and Communities (Povos e Comunidades Tradicionais), refugees, migrants and other displaced people, as well as children and adolescents, the elderly and people with disabilities, among others.

Climate justice encompasses four essential dimensions: procedural, distributive, restorative and intergenerational. The **procedural dimension** focuses on guaranteeing fair and equitable procedures, ensuring accessibility and inclusive approaches, as well as promoting transparency at all stages (Araújo, 2023; Kerber, 2010). The **distributive dimension** questions which benefits and burdens are being distributed, to whom and how best to distribute them, prioritizing adequate funding for the most in need areas (Torres *et al.*, 2021; Kerber, 2010).

The **restorative dimension** emphasizes reparation and recognition of the rights of native peoples, quilombola communities[3], other traditional peoples and communities, women living in peripheral areas, both urban and rural, who have historically suffered from climate inequalities (Kerber, 2010). Finally, the **intergenerational dimension** seeks sustainable development that does not compromise future generations, especially considering the social impacts on girls from vulnerable communities, ensuring that their needs and rights are met (Vianna, 2022).

Women

The UNFCCC Gender Work Plan underlines the importance of incorporating a gender perspective into all climate policies. Studies indicate that women are more vulnerable to the impacts of climate change due to structural inequalities, such as unequal access to resources and less participation in decision-making processes (IPCC, 2022). It is, therefore, essential that adaptation planning takes these inequalities into account and includes strategies to overcome them.

Women and girls play a key role in the communities most affected by the climate crisis, often being responsible for the resilience and reconstruction of their homes and communities after disasters. They are key actors in the implementation of sustainable practices. By being actively and meaningfully included in climate solutions, women and girls bring innovative perspectives and adaptive practices that are fundamental to building a more resilient and balanced future.

Gender mainstreaming is not just a question of justice, but also of the effectiveness of public policies. Incorporating a gender perspective into all phases of climate policy planning and implementation ensures that actions are inclusive, equitable and more successful in combating the impacts of climate change.

The Ministry of Women highlights the importance of the Climate Adaptation Plan being a powerful tool not only to promote gender equality, but also to achieve climate justice in Brazil, taking full advantage of the potential of women and girls as leaders and solvers in tackling the climate crisis. Thus, by promoting the empowerment of women and girls, the Climate Adaptation Plan can not only improve gender equality, but also increase its own effectiveness in achieving its goals.

[3] Afro-Brazilian descendants of enslaved people who established autonomous communities, known as quilombos, as a form of resistance during slavery. Today, quilombola communities are recognized for their cultural heritage and collective land rights in Brazil.

Environmental Racism

Environmental racism is manifested through the disproportionate environmental and climate impacts on the black populations, traditional peoples and communities and indigenous peoples, while also considering the intersectionalities of gender and territory. These communities face severe and multifaceted consequences, resulting not only from extreme weather conditions, but also from a social and economic context that increases their vulnerability. Environmental racism is not only constituted by actions that have a racist intention, but also by actions that have a "racial" impact, regardless of the intention that gave rise to them (Pacheco, 2007).

The impacts of climate change and extreme climate events, coupled with historical, social, economic and political factors, increase and deepen the vulnerability of the black population, traditional peoples and communities and indigenous peoples. Some of these impacts include limited access to basic resources and services, loss of territory and livelihoods, racial discrimination and deteriorating health.

Studies show, for example, that heat-related mortality in large cities is significantly higher among the black population, showing a pattern of racial inequality (Monteiro dos Santos *et al.*, 2024). This unequal distribution of the impacts of climate change reproduces the unequal distribution of the burdens and benefits of the country's development, which highlights the environmental injustice (Bullard *et al.*, 2016). In this context, black and brown communities face the most severe consequences, despite their minimal historical contribution to current climate problems (Rede Adaptação Climática Antirracista (Anti-Racist Climate Adaptation Network, 2023), 2023; Dias, 2023; Pereira e Amparo, 2023; Moraes-Filho *et al.*, 2024).

To combat environmental racism and promote climate justice, it is necessary to implement policies that seek to reduce the inequalities of Brazil's historical development process. It is crucial to implement policies that recognize the specificities and intersectionalities of historically vulnerable social groups, both in urban areas and in natural and rural areas, considering, for example, aspects such as the leadership of black women and of women living in peripheral communities. This requires an integrated and continuous dialogue between different sectors, in order to ensure the inclusion of traditional and local knowledge and social participation in the processes of drafting, discussing and monitoring public policies, thus guaranteeing an anti-racist approach that is interconnected with other fundamental human rights (Rede Adaptação Climática Antirracista, 2023).

Human Mobility

In recent decades, the gathering of empirical evidence has shown that climate change impacts human mobility and interacts with existing social inequalities, exacerbating displacement factors both within and across national borders. In the last 10 years, climate-related disasters have caused 220 million internal displacements across the planet - which is equivalent to approximately 60,000 displacements per day (IDMC, 2024). By mid-2024, around 90 million of the current 123 million forcibly displaced people were living in countries with high to extreme exposure to climate-related hazards (Craparo, *et al.*, in press). This represents an increase of around 5 million forcibly displaced people living in highly vulnerable areas since the end of 2023 (UNHCR, 2024).

As climate-related hazards increase in the coming decades, the risks for displaced people and host regions will grow significantly (Craparo *et al.*, in press) (UNHCR, 2024). Its effects will continue to have an impact on internal and cross-border displacement, with the potential to generate conflicts, increase poverty and other social vulnerabilities. The IPCC 6th Assessment Report identifies some regions of the Americas that are particularly sensitive to **climate migration**, including the drought areas of the Amazon and Northeast Brazil (IPCC, 2022, p. 1751).

In recent decades, according to data from Civil Defense, compiled in the Digital Atlas of Disasters (Brasil, 2025), there has been an increase in the number of people who have had to leave their homes (displaced and homeless) in the context of disasters in Brazil. Extreme events, such as droughts and floods, can increase the factors that lead people into poverty and affect, in addition to the right to the city and access to housing, livelihoods, food and water security, human health and the well-being of populations, contributing to **forced displacement**. Internal migration and the densification of urban settlements in situations of poverty put pressure on environmental preservation areas and cities, which can lead to the overloading of urban infrastructures and public services and the increased risk of disasters (Brasil, 2020, p. 271).

Another relevant aspect for all climate scenarios, pointed out by the 6th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (2022, p. 1086-1117), refers to the need to increase efforts in the **planned relocation** of people around the world in the coming years. Countries like Brazil, which has a densely populated coastal zone, including by traditional peoples and communities whose activities depend on the sea, could be particularly impacted, making it impossible, in extreme cases, for these populations to remain in traditionally occupied territories.

Planned relocation should be carried out as the last adaptation measure, ensuring that risk mitigation and adaptation measures are exhausted in territories that allow populations to remain in them. In order to guarantee the fundamental rights of relocated populations, in cases where relocation is proven to be necessary, the people affected must be guaranteed participation and decision-making throughout the risk assessment and planned relocation process.

When it involves traditional peoples and communities, displacement cannot be treated as a technical planning action, as it implies a loss of identity and culture, threatening their way of life. Relocation should, therefore, respect peoples' right to self-determination, guaranteeing their well-being, human dignity and the maintenance of their cultural and social ties. This process

requires an inclusive and sensitive approach that values the role of affected communities and promotes solutions that enable environmental protection and social justice.

Therefore, from the perspective of human mobility, adaptation measures should include the early adoption of mechanisms that seek, whenever possible, to prevent new forced displacements; the establishment of specific guidelines on how to carry out the relocation of people displaced or at risk of displacement for reasons associated with the effects of climate change and disasters, as well as the long-lasting solutions to be developed.

These measures should also consider promoting the active participation of displaced people or those at risk of displacement, and affected communities, in identifying risks, adaptation needs and implementing the identified measures; in addition to creating regulations, plans, and programs that expressly recognize that the adverse effects of climate change cause human displacement.

Future patterns of climate migration will depend not only on climate impacts, but also on the development of public policies and planning focused on tackling these impacts and reducing existing vulnerabilities (IPCC, 2022). Thus, this Climate Plan recognizes human mobility as part of the climate change adaptation agenda, with the understanding that when it occurs safely and with dignity, it can contribute to reducing or preventing the stresses caused by extreme events or gradual changes in vulnerable regions.

Nature-based Solutions and Ecosystem-based Adaptation

Nature-based Solutions (NbS) are solutions inspired and supported by nature that provide environmental, social and economic benefits at the same time (IUCN, 2016). They consist of actions to protect, sustainably manage and restore natural or modified ecosystems, which help to face society's challenges in an effective and adaptive way. Green infrastructure, the protection of springs and wetlands (e.g. filtering gardens and artificial wetlands) are some types of NbS.

Ecosystem-based Adaptation (EbA) is an integrating strategy of NbS that uses ecosystem management to increase resilience and reduce the exposure and vulnerability of people, activities, and ecosystems to climate change. EbA approaches, such as urban ecology, wetlands restoration and upstream forest ecosystems, reduce a range of climate change risks, such as flooding and urban heat, and provide multiple co-benefits (IPCC, 2022). This approach recognizes, among other factors, that biodiversity and ecosystem services have the power to buffer the disturbances caused by climate change, providing greater capacity to absorb the changes (Seixas, 2023). Therefore, they are elements that have the potential to promote the success of actions in various thematic areas covered by this Climate Plan, since they depend on it or benefit from it, directly or indirectly.

In this sense, the Climate Adaptation Plan adopts EbA as a guideline for defining and implementing adaptation actions, as will be presented in Chapter 5.

Sustainable Development

Sustainable development integrates the three pillars of society, economy, and environment in a balanced way. Adopted in 2015, the 17 Sustainable Development Goals (SDGs) seek to tackle the main global challenges, including climate change (SDG 13). In a context of intensifying climate change, development will be effectively achieved if it is climate resilient, i.e., with the capacity to integrate climate action into the pillars of sustainable development.

The Climate Plan states that sustainable development is a fundamental condition for Brazil to adapt to climate change. The IPCC reinforces that adaptation strategies are more effective when implemented within a context of sustainable development, as they respond to the underlying causes of vulnerability, such as poverty, inequalities and environmental degradation. If adaptation aims to increase adaptive capacities, strengthen resilience and reduce vulnerabilities to climate change, sustainable development is the model needed to balance economic growth, environmental protection and social well-being for this and future generations.

The relationship between sustainable development and adaptation is even more evident through the targets set under the Global Goal on Adaptation, which are directly related to the Sustainable Development Goals. These are: 1) water (clean water and sanitation – SDG 6); (2) food and agriculture (zero hunger and sustainable agriculture – SDG 2, and responsible consumption and production – SDG 12); (3) health (good health and well-being – SDG 3); (4) ecosystems and biodiversity (life below water – SDG 14, and life on land – SDG 15); (5) infrastructure and human settlements (industry, innovation, and infrastructure – SDG 9, and sustainable cities and communities – SDG 11); (6) poverty and livelihoods (no poverty – SDG 1, and decent work and economic growth – SDG 8).

By promoting a balanced approach, sustainable development contributes to reducing the vulnerability of communities, ecosystems and economies, making them better prepared to face extreme climate events and long-term changes. In this sense, sustainable development is an important adaptation tool, because as it increases the capacity to respond to climate shocks, it strengthens institutions and infrastructures, promotes social justice and encourages the rational use of natural resources.

Including sustainable development as one of the guidelines of the Climate Adaptation Plan is, therefore, an intergenerational justice and climate justice measure, ensuring that adaptation policies consider social, economic and environmental needs in a balanced manner, and take into account both the limitations to development imposed by climate change and the needs of future generations.

3.2. Climate change in Brazil

3.2.1. Characteristics of the climate in Brazilian territory and climate phenomena

Brazil's vast territory, with a total area of more than 8.5 million square kilometers, has a highly diverse climate. The country has equatorial (North), tropical (about 81.4% of the territory), semi-arid (Northeast, in 4.9% of the territory), high altitude tropical (Southeast) and subtropical (13.7% of the territory) climates (IBGE – Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística), 2017). Although the average annual rainfall in Brazil is estimated at 1,760 millimeters (mm), regional climate differences are very marked. While the semi-arid region of the Northeast has less than 500 mm of rain, in the Amazon region, which has a rainy climate, it can exceed 3,000 mm.

During the rainy season in the Amazon, the large amount of clouds is associated with rising air currents that descend largely over the Northeast, inhibiting local cloud formation in this region. In the central region of Brazil and in the Southeast, there are well-defined dry and rainy seasons. The rainy season has a monsoon-like regime, with rainy periods in which the South Atlantic Convergence Zone (SACZ) predominates, and dry periods in which the rainfall regime is more localized. In the South, the rainfall regime is dominated by cold fronts all year round, by cyclones that form locally and extratropical cyclones that pass through, as well as Mesoscale Convective Systems (MCSs). In all regions of the country, there are intensifications and de-intensifications of weather systems caused by topography (Cavalcanti *et al.*, 2016).

Atmospheric and oceanic interactions: El Niño and La Niña

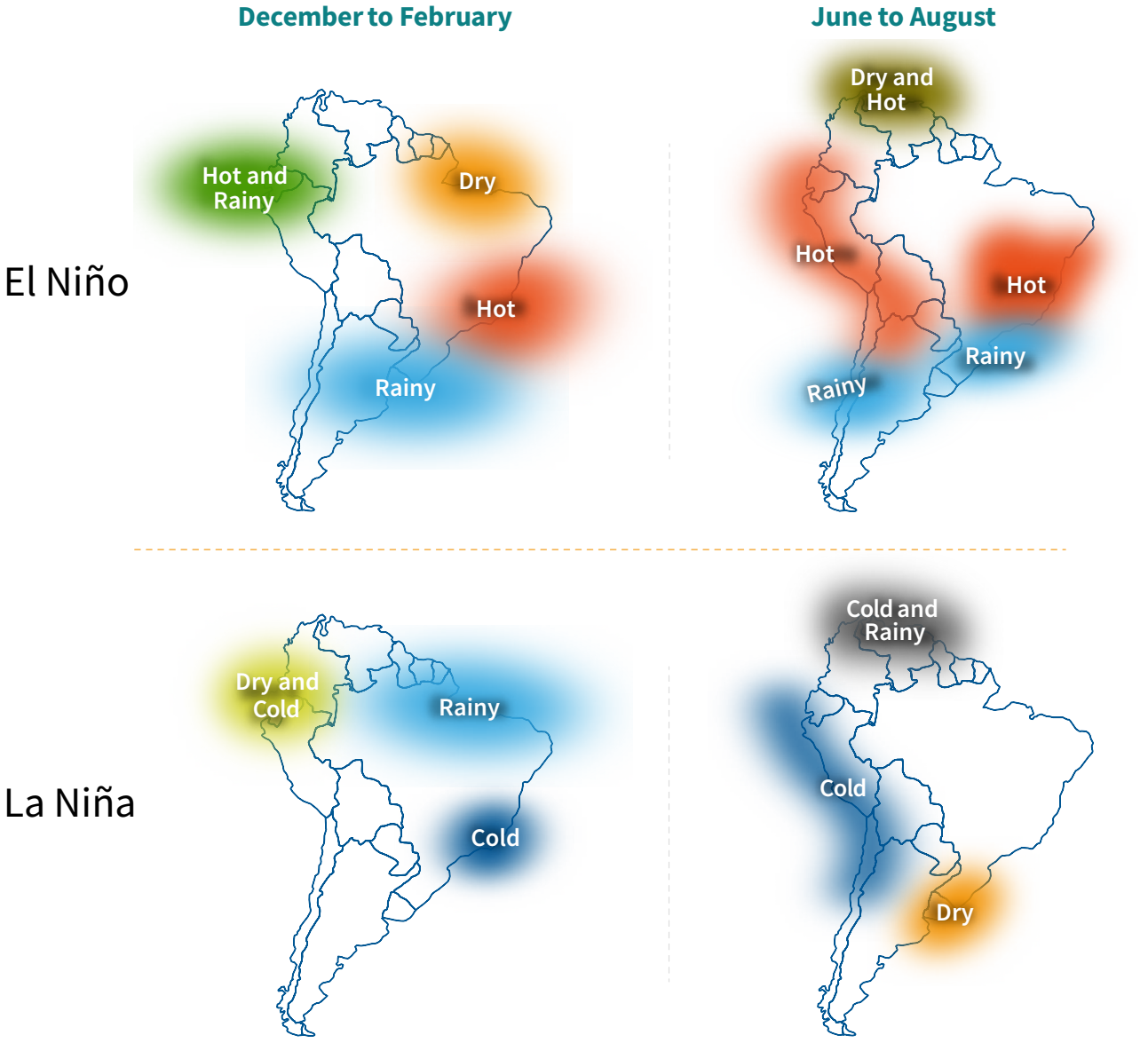
Weather and climate are highly dependent on the ocean and vice versa. Disturbances coming from the Tropical Atlantic Ocean, associated with disturbances from the Intertropical Convergence Zone (ITCZ) or in the form of easterly waves, for example, alter the weather conditions in the North and Northeast regions (Cavalcanti *et al.*, 2016).

One of the atmospheric-oceanic phenomena that significantly affects Brazil is known as the El Niño Southern Oscillation (ENSO), which occurs in the Equatorial Pacific Ocean, especially in the central and central-eastern regions, including the coastal region of Ecuador and Peru. The natural cycle includes phases of warming (El Niño), neutral and cooling conditions (La Niña) in this ocean, causing global impacts on atmospheric circulation patterns, moisture transport, temperature and precipitation. A La Niña or El Niño episode can last for months or even years, which enhances its effects.

In Brazil, El Niño brings specific climate conditions to each region (Figure 5). In the North and Northeast regions, droughts become more frequent, which increases the risk of wildfires and water shortages. In the South, on the other hand, there is persistent rainfall in the spring and heavy rainfall in the fall, with an increase in the average temperature. In the Southeast, temperatures tend to be above average during El Niño. In the south of Mato Grosso do Sul, there is also evidence of above-average rainfall and temperatures.

During La Niña, these patterns are reversed. The North and Northeast experience increased rainfall and flows, while the South faces scarce rainfall (Grimm; Tedeschi, 2009). However, in each La Niña or El Niño episode, rainfall distribution patterns can be different, which is due to the combination of atmospheric and oceanic conditions during the period, such as the temperature conditions of the Atlantic Ocean.

Figure 5 – Impacts of El Niño and La Niña in Brazil during summer (December, January and February) and winter (June, July and August)



Source: CPTEC – Center for Weather Forecasting and Climate Studies (Centro de Previsao de Tempo e Estudos Climaticos/INPE - National Institute for Space Research (Instituto Nacional de Pesquisas Espaciais), 2024.

Significant progress has been made in the forecasting of ENSO, with more sophisticated climate models, capable of forecasting its occurrence months in advance. This ability to forecast ENSO is crucial to guide the preparation for its impacts (Kushnir *et al.*, 2019) on the national territory, such as the Amazon droughts and the devastating floods in southern Brazil observed in 2023 and 2024, when the El Niño phenomenon occurred. It is worth noting that over the last decade, the occurrence of El Niño or La Niña has been recorded every year. IPCC projections indicate that throughout the 21st century there will be a greater frequency of marine heat waves and extreme El Niño and La Niña events (IPCC, 2018).

3.2.2. Observed climate change

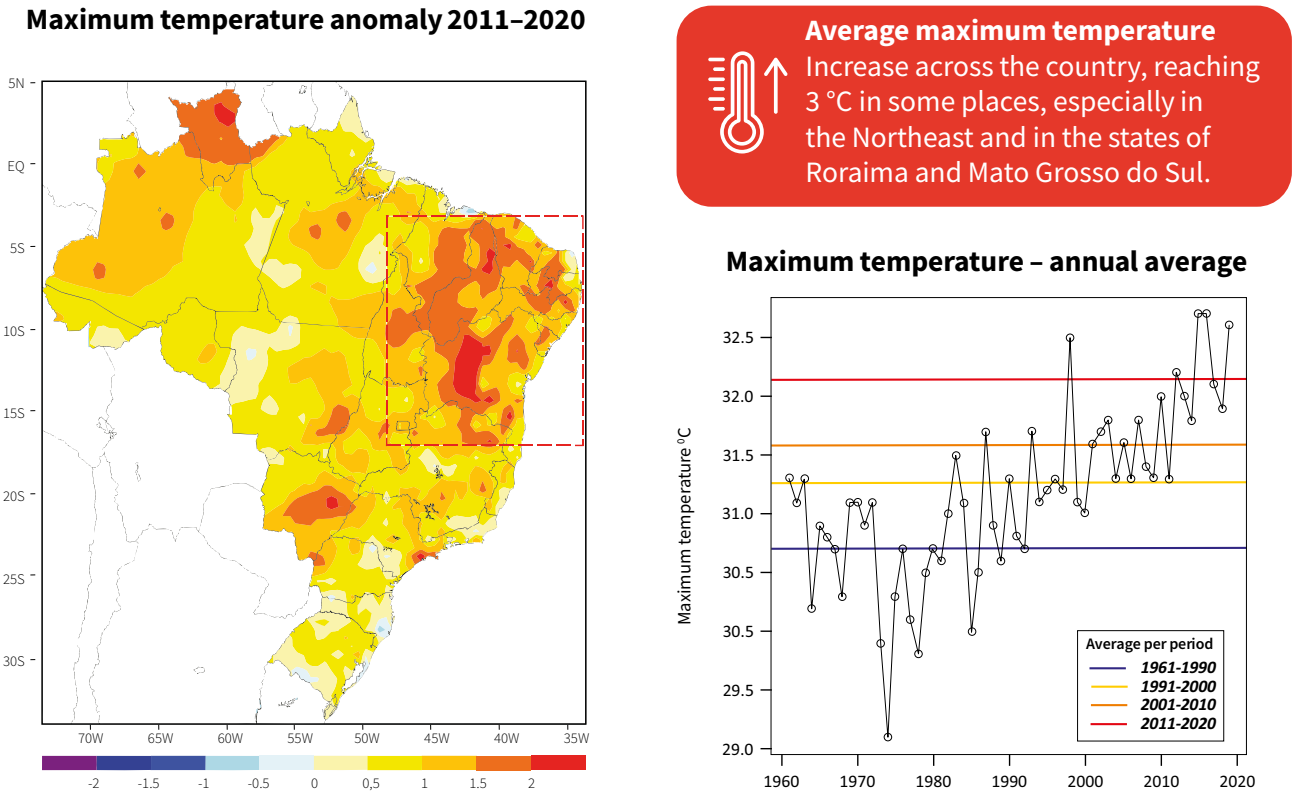
To analyze observed climate change in Brazil, data from 1,252 weather stations and 11,473 rain gauges were used from 1961 to 2020, based on dataset from Xavier *et al.* (2022). The period from 1961 to 1990 was taken as a reference for comparison. The differences between the averages in each period enabled the identification of the spatial distribution and the changes observed in the country. The warming trend of the sea surface temperature along the western edge of the South Atlantic, also analyzed, was measured in degrees Celsius per year (°C/year) from 1993 to 2022.

There was an observed increase in the maximum temperature and in the duration of heat waves, as well as a longer duration of droughts in much of the country. Prolonged extreme rainfall also increased, especially in the South, where average annual rainfall also increased. The Northeast, part of the Southeast, the Center-West and the North, on the other hand, recorded a decrease in rainfall.

For the warming trend in sea surface temperature at the western edge of the South Atlantic, it can be seen that practically the entire area sampled showed an increase in sea surface temperature over the period, with a more pronounced warming trend at latitudes between 25°S and 40°S (Figure 12). The following maps and charts illustrate the results and main conclusions for the variables analyzed (Figures 6 to 10).

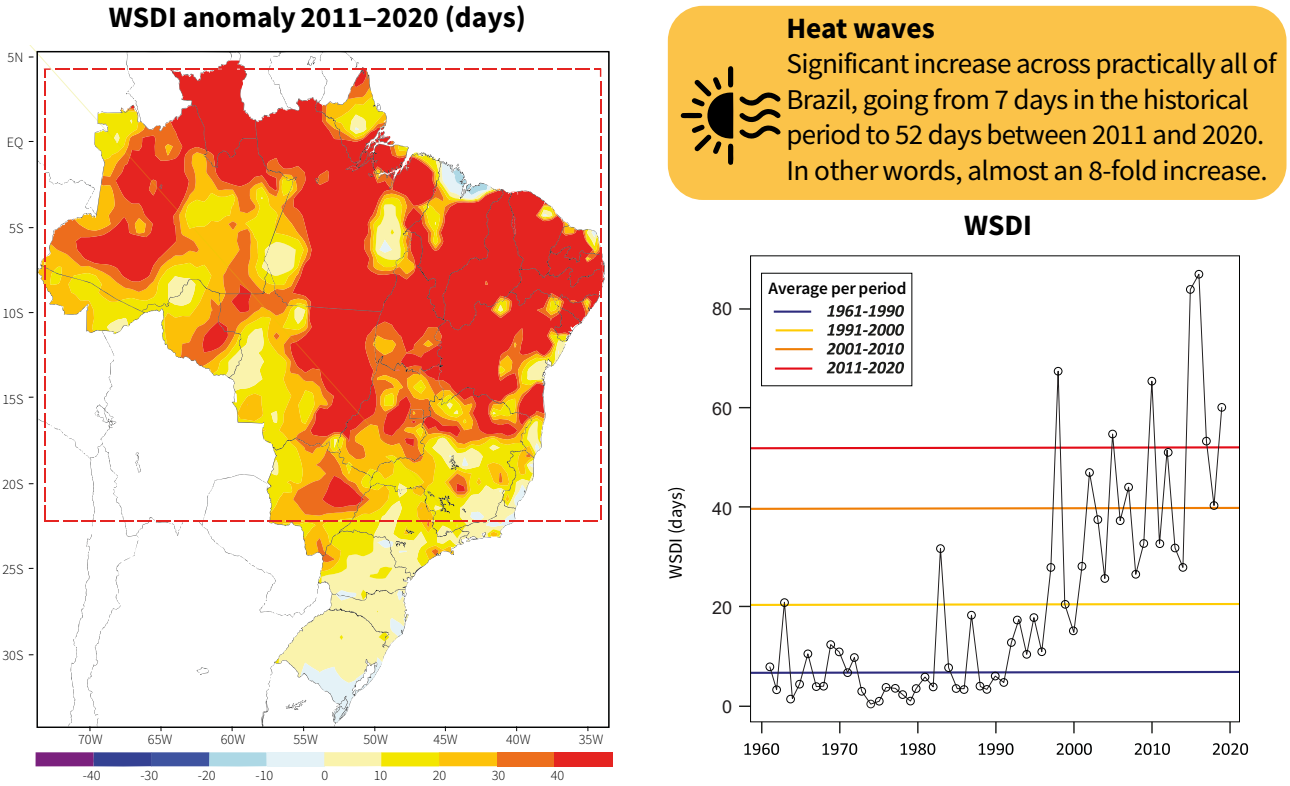
Climate change is already happening and has been intensifying in recent decades.

Figure 6 – Observed average maximum temperature anomaly for 2011-2020, using the 1961-1990 period as a reference with the area of interest selected on the map and time series of annual average maximum temperature values (chart on the right), including the average lines by period



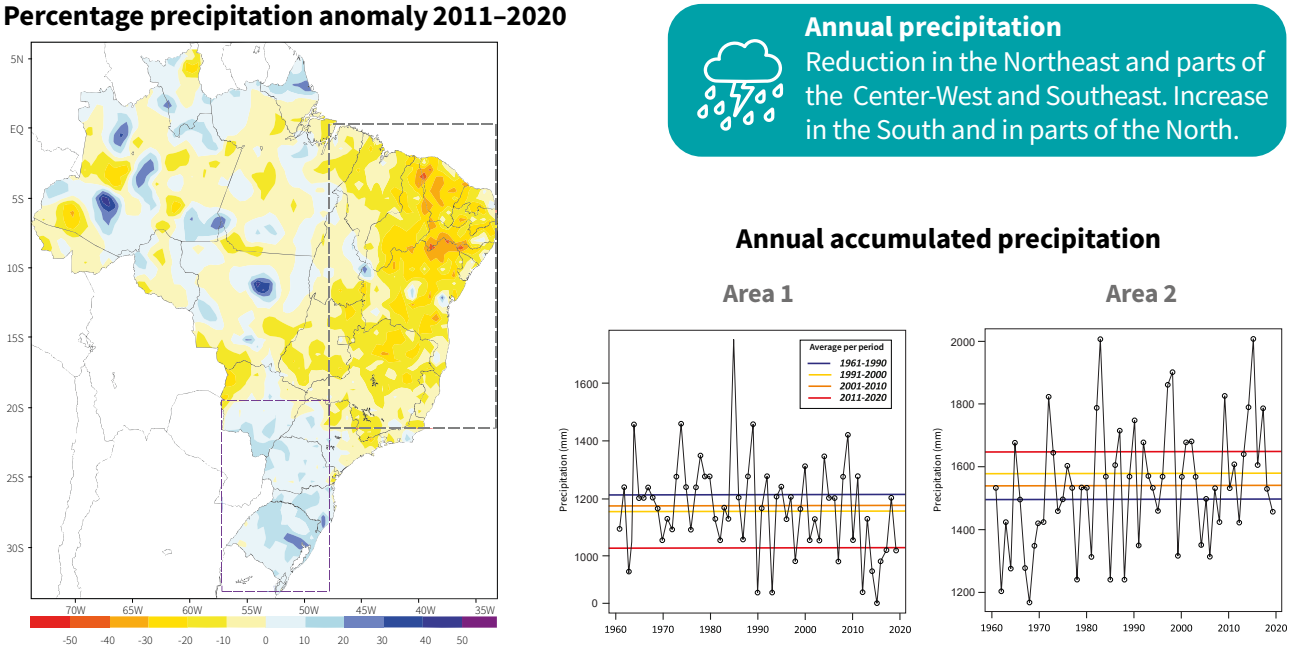
Source: INPE, 2023.

Figure 7 – Warm Spell Duration anomaly (WSDI[4], Warm Spell Duration Index) observed for 2011-2020, using the 1961-1990 period as a reference with the area of interest selected on the map and its time series of annual WSDI values (on the right), including the average lines by period



Source: INPE, 2023.

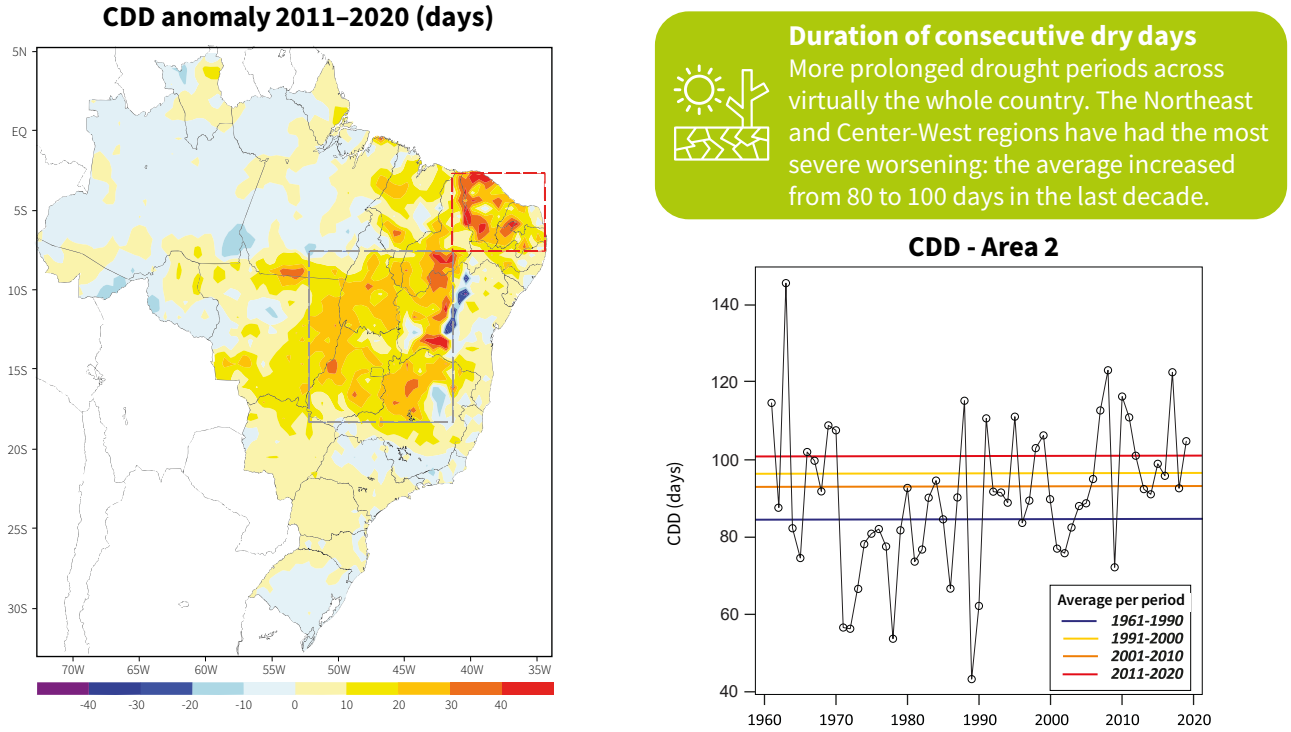
Figure 8 – Percentage precipitation anomaly observed for 2011-2020, using the 1961-1990 period as a reference with the areas of interest selected in the gray (area 1) and purple (area 2) boxes and their corresponding series of average annual precipitation values (on the right), including the average lines by period



Source: INPE, 2023.

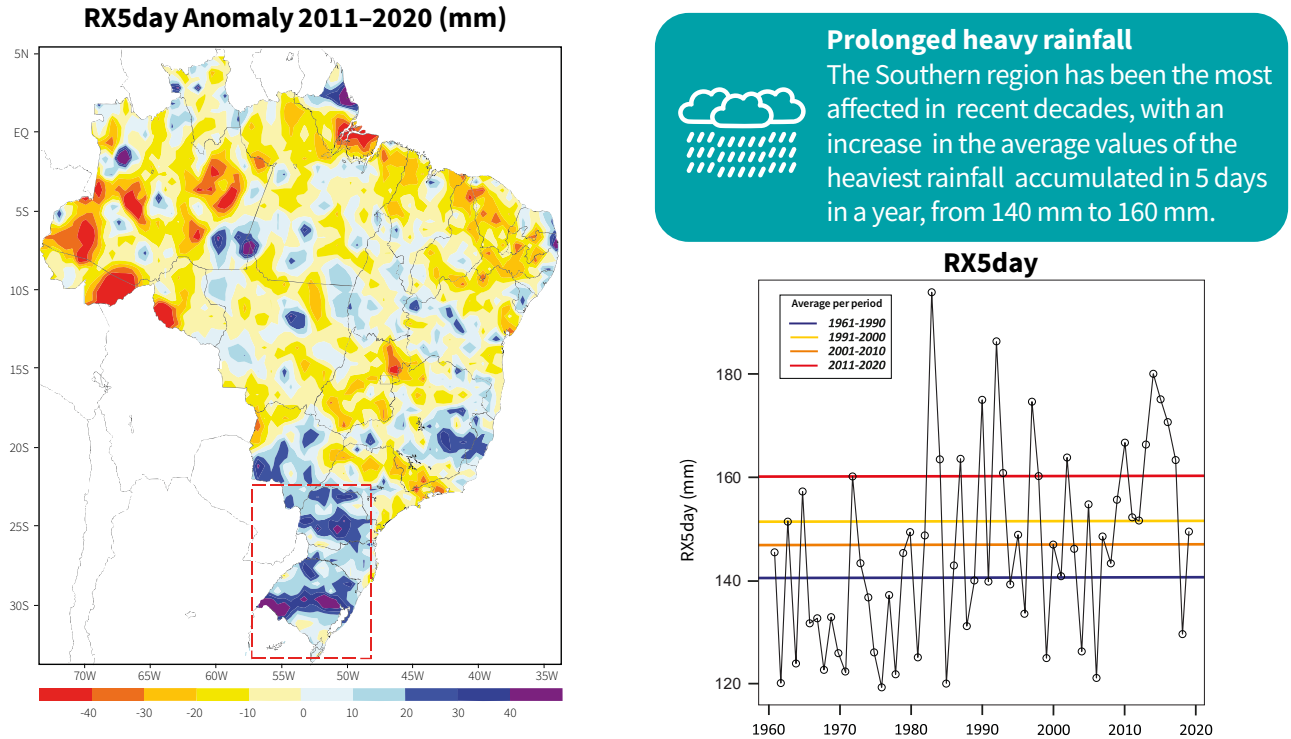
[4] The WSDI is obtained by computing heat waves with at least 6 consecutive days in which the maximum temperature was higher than the 90th percentile of the maximum temperature (centered on a 5-day moving window) of the reference period (1961-1990).

Figure 9 – Consecutive dry days (CDD) anomaly[5] observed for 2011-2020, using the 1961-1990 period as a reference, with the area of interest selected on the map and the time series of the corresponding annual CDD values (on the right), including the average lines by period



Source: INPE, 2023.

Figure 10 – Anomaly in the maximum annual rainfall in five days (RX5day) observed for 2011-2020, using the 1961-1990 period as a reference, with the area of interest selected on the map and its time series of annual RX5day values (on the right), including the average lines by period



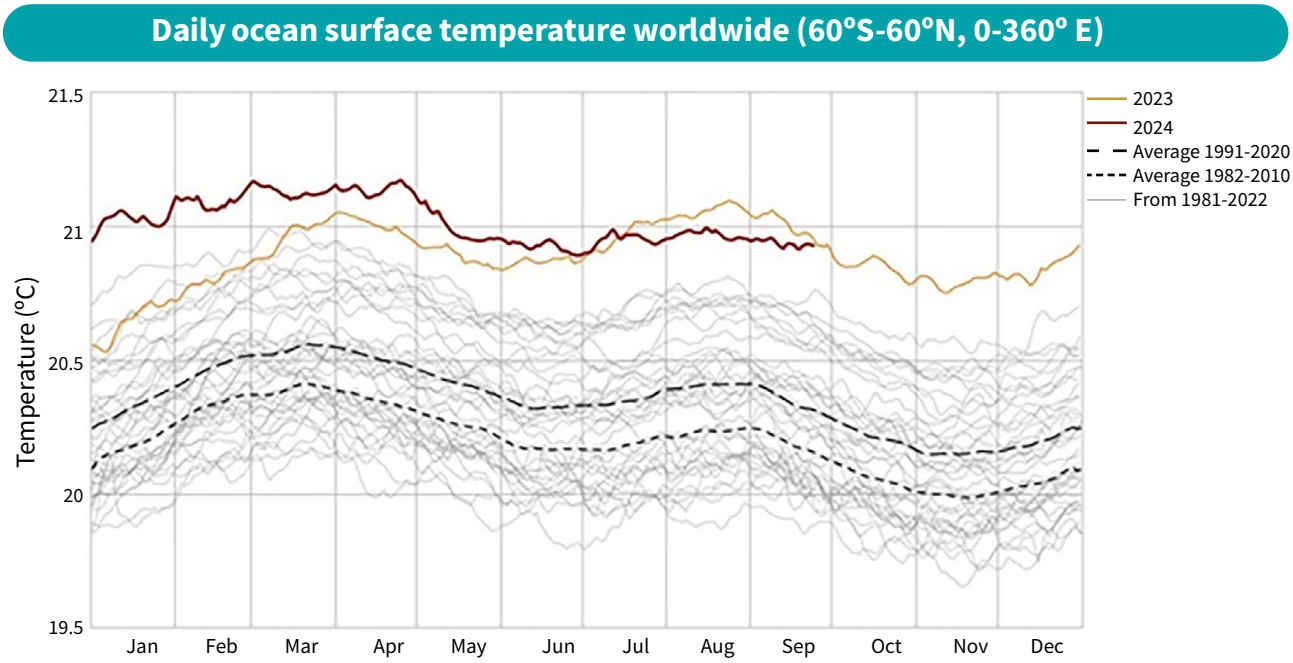
Source: INPE, 2023.

[5] Consecutive Dry Days (CDD) Index indicates the maximum number of consecutive dry days with daily precipitation of less than 1 millimeter.

In relation to the ocean, the temperature has been increasing over time worldwide (Figure 11). In 2023 (orange line) and 2024 (red line), all the temperature records for every day of the last 34 years were broken. In addition, this period also saw the greatest temperature differences between one day of the year and previous periods. In other words, 2023 and 2024 have seen the highest average ocean temperatures and the steepest temperature rises ever recorded in the entire time series (and the process is still ongoing, with new records being broken).

Part of this increase in temperature can be explained by climate change and the El Niño phenomenon, but research is still being carried out to try to understand what is causing this excess warming of the ocean. The scenario is worrying, and serious consequences are already being observed, such as a new global wave of coral bleaching, which began in February 2023 and continues into 2024, strongly affecting coral reefs in the northeast coast of Brazil (ICRI, 2024).

Figure 11 – Global daily average of the Ocean's Sea Surface Temperature (SST), from January 1981 to September 2024



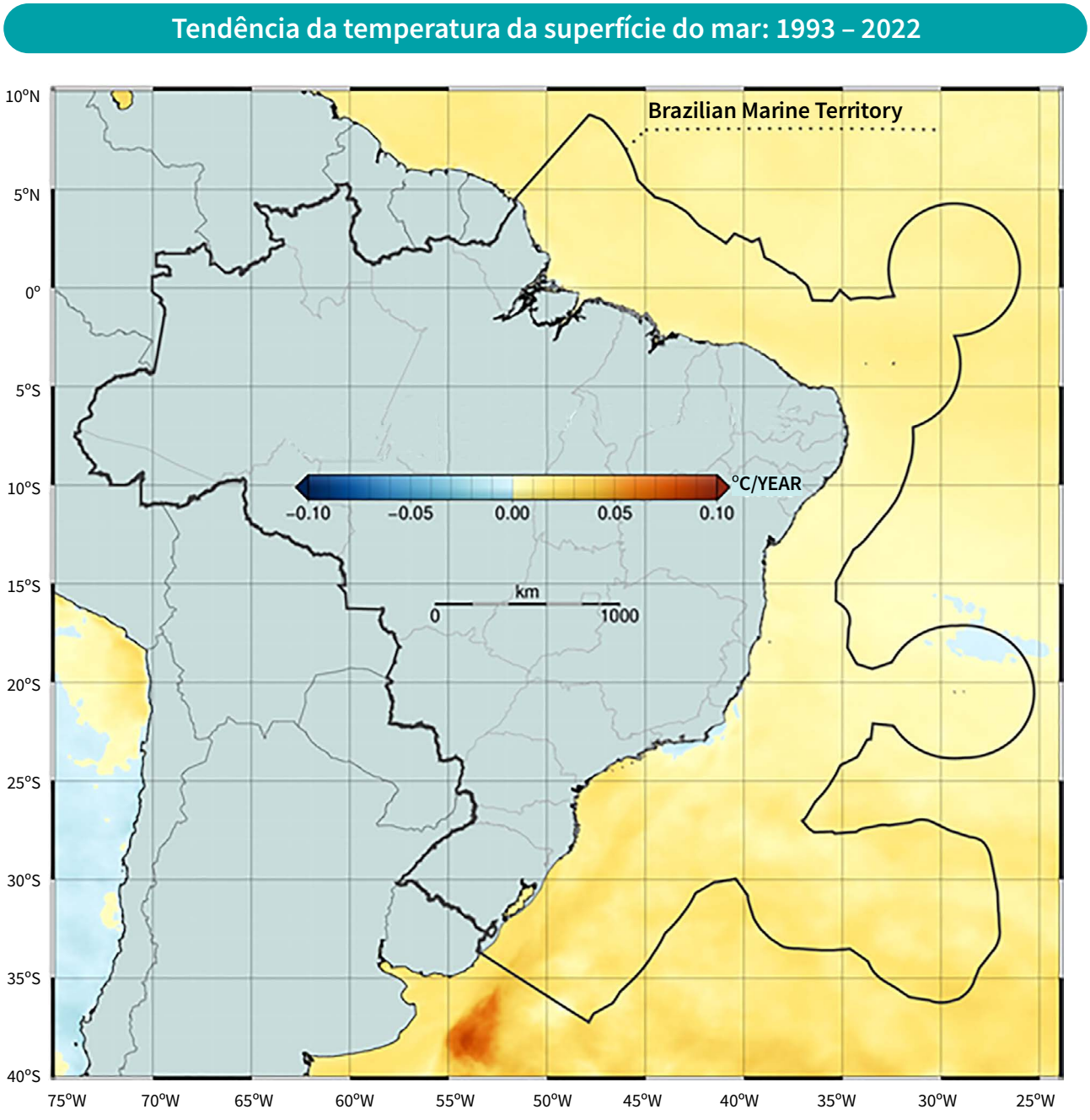
Data set: NOAA OISST V2.1 | Image credit: adapted from Climate Reanalyzer.org. Institute of Climate Change. University of Maine.

Source: Climate Reanalyzer[6]

Note: Each solid line represents the daily temperature averages in one year, with 2023 (orange line) and 2024 (red line) standing out, while the dashed lines represent the averages from 1982 to 2010 and from 1991 to 2020.

[6] Climate Reanalyzer. Available at: **https://climatereanalyzer.org/clim/sst_daily/?dm_id=world2**. Accessed on: Sep. 28, 2024.

Figura 12 – Tendência de mudança de temperatura superficial do oceano no Atlântico Sul, com a delimitação do Sistema Costeiro-Marinho



Fonte: CPTEC/INPE

What would happen in Brazil if we reached climate tipping points?

Climate tipping point is a limit which, when reached, no longer allows a return to a previous climate condition. This change would lead to abrupt, irreversible and extremely dangerous impacts, with serious implications for humanity (Lenton *et al.*, 2019).

In Brazil, global warming of more than 1.5 °C above the pre-industrial period, in combination with increasing deforestation and wildfires, would lead to the collapse of the Amazon rainforest (Flores *et al.*, 2024). This would cause significant changes in the climate, for example, a reduction in rainfall in the Center-West and in the Southeast, since a large part of the rainfall in these regions is the result of moisture transported from the Amazon and coming from the evapotranspiration of the forest (Marengo *et al.*, 2012).

A tipping point with a direct impact on Brazil concerns the extinction of coral reefs, indicated by the IPCC as the first ecosystem to become functionally extinct due to climate change. In this context, it is known that Brazil has the only reef environments in the South Atlantic and this tropical water ecosystem is facing unprecedented ongoing anthropogenic threats, which jeopardize the existence of this functional and biodiverse ecosystem. The significant loss of biodiversity and the ecological processes associated with coral reefs adversely affect hundreds of millions of people who depend on them (Pearce-Kelly *et al.*, 2024).

Other phenomena that can reach tipping points and are critical for the country are the Atlantic Meridional Overturning Circulation (AMOC), the convection in the Labrador-Irminger Seas, the West Antarctic ice sheet and the Greenland ice sheet. The eventual collapse or slowdown of the AMOC could destabilize the El Niño Southern Oscillation (ENSO), which in turn could accelerate coral bleaching, destabilize the Amazon rainforest and the West Antarctic ice cover. This would accelerate the melting of Greenland, which in turn could destabilize the AMOC (Wunderling *et al.*, 2024).

The collapse of the AMOC would cause temperatures to rise and the Intertropical Convergence Zone (ITCZ) to shift, affecting the rainfall regime in the semi-arid region and in the Amazon. The collapse of the convection in the Labrador-Irminger seas would also affect the ITCZ and this would happen in just 10 years after the average global temperature exceeded 1.8 °C. The collapse of the West Antarctic and Greenland ice sheets would raise sea levels by between three and seven meters, respectively (Wunderling *et al.*, 2021).

All these phenomena are interdependent, so reaching tipping point in one of these systems would destabilize others, which would cause a domino effect. Once triggered, this process would lead to a global average temperature much higher than that of the last 1.2 million years, resulting in serious consequences for society and ecosystems (Steffen *et al.*, 2018).

3.2.3. Projections for climate change in Brazil

The assessment of climate change in Brazil used the best scientific knowledge available to date. This summary is based on the conclusions of the main data sources and references, covering both the observed period and future projections. With regard to the future climate, scenarios of global warming levels of 1.5 °C and 2 °C were considered.

Tables 1 and 2 show, respectively, the sign of change and the key messages for 14 climate-related hazards in five Brazilian macro-regions. The selection of these hazards took into account their relevance to the sectors and themes addressed in the Climate Adaptation Plan. The tables summarize the conclusions of the following studies: Avila-Diaz *et al.*, 2020; Ballarin *et al.*, 2023; Dunn *et al.*, 2020; Gutiérrez *et al.*, 2024; INMET, 2024; INPE 2024; IPCC 2023; Li *et al.*, 2021; NASA, 2024; Oliver *et al.*, 2018; Pes *et al.*, 2017; Pires *et al.*, 2021; Regoto *et al.*, 2021; Tomasella *et al.*, 2022; and Vousdoukas *et al.*, 2018.

The analysis compared the agreement between the different studies to estimate the level of evidence of the signs of change and the confidence in the trends identified (key messages). This approach is essential for understanding uncertainties (Appendix A) and guiding more effective adaptation strategies. In short, the most **plausible changes, those that are most certain to occur in the future**, are:

- Increase in temperature and heatwaves in all macro-regions;
- Increase in annual rainfall in the South;
- Increase in extreme rainfall and persistent extreme rainfall in the North, Southeast and South regions;
- Increase in the frequency and duration of droughts in the Northeast, Center-West and Southeast regions;
- Increase in severe winds in the North, Northeast, Southeast and South regions; and
- Rising sea levels and sea temperature, marine heatwaves and ocean acidification along the entire Brazilian coast.

Table 1 – Observed and future changes by region for 14 types of climate-related hazards

Climate-related hazards	North			Northeast			Center-West			Southeast			South		
	Observed	Future		Observed	Future		Observed	Future		Observed	Future		Observed	Future	
		1.5 °C	2 °C		1.5 °C	2 °C		1.5 °C	2 °C		1.5 °C	2 °C		1.5 °C	2 °C
Average temperature	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Maximum temperature	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Minimum temperature	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Heat waves	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Annual rainfall	– *	▼	▼	▼	▽	– *	– *	▽	▽	▽	△	△	▲	▲	▲
Extreme rainfall	▲	▲	▲	▼	▲	▲	△	▲	▲	▲	▲	▲	▲	▲	▲
Extreme persistent rainfall	△ *	△	▲	▼ *	▲	▲	– *	▲	▲	▲ *	▲	▲	▲	▲	▲
Frequency of drought	–	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▽	▽	▽
Duration of drought	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▽	△	△
Severe wind	▲	▲	▲	▲	▲	▲	△	▲	▲	▲	▲	▲	▲	▲	▲
Mean sea level	▲	▲	▲	▲	▲	▲				▲	▲	▲	▲	▲	▲
Sea surface temperature	▲	▲	▲	▲	▲	▲				▲	▲	▲	▲	▲	▲
Marine heatwaves	▲	▲	▲	▲	▲	▲				▲	▲	▲	▲	▲	▲
Ocean acidification	▲	▲	▲	▲	▲	▲				▲	▲	▲	▲	▲	▲

▲ increase with a lot of evidence (more than half of the sources agree)

△ increase with some evidence (half or fewer of the sources agree)

▼ decrease with a lot of evidence (more than half of the sources agree)

▽ decrease with some evidence (half or fewer of the sources agree)

– undefined (no evidence or source with opposing signs of change)

* shows differences in the sign of change within the macro-region

plausible trend (high confidence)

possible trend (medium confidence)

uncertain trend

Not Applicable

Source: Own elaboration based on multiple sources[7].

[7] Source: Avila-Diaz *et al.*, 2020; Ballarin *et al.*, 2023; Dunn *et al.*, 2020; Gutiérrez *et al.*, 2024; INMET, 2024; INPE, 2024; IPCC, 2023; Li *et al.*, 2021; NASA, 2024; Oliver *et al.*, 2018; Pes *et al.*, 2017; Pires *et al.*, 2021; Regoto *et al.*, 2021; Tomasella *et al.*, 2022; Vousdoukas *et al.*, 2018.

Most of the observed and future trends in climate change have a high confidence level and indicate plausible futures. Even with the efforts to achieve the Paris Agreement's target of limiting global warming to 1.5 °C, all regions of the country will continue to experience changes in climate patterns. The **main trends** regarding climate change in Brazil, together with the confidence level assigned to them, are detailed in the Table 2 below.

Table 2 – Trends in climate change in Brazil by climate-related hazards category

Category	Trends (key messages)	Regions
Temperature and heat wave 	Observed increase in temperature (average, maximum and minimum) and heat waves are likely to continue in the future	**All regions**
Rainfall 	An increase in annual rainfall expected to continue in the future	**South**
	A reduction in rainfall is possible, however, some sub-regions may experience an increase	**North, Northeast, and Center-West**
	Uncertainty about the trend of annual rainfall in the region	**Southeast**
Extreme rainfall 	An increase in the magnitude of extreme rainfall is expected to continue in the future	**North, Southeast, and South**
	An increase in the magnitude of extreme rainfall is possible	**Center-West**
	Uncertainty about the trend of the magnitude of extreme rainfall and persistent extreme rainfall	**Northeast**
	An increase in persistent extreme rainfall is expected to continue in the future	**Southeast, and South**
	An increase in persistent extreme rainfall is possible, however, some sub-regions may experience a reduction	**North, and Center-West**
Drought 	An increase in the frequency and duration of droughts is expected to continue in the future	**Northeast, Center-West, and Southeast**
	Potential increase in the frequency and duration of droughts	**North**
	Potential reduction in the frequency of droughts	**South**
	Uncertainty about the trend of drought duration	**South**
Wind 	An increase in severe wind is expected to continue in the future	**Northeast, Southeast, and South**
	An increase in severe wind is possible	**Center-West**
Ocean 	An increase in mean sea level, sea surface temperature, marine heat waves and ocean acidification is expected to continue in the future in all coastal zones	**Coastal Zones**
Confidence level: High / Medium / Low		

Source: Own elaboration.

It should be noted that, for some hazards and macro-regions, there may be regional differences in the sign of change. The main regional differences are: (I) places with increased or decreased annual rainfall in the North, Northeast and Center-West; and (II) places with persistent extreme rainfall in the North, Northeast, Center-West, and Southeast. In many cases, these sub-regional differences are associated with proximity to the ocean and the topography of the coastal zone, which are factors that influence rainfall patterns (Cavalcanti *et al.*, 2009).

Severe impacts of multiple climate events

Climate change adaptation planning also needs to consider the capacity to deal with compound events, in which multiple climate events occur simultaneously or in sequence. This is because such **compound events generate more significant and complex impacts than an isolated event**.

For example, a severe drought combined with a heatwave may result in water shortages and ideal conditions for wildfires. Or the combination of heavy rain with high tides and rising sea levels can result in severe coastal flooding. In addition, droughts followed by heavy rainfall may cause flash floods and inundations, as the soil, previously parched and devoid of vegetation cover, becomes less permeable, causing water to run off instead of being absorbed by the soil (IPCC, 2023).

All the country's macro-regions show a strong trend towards an increase in at least six climate-related hazards, as shown in Table 1. In this context, the successive displacement of the same affected population may be necessary as a result of its exposure to associated or repeated events over time, hindering the possibility of recovery and increasing pre-existing vulnerabilities, as well as generating new ones. Therefore, **it is essential that planners take into account the possibility of facing impacts resulting from compound events**.

3.3. Main risks, impacts and vulnerabilities in Brazil

The following is a summary of the main risks, impacts and vulnerabilities in Brazil, according to the analyses contained in Brazil's Fourth National Communication to the United Nations Framework Convention on Climate Change (Brasil, 2020). The information was organized into two segments, which are discussed in the following sections: the observed impacts and the main risks and vulnerabilities. The former presents an overview of climate-related impacts that have been occurring in Brazil, with examples of the most significant occurrences. The latter analyzes future scenarios combined with risk conditioning factors.

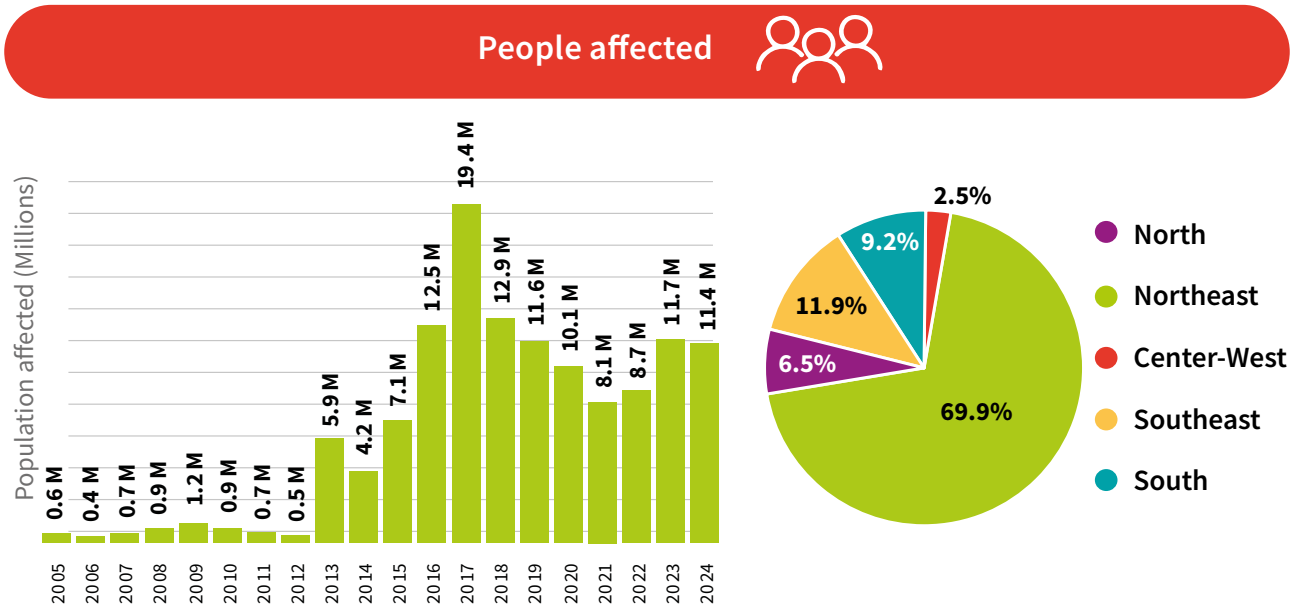
3.3.1. Observed impacts

With the increased occurrence of extreme climate events and gradual climate change in recent decades, all regions of Brazil have faced intensified impacts, in addition to climate-related losses and damages, which demonstrates the urgency of putting adaptation actions into practice in the country. Loss of life, damage to health, reduced quality of life in the cities, losses in crop harvests, compromised water supply, energy generation and damage to infrastructure are some of the impacts that affect Brazilians. The information available on climate change, as well as its analysis provide support for the planning and implementation of adaptation measures.

Disasters resulting from climatological and hydrological events have historically occurred in all regions of the country. In recent years, there has been a consistent increase in the number of people affected[8] by droughts, heatwaves, wildfires, floods and landslides. However, this data should be interpreted with caution, as the increase in the records also reflects significant progress in monitoring and reporting capacity over recent years. Figure 13 shows the increase in the number of records of people affected over the last two decades, as well as their distribution among the country's macro-regions. The Northeast is the macro-region with the highest number of people affected, followed by the Southeast and the South.

Most of the population in Brazil is already suffering from the impacts of climate change.

Figure 13 – People affected by year and region, considering climatological, hydrological and meteorological disasters



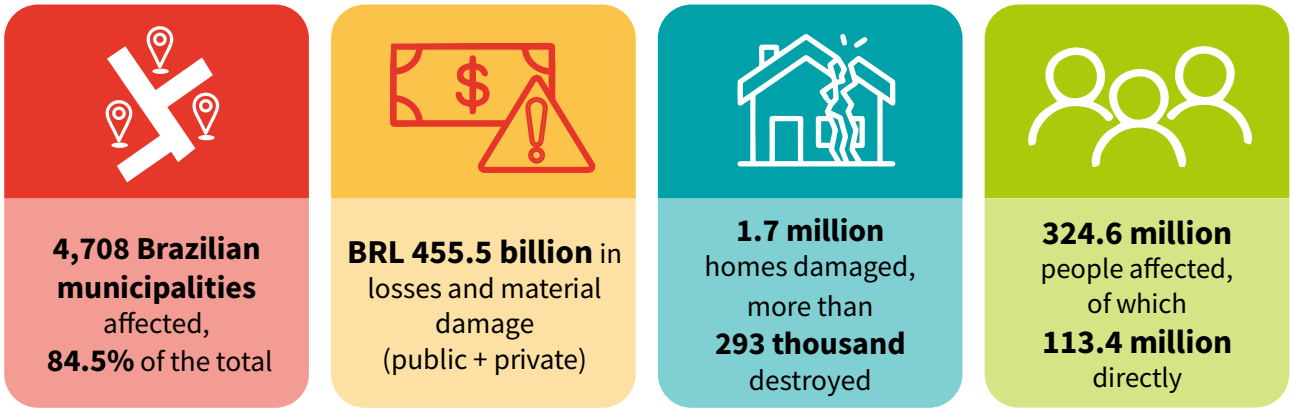
Source: Digital Atlas of Disasters in Brazil (Atlas Digital de Desastres no Brasil), Brasil, 2025.

Since cities account for 85% of the country's population, most of the people affected by these disasters are users and residents of urban environments. Disasters have had a significant impact on the country over the last decade. Between 2015 and 2024, 84.5% of Brazil's 5,570 municipalities were affected, causing economic damage and losses, including public and private losses, totaling BRL 455.5 billion (Brasil, 2025).

During this period, 1.67 million homes were damaged, 293 thousand homes were destroyed and 324.6 million people were affected. Of this total, 5.9 million people were directly affected, excluding those affected by the shortage of goods and services (Figure 14). It should also be noted that the data presented reflects accumulated and repeated exposure to disasters, i.e., the same person or place may have been impacted more than once over the years.

[8] The number of people affected is the sum of the records made using the Disaster Information Form (FIDE, Formulário de Informações do Desastre), which includes the number of dead, injured, sick, homeless, displaced, missing and other people affected.

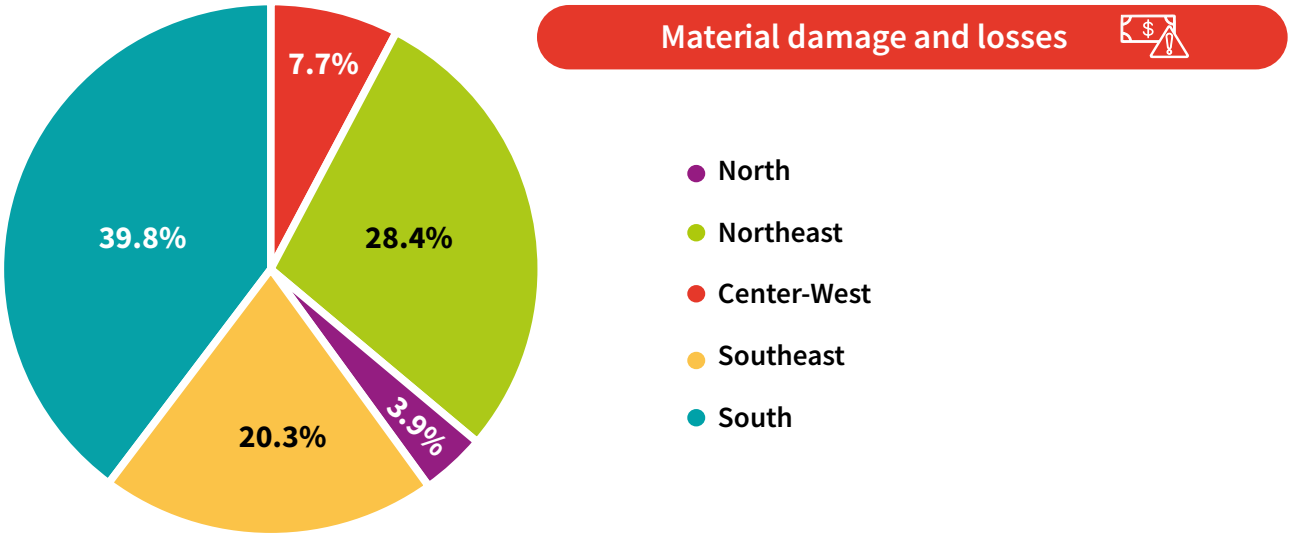
Figure 14 – Climate-related impacts in Brazil over the last decade (2015-2024)



Source: Digital Atlas of Disasters in Brazil (Atlas Digital de Desastres no Brasil), Brasil, 2025.

During this period, the South accumulated the greatest material damage and financial losses, corresponding to 39.8%, followed by the Northeast, with 28.9%, and the Southeast, with 20.3% (Figure 15).

Figure 15 – Distribution of material damage and losses caused by natural disasters by region between 2015 and 2024



Source: Digital Atlas of Disasters in Brazil (Atlas Digital de Desastres no Brasil), Brasil, 2025.

The proportion, frequency and magnitude of disasters have been increasing.

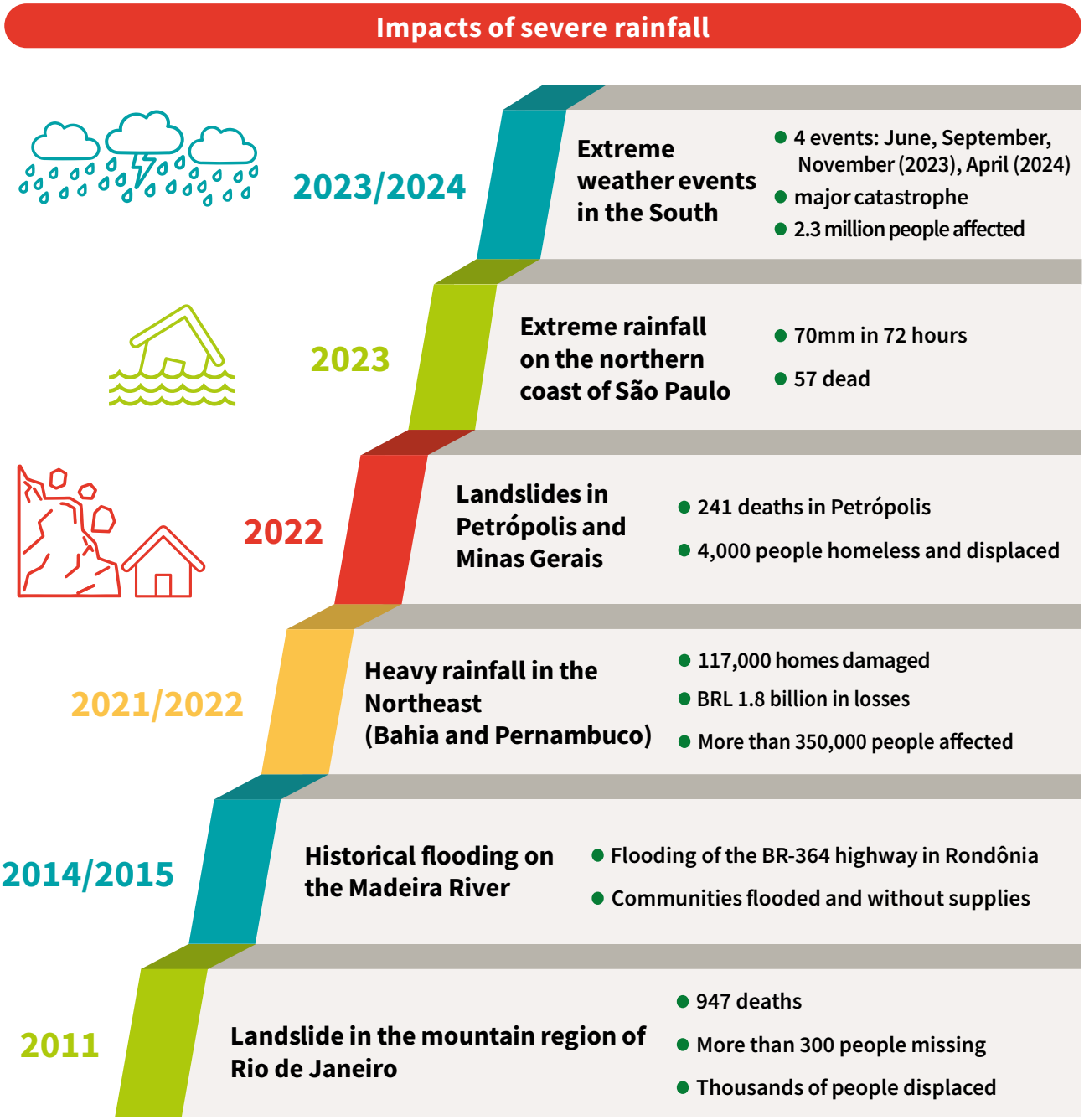
In recent years, the Brazilian population has experienced extreme events in different regions of the country[9], both related to the occurrence of severe rainfall and critical periods of drought.

[9] The disasters and extreme climate events highlighted in this chapter serve as an example of the severity and frequency with which they occur in Brazil, but there was no attempt to present an exhaustive literature review, as several other events that have occurred in Brazilian regions may not have been mentioned.

Droughts are becoming increasingly prolonged and intense in Brazil, even impacting the same regions that suffer from periods of extreme rainfall. The Amazon biome, in the last two decades, has been hit hard by both droughts and extreme floods (Marengo *et al.*, 2013; Pinho; Marengo; Smith, 2015; Tomasella *et al.*, 2013). In 2024, the Amazon, the Pantanal and the Atlantic Forest biomes experienced a significant increase in the number of wildfires, mostly caused by human action and aggravated by severe droughts, intensified by climate change (MapBiomas, 2025).

Figure 16 shows some of the main events related to **severe changes in rainfall patterns**.

Figure 16 – Impacts of severe rainfall in Brazil between 2011 and 2024



Source: Digital Atlas of Disasters in Brazil (Atlas Digital de Desastres no Brasil), Brasil, 2025.

Figure 17 – Droughts and floods in the Amazon in 2023

Source: (a) Pedro Devani/Secom do Acre (Acre's State Department of Communication); (b) Miguel Monteiro/Instituto Mamiraua (Mamiraua Institute).

Note: (a) In 2023, the level of the Acre River rose 17.55 meters and around 56,000 people in Rio Branco were affected. (b) In that same year, drought and extreme heat caused the death of more than 250 pink river dolphins and tucuxis (grey river dolphins) in Tefe and Coari lakes in the Amazon (ICMBio – Chico Mendes Biodiversity Conservation Institute (Instituto Chico Mendes de Conservacao da Biodiversidade), 2023).

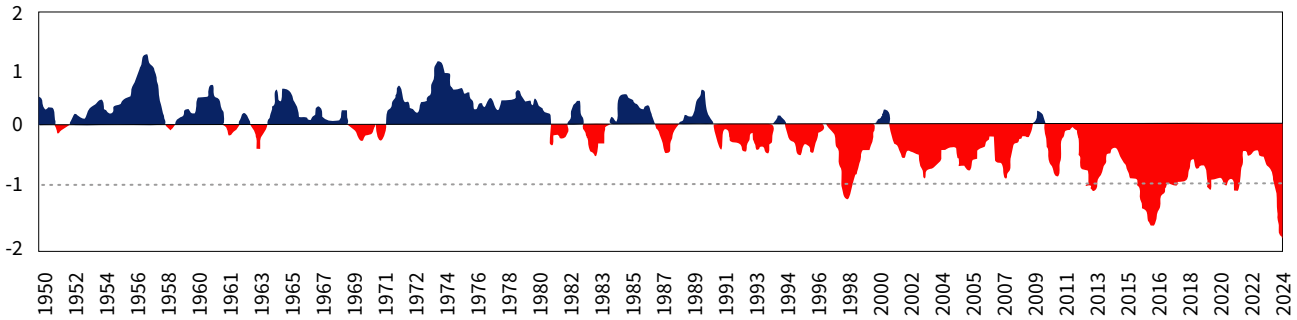
Severe droughts and hotspots - Episodes of extreme drought, hydrological droughts and hotspots have been increasing significantly since 2018 (Figure 17). The Amazon and the Pantanal are experiencing an increase in the number of hotspots due to fires during droughts, which have become more frequent (Cemaden, Centro Nacional de Monitoramento e Alertas de Desastres Naturais (National Center for Monitoring and Early Warnings of Natural Disasters) (2024). In addition to increasing frequency, the duration of droughts in regions of Brazil's territory is getting longer. A technical note published by the National Center for Monitoring and Early Warnings of Natural Disasters (CEMADEN) shows that in the region stretching from the states of Acre and Amazonas to the state of São Paulo and the Triângulo Mineiro (The Minas Gerais State Triangle), the drought that began in the second half of 2023 lasted for 12 months in many municipalities.

Since the 1990s, droughts in Brazil have become more frequent and intense, showing more negative values of the Standardized Precipitation Evapotranspiration Index (SPEI). The SPEI is a tool used to measure and monitor droughts, taking into account two main aspects: the amount of rainfall and the amount of water that is lost through evaporation (soil, rivers, etc.) and plant transpiration. Evapotranspiration depends on temperature and on available water, while evaporation depends on temperature: the warmer it is, the more water evaporates (Cemaden, 2024).

The drought that happened between 2023 and 2024 was the most extensive one and affected 59% of the Brazilian territory.

According to the data below (Figure 18), the country has faced three major droughts (negative SPEI peaks): the first one between 1997 and 1998, the second one between 2015 and 2016, and the last one between 2023 and 2024. It is worth noting that the drought of 2015-2016 surpassed that of 1997-1998, but the one from 2023-2024, even with partial data, already shows more negative SPEI values, indicating that it is the most severe and extensive one in the time series. Thus, in terms of extension, the 2023-2024 drought leads the way, covering around 5 million km², which corresponds to approximately 59% of Brazil's territory (Cemaden, 2024).

Figure 18 – Temporal evolution of droughts in Brazil considering the Standardized Precipitation-Evapotranspiration Index, from December 1951 to April 2024

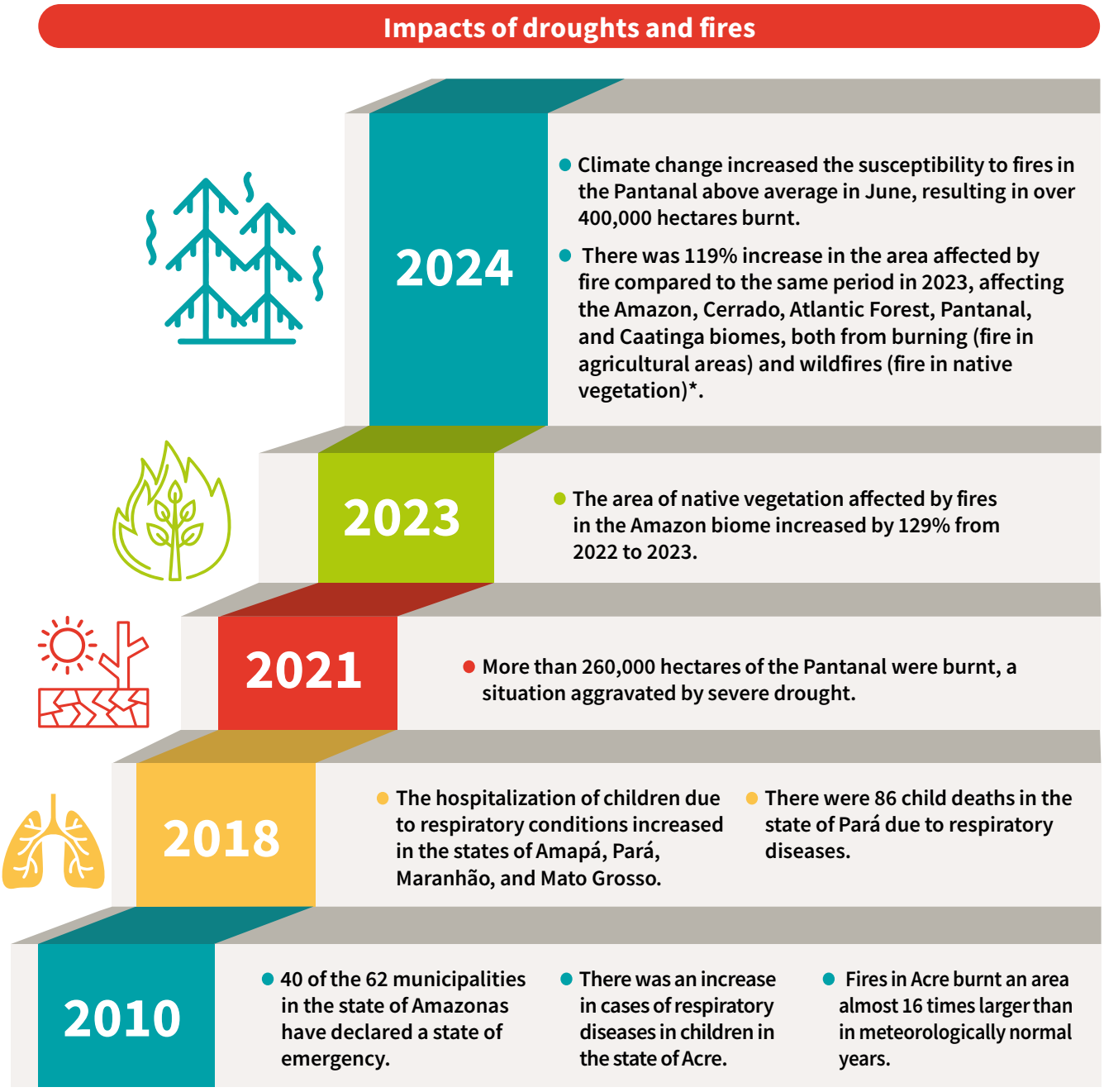


Source: Cemaden, 2024.

Note: The blue bars indicate periods with aboveaverage rainfall, while the red bars indicate periods with below-average rainfall.

Figure 19 highlights some of the main extreme weather events related to intense and prolonged drought in Brazil.

Figure 19 – Impacts of droughts and fires in Brazil between 2010 and 2024



**Data for the first half of 2023 and 2024.*

Source: Smith *et al*., 2014; Pinho, 2016; Alencar *et al*., 2024 e Barnes, Santos, Libonati *et al*., 2024.

Agricultural and livestock activity – Between 2014 and 2023, the losses to agricultural and livestock activity caused by rainfall and droughts (especially droughts) totaled BRL 282 billion, with droughts causing losses of BRL 59.2 billion in 2022 alone, equivalent to 21% of the total for the period analyzed (Brasil, 2025). The regions with the greatest damages and losses were the South and the Northeast, with 45.8% and 27% of the total, respectively. In this context, the excess rainfall caused more severe damage to agricultural production in the Center-West and South, while the damages caused by drought is concentrated in the Northeast, Southeast and South.

Human mobility – Hard hit by climate events, the most vulnerable population may be forced to move in search of better living conditions. In 2023, Brazil stood out as the country in the Americas with the highest number of internal displacements, with more than 745,000 displacements due to disasters, mainly due to events in Rio Grande do Sul (IDMC, 2024). This number is even higher because the current calculation does not take into account all disaster-related migrations, such as those that occur gradually over the months following the event.

Ocean, coastal zone and biodiversity – At the mouth of the Amazon River, the advance of the sea is becoming more frequent, causing salinization of the waters that supply communities in Amapá and compromising activities, such as access to drinking water, fishing, family farming and açaí cultivation. In Baixada Santista, on the coast of the state of São Paulo, between 1993 and 2021, the rate of sea level rise was estimated at 2.38 to 3.39 mm per year, close to the averages for Ubatuba (2.24 mm per year) and Cananéia (2.23 mm per year) (Marengo *et al.*, 2022). In the cities of Rio de Janeiro and Atafona (RJ, State of Rio de Janeiro), the rise in sea level observed from 1990 to 2020 reached 13 centimeters (UN, 2024).

If the pace of emissions and deforestation continues, the decrease in biodiversity could reach 45% by 2050.

In 2023, five of the 10 lakes monitored in the Amazon showed exceptionally high daytime temperatures (>37 °C). This extreme warming of the Amazon's waters follows a long-term increase of 0.6 °C/decade, shown by satellite estimates in the region's lakes between 1990 and 2023 (Fleischmann *et al.*, 2024).

Changes in land use have always played a major historical role in changing terrestrial ecosystems and marine environments (Joly *et al.*, 2019). By 1970, there had been an estimated 22.6% reduction in species abundance, with limited influence from climate change. However, since then, there has been a growing influence of climate change on biodiversity loss (Ometto *et al.*, 2018). A study carried out by CEMADEN and INPE found that areas of the country's semi-arid region have increased at an average rate of more than 75,000 km2 every decade. The last period considered, 1990 to 2020, saw the emergence of an area defined as arid in the north of the state of Bahia, which had never been observed in previous decades[10].

[10] Technical Note: Drafting of Aridity Index Maps and Total Accumulated Precipitation for Brazil. Available at: **https://www.gov.br/cemaden/pt-br/assuntos/noticias-cemaden/estudo-do-cemaden-e-do-inpe-identifica-pela-primeira-vez-a-ocorrencia-de-uma-regiao-arida-no-pais/nota-tecnica_aridas.pdf**.

Ocean acidification, the result of the absorption of carbon dioxide (CO2) from the atmosphere, has serious consequences for all marine life, especially for organisms with calcareous structures, such as corals, mollusks and crustaceans (IPCC, 2019). On the other hand, ocean warming contributes to rising sea levels, a higher incidence of extreme events, and has led to the loss of coral reefs, mangroves, seaweed beds and sea grasses (Cramer *et al.*, 2014; Oppenheimer *et al.*, 2014), weakening their ecosystem services, such as food security and natural protection of ocean cities.

Since the beginning of 2023, mass bleaching of coral reefs has been confirmed throughout the tropics. This is the 4th global bleaching event considered as the most severe in recent decades, in which high mortality has already been recorded in northeastern waters with average sea surface temperatures reaching 33ºC (NOAA, 2024).

Water shortages – In recent decades, all regions of Brazil have experienced impacts related to water shortages. Records show that these impacts are becoming increasingly frequent, mainly due to changes in rainfall patterns, increased water use in agricultural areas, increased deforestation and other changes in land use and occupation. To illustrate the seriousness of the water issue in the face of climate change, the following are some of the repercussions of severe climate events for the Northeast and Southeast regions, that have already been systematized in publications:

- **Severe droughts have hit the Northeast region for seven years in a row, between 2011 and 2017, affecting more than 80% of the municipalities** (IBGE, 2017). Among the impacts caused by drought in this region are the emergence and/or increase of areas with desertification; the depletion and contamination of water reservoirs with consequences for human and animal supply; outbreaks of diarrhea; hospitalizations and deaths of children and the elderly (Rufino *et al.*, 2016; IBGE, 2017). Thirty million people were affected in this region, considering only the historic drought of 2012 (Novaes; Felix; Souza, 2013).

- **In the Southeast region, as a result of the prolonged drought of 2014, the production capacity of industry, energy generation, agricultural productivity and even the operation of hospitals and schools were compromised** (Nobre *et al.*, 2016), as well as the Cantareira urban supply system in São Paulo. Activities on the Tietê-Paraná Waterway, one of the most important in the country, were also affected (ANA – National Water Agency (Agência Nacional de Águas), 2019), as well as the sugarcane harvest, especially in the states of São Paulo and Minas Gerais (Unica - Brazilian Sugarcane Industry Association (Associação Brasileira da Indústria de Cana-de-Açúcar) 2014; Nobre *et al.*, 2016).

Energy generation – Over the last few years, the rainfall observed in some of the main river basins with hydroelectric plants that are part of the SIN – Brazilian Interconnected System (Sistema Interligado Nacional) has been significantly below the historical average. As a result, in the period between December 2020 and November 2021, there was the worst hydropower generation ever seen for this period in history, causing a reduction of 8.5% in the supply of energy from hydroelectric power sources compared to the previous year (EPE – Energy Research Office (Empresa de Pesquisa Energética), 2022).

Additionally, the Report on the Structuring of the Actions and Global Indicators of the Recovery Plan for the Country's Regularization Reservoirs (MME, 2023) presents an analysis of the behavior of the SIN's equivalent storage (EAR - Stored Energy) on a daily basis between 2000 and 2022.

When comparing the decade from 2003 to 2012 with the decade from 2013 to 2022, there was a decrease of approximately 27% in EARmax[11] (Maximum Stored Energy), which shows the reduction in energy availability from hydraulic resources.

It should be noted, however, that in addition to the worsening of the average hydro-meteorological conditions in recent years, the decrease in storage capacity (mainly due to the lack of generation from new reservoirs entering the system) has also been a decisive factor in the relative decrease in EARmax capacity compared to the growing total demand for electricity. As a result, especially in the period from 2013 to 2022, there was a need for the use of additional thermoelectric plants, using fossil fuels, which emit more greenhouse gases (GHG), leading to an increase in the cost of electricity generation.

Heat stress and heat waves – One of the consequences of rising temperatures is the occurrence of heat stress in people, animals and plants. Since the beginning of the century, there has been an increase in the number of days with maximum temperatures above 35ºC and heat waves in all regions. In the last decade, cities such as Brasilia, Fortaleza, Manaus, Rio de Janeiro and São Paulo have faced a significant increase in the number of consecutive hours of heat stress. This means that weather conditions that exceed the human body's ability to withstand them without suffering health problems have become more frequent and prolonged, lasting for up to 12 consecutive hours of heat stress (Miranda *et al.*, 2023).

Adding to the climate-related hazards is the setting of urban centers, which often contribute to the creation of heat islands. Given this, it should be noted that several factors can influence wind circulation, shading, and sun reflection in cities, such as road morphology, building geometry, the amount of green areas, soil impermeabilization, and the building materials used. When inadequate, the latter can increase anthropogenic heat and directly interfere with the thermal comfort of urban populations.

The North and Northeast regions have experienced more than 50 heat waves per year (Silva *et al.*, 2022). In 2022, a heat wave hit Rio Grande do Sul, where for about two weeks the maximum temperatures exceeded 40°C in several cities. In 2023, extreme heat waves were recorded in most parts of the country, such as Cuiabá and São Paulo, which had the warmest winter in 63 years (INMET– National Institute of Meteorology (Instituto Nacional de Meteorologia), 2023).

The unequal distribution of climate impacts on black and brown populations is seen in the higher heat-related mortality of these population segments, especially in large Brazilian urban centers. Between 2000 and 2018, a study highlighted significant racial inequalities in heat-related excess mortality in large Brazilian cities, showing that the rate for black and brown people was 32% in Rio de Janeiro (RJ, Rio de Janeiro State) and 44% in São Paulo (SP, São Paulo State), in contrast to 23% and 36%, respectively, for white people mortality in these cities. In Fortaleza (CE, Ceará State), excessive heat-related mortality reached 17% for black and brown people, compared to 11% for white people, showing a clear pattern of racial inequality in the impacts of extreme heat (Monteiro Dos Santos *et al.*, 2024).

Corroborating the inequality that exists among people affected by heatwaves, data shows that in the state of São Paulo, black and indigenous people and women who are heads of households are proportionally the groups that live in the hottest areas of the cities. In addition, the temperature

[11] Stored energy (% of Maximum Stored Energy – %EARmax) represents the energy associated with the volume of water available in the reservoirs that can be converted into generation at the plant itself and at all the plants downstream in the cascade, the variation of which is directly related to the volume of the reservoirs of the hydropower plants (ONS – National Electric System Operator (Operador Nacional do Sistema Elétrico), n.d.).

in the slums can be up to 9°C higher than in nearby neighborhoods with different urban settings. The impacts of rising temperatures are, therefore, intrinsically linked to urban socio-territorial inequality (UrbVerde, 2024).

Impacts on health – The impacts of climate change on health are complex and involve several dimensions, given that health and disease are the result of biological, social and environmental processes, which are interconnected at the individual and collective levels. In this context, it can be seen that the implications of climate change can be direct and indirect, considering the increase in costs, the burden on the health system and health workers, chronic effects, among others.

There are many health implications being studied in the country. In addition to the impacts mentioned above, relating to the increase in hospitalizations and deaths resulting from atmospheric pollution from fires and heat waves, there is an increase in dengue cases related to the increase in temperature and rainfall extremes, as seen in the state of Maranhão (Silva *et al.*, 2016), in the Amazon biome (Horta *et al.*, 2014), in the city of Rio de Janeiro (Gomes; Nobre; Cruz, 2012) and in Brazilian capitals and large cities, such as Manaus, Fortaleza, Cuiabá, São Paulo, and Porto Alegre (Barcellos; Lowe, 2013).

Weather and climate extreme events in a changing climate

Immediately after an extreme climate event, the question arises as to what extent has human-caused climate change contributed to the likelihood or severity of the event. The emerging scientific field of **attribution of extreme events** has made it possible to answer this question (Otto *et al.*, 2022), and there are already studies demonstrating this relationship in Brazil. In the **tragedy that occurred in Rio Grande do Sul** in May 2024, which resulted in more than 169 deaths and 1.9 million people affected, it was found that although the El Niño climate phenomenon contributed to intensifying rainfall, **global warming doubled the probability of the event occurring** and increased its intensity by between 6 and 9% (Clarke *et al.*, 2024b).

The exceptional water shortage that affected 30 million people in the Amazon River Basin between 2023 and 2024 was the result of low rainfall and high temperatures caused by El Niño and, above all, human-caused climate change (Clarke *et al.*, 2024a). The heatwaves in the spring of 2023, which exceeded 40ºC in most parts of Brazil, were strongly influenced by human action, increasing the likelihood of this type of event occurring by at least 100 times (Kew *et al.*, 2023).

After the 2022 disaster in the city of Recife (PE - state of Pernambuco), which resulted in the death of 138 people and more than 25,000 homeless people, scientists concluded that climate change had made rainfall around 20% heavier than it would have been under normal conditions (Zacariah *et al.*, 2022). The water shortages experienced in southern Brazil in 2022 and 2023, although driven by the natural phenomenon of La Niña, were exacerbated by the increase in temperatures caused by climate change (Arias *et al.*, 2023).

Attribution studies have shown that climate change is already happening and that its effects can no longer be ignored. Furthermore, these studies also help to identify critical regions, prioritize measures and assess the scale of new infrastructures (Otto *et al.*, 2022).

The mapping of all the impacts related to climate change is still in its early stages in the country. Some impacts have more robust systems and indicators that are constantly monitored, such as disasters, while others need further investigation, such as the effects on biodiversity and on the coastal zone. However, it should be noted that the **available evidence is clear that the negative impacts of climate change are worsening throughout the country and at a faster rate than the projections indicated**. This highlights the vulnerabilities that exist within each region and indicates the urgent need to plan and implement adaptation and resilience measures that are effective in tackling these challenges.

3.3.2. Main risks and vulnerabilities

This section presents Brazil's main climate risks and their conditioning factors, resulting from climate-related characteristics, existing vulnerabilities or the degree of exposure of the systems assessed. To this end, their complexities and interdependencies are taken into account, which are presented in a grouped format in relevant key themes. Various sectors, thematic areas, systems and populations interact with these issues in a direct or cross-cutting way, and they are duly detailed in the Sectoral and Thematic Plans for Adaptation to Climate Change.

Water, energy and food security

The security of access to water, energy and sustainable and healthy food is related to the availability of resources and to the elements linked to sustainability, such as the supply and fair distribution of resources among the population, environmental protection and economic development. These issues also involve political, circumstantial and institutional factors.

In cities, socio-territorial inequality results in access to water, energy and food that is different for each social group, depending on where they live. This situation is accentuated in cases of extreme weather events, especially in peripheral areas where the infrastructure for urban mobility, sanitation and energy is precarious or non-existent. The main risks and vulnerabilities in these sectors are briefly described below.

WATER SECURITY – Projections indicate a reduction in long-period flow rates (Q90) and an increase in episodes of extreme drought, especially in the Center-West. In addition, non-climatic pressure factors are combined with climate change, such as the increase in demand for multiple uses of water with the growing need to supply large cities, agricultural and industrial activities. Furthermore, water quality is also impacted by diffuse pollution, inefficiencies in solid waste management, as well as low sewage collection rates, which currently average around 56% nationally (Brasil, 2022), but are unevenly distributed across the country (the North region has only 23% of sewage collected), highlighting regional discrepancies and the importance of universal access to sanitation services.

In the Northeast and Southeast regions, scenarios indicate reduced flow rates and the intensification of extreme drought and flood events. In the South, despite the current high availability of water, socioeconomic pressures and the use of water for irrigation are vulnerabilities that aggravate future conditions, given the increase in droughts and floods. In the coastal zone and in the ocean, there is saturation and salinization of basins that flow into the ocean, as well as worsening coastal flooding.

With regard to **governance**, although Brazilian legislation emphasizes the decentralization of water management, there is a difficulty in complying with this requirement throughout the country, which shows high variation in terms of institutional capacity between states and municipalities. There is potential for strengthening and improving water resources management

in order to address extreme events and conflicts over water use in the country. One of the actions to achieve this is to consider **climate change** in existing instruments, such as **Water Resource Plans and Basin Committees.**

Water management and the necessary debate on strategic water reservoirs for climate resilience

Water is an essential and cross-cutting resource for climate change adaptation, with direct implications for water, food, energy, health and environmental security. Given the intensification of climate change, with implications for the water balance and the occurrence of extreme flood and drought events, there is an urgent need to improve water management in order to guarantee multiple uses, ecological flows and the maintenance of ecosystem services in a sustainable and efficient manner.

In this context of increased water scarcity in most regions, the country needs to advance and define adaptation pathways. Among the strategies to be considered, the following stand out, depending on the specific climate risk conditions and vulnerabilities of different places: strengthening basin committees, as the central bodies for river basin governance; improvement of water resource management tools; application of social technologies; more efficient and sustainable use of water—including production systems—; and implementation of measures to minimize water shortages and the impacts of flooding in the most vulnerable areas, such as improving water reservoirs and regulating the hydrological cycle.

With regard to reservoirs, by allowing water to be stored, regulated, and distributed, this measure can both provide a more regular supply during critical periods of drought and mitigate peak flows during periods of flooding. The prospect of multiple-use reservoirs and their proper operation should be considered, in order to increase the adaptive capacity of vulnerable areas and guarantee the continuity of ecosystem services and productive activities. In addition to identifying territorial gaps in strategic water reservoirs, especially in regions with high climatic variability, it is important to highlight that strategic reservoirs must be proposed under a new paradigm, in which climate justice criteria are taken into account, considering territories, vulnerable populations and their ways of life, recovery of degraded areas consistent with nature-based solutions, circular water economy and territorial and water resource management instruments.

Therefore, it is understood that this is a cross-cutting issue whose debate should involve all the Sectoral and Thematic Plans of the Climate Adaptation Plan.

ENERGY SECURITY – On the other hand, in the southern region of the country, water availability is likely to increase by up to 5% by 2040. However, there will be greater unpredictability and an increase in the frequency of floods, as has been the case in the region in recent years.

According to estimates made for Brazil's Fourth National Communication to the United Nations Framework Convention on Climate Change (Brasil, 2020), the effect of climate change on flows and on affluent natural energy (ANE) indicates scenarios of a decrease of between 6% and 41% in Brazil's hydroelectric generation capacity.

It can be seen that the increase in the frequency and duration of droughts, the increase in average, maximum, and minimum temperatures, the decrease in annual rainfall, in addition to the increase and the frequency of heat waves, are the main climate-related hazards to energy security. These climate change trends have the potential to have a decisive impact on the operation of the SIN, increasing its costs and requiring greater flexibility, with the adoption of other complementary sources, possibly at a higher energy cost.

Ultimately, measures aimed at forcibly reducing electricity demand could be necessary in the country, reducing the pressure on the system. It is important to note, however, that these measures would affect society differently, having a greater impact on vulnerable populations and lower-income groups.

Water availability could fall by more than 40% in hydrographic regions in the North, Northeast, Center-West and part of the Southeast by 2040 (ANA, 2024).

Another vulnerability that was identified is the stagnation of the country's hydroelectric reservoir capacity, since the policy of generating electricity from hydroelectric plants with reservoirs (considered as firm energy) has been discontinued in the last decade. At the same time, there has been an increase in the use of intermittent renewable sources (wind and solar), which need to be complemented when there is no production. In the recent water crises, maintaining energy security resulted, for example, in the alternative use of non-renewable sources.

In addition, the rise in temperature leads to an increase in the demand for electricity for cooling throughout the country, especially in the Southeast due to the population concentration. However, this demand is also critical in the North, Northeast and Center-West, where temperatures are projected to rise the most. Furthermore, rising temperatures also have an impact on reduced efficiency and increased maintenance and cooling of equipment, power plants and systems.

Electricity transmission and distribution infrastructures, which connect the different regions and are very extensive, are becoming more exposed to extreme weather events throughout the country, especially in the case of the storms in the South.

With regard to the production of biofuels, the projected reduction in areas of low agroclimatic risk for soybeans (around 80%) and sugarcane (more than 30%) affects the production of biodiesel and ethanol, respectively. Areas with drier soil will require more irrigation. This is one of the potential impacts for the energy sector that will generate possible conflicts of choice (trade-offs) with other sectors and themes, since there will be a reduction in water availability.

FOOD SECURITY – Food supply is negatively affected by climate change due to the reduction in areas suitable for agricultural production, varying according to crop cultivation. This could lead to a decrease of up to 80% in areas suitable for agricultural production, including areas available for the cultivation of crops that are more sensitive to water stress in more pessimistic scenarios. With longer periods of drought and variability in rainfall, there will be a greater need for irrigation, especially in the Cerrado and Caatinga biomes. Demand for irrigation is expected to increase by 66% by 2040 (ANA, 2021), requiring compatibility with other water uses. In addition, the intensification of extreme events may also require greater allocation of financial resources for agricultural insurance, as well as reducing producer's profits.

In fisheries and aquaculture, the increase in surface water temperature has a direct impact on the survival and reproduction capacity of fish, as well as on other biological processes of aquatic

ecosystems, such as changes in water pH that affect the availability of nutrients. These changes could lead to the migration of shoals or even to their death and a reduction in production (catches) throughout the coastline, rivers and lakes, increasing the role of aquaculture in ensuring fisheries production and directly influencing food security.

Along with climatic factors, other elements affect the current and future prospects of food security in the country. Population growth and food consumption per capita, combined with the rural exodus of family farmers, put pressure on the food production chain. In addition, the predominance of a production model based on commodities and the intensive use of chemical inputs have reduced food diversity, impacting the quality of diets and increasing dependence on ultra-processed foods. This system also contributes to environmental degradation and loss of biodiversity and puts pressure on natural resources (Brasil, 2014).

In this context, the northern region has vulnerabilities associated with subsistence farming by traditional communities and land conflicts. In addition, the South and Southeast are characterized by intense occupation, production diversity and land use, as well as a high demand for food. Furthermore, the Center-West is the region with the largest irrigated area in the country. Finally, the Northeast has 35% of the country's family farming area, with high losses due to droughts (Brasil, 2014).

Family farming, which accounts for a large portion of food production in Brazil, is a very vulnerable sector. More precisely, family farmers are responsible for 60% of the Gross Value of Production (GVP) of vegetables, 48% of the area harvested for beans, 17% for corn and 16% for rice, accounting for 25%, 17% and 12% of the GVP for these foods, respectively (IBGE, 2019).

On the other hand, farming families are faced with the historical and structural challenge of having access to only 23% of the total area allocated for agricultural activities. In addition, they are more vulnerable to climate change, which could jeopardize Brazilian food security, given the large share of this segment in food production (Gomes *et al.*, 2024).

LAND LOSS AND MIGRATION FLOWS – Climate variability and the expansion of desertification areas affect family farmers with harvest losses, loss of livelihoods and increased food prices, which can exacerbate migration or displacement to precarious urban settlements and increase poverty (Olsson *et al.*, 2014). Moreover, drought events in the Northeast may become even more frequent with climate change (Marengo *et al.*, 2016; Cunha *et al.*, 2019), with an increase in aridity and rainfall deficit, bringing the risk of desertification (Marengo; Bernasconi, 2015; Vieira *et al.*, 2015).

In future scenarios, practically all the northeastern states will suffer from a loss of land suitable for farming. These impacts could drive new migratory flows or human displacement either internally or to other regions of the country, with the emptying and overloading of services and infrastructures in some cities. They could also result in food insecurity for Brazilians, since the Northeast region accounts for a significant portion of the country's food production.

In this respect, it can be seen that the pressure of climate change on food production has a direct impact on the availability, supply, price and quality of food. The decrease in the availability and supply of food, combined with the increase in price, reduces the consumption of healthy options and increases that of ultra-processed foods. This transition to unhealthy foods aggravates the population's food and nutritional insecurity, causing all forms of malnutrition (undernourishment, obesity and nutritional deficiencies), as well as a greater risk of developing diseases that overburden the health system.

Socially vulnerable populations are the most affected, requiring actions that promote social and environmental justice.

The vulnerability is exacerbated by inequality and marginalization linked to, for example, gender, ethnicity, low income, informal settlements, disability, age and historical and ongoing patterns of inequality, such as colonialism, especially for many indigenous peoples and local communities (IPCC, 2023, p.31).

The IPCC recognizes the historical influence of colonialism and its relationship with the process of unequal production in countries and territories.

Academic studies and publications based on the territories show this relationship in a direct and clear way (Farhana, 2022; Louback, 2022), shedding light on the severity of climate injustice and the urgency of focusing on combating inequalities and promoting adaptation at the same time (Pelling and Garschagen, 2019).

In 2023, food insecurity was found in 21.6 million households, of which 3.2 million faced severe food insecurity. The data also highlights the need to pay close attention to women and black people, who headed 59.4% and 49.7% of households, respectively, with some degree of food insecurity. Most of these households (18.3 million) were located in cities, which are places that are frequently affected by climate disasters (IBGE, 2024).

As an aggravating factor in this situation, the high volume of food losses and waste in the country leads to a rise in costs and prices, which affects the availability of and access to these goods, especially for low-income families or those living in extreme poverty. It is estimated that losses along the production and supply chains vary between 10% and 30%, reaching 40% in some cases (IPEA, 2018).

In addition to issues of gender, color, ethnicity and region, age vulnerability should also be considered. Climate change poses a significant risk to the education of children, adolescents and young people, especially those in vulnerable situations. In Brazil, more than 370,000 children attend schools located in areas susceptible to extreme weather events, such as floods, flash floods and landslides. Exposure to risk is greater in public schools than in private ones, and almost 90% of these schools are close to slums and urban communities. There is also a significant racial perspective. More than half of the schools in at-risk areas serve predominantly black children and adolescents (Alana, 2024).

CRITICAL INFRASTRUCTURES – Some of the country's critical infrastructures, such as those related to water supply, food production and distribution, electricity generation and transmission, as well as road and port systems, are already vulnerable to the current climate, due to low levels of efficiency and/or poor maintenance (IIS, 2019).

Given the long distances in the Brazilian territory, the increased occurrence of extreme weather events can impact the infrastructure of various systems, such as energy and transport, representing a greater risk of interruption in the supply of inputs, services and food, as well as causing systemic and cascading effects. For example, the non-planning or lack of resilient infrastructure on the various roads that connect cities and regions intensifies the difficulty of mass displacement of communities when heavily impacted by extreme weather events.

Failure to act entails high socioeconomic costs, especially as climate-related impacts intensify in Brazil, leading to worsening future scenarios. These negative impacts directly affect people's lives and ecosystems, as well as key sectors of the country's economy. Losses to the economy caused

by climate change are more likely to occur in developing countries, which have poor infrastructure systems, vulnerable populations, and fewer resources to cope with and adapt to extreme weather events (IPCC, 2022).

The cost of inaction

It is estimated that the cost of inaction could result, by 2050, in a loss of BRL 17.1 trillion in Gross Domestic Product (GDP) and the loss of approximately 4.4 million jobs in Brazil.

The Strategic Study on the Economic Impacts of Climate Change in Brazil, prepared as part of the Brazil 2050 Strategy (Brasil, 2025), used computable general equilibrium economic models (CGE) and integrated assessment models (IAM) to estimate the costs of climate inaction for the Brazilian economy. The analysis was carried out at different levels of disaggregation: national, macro-regional and the 27 federal states. The results point to a **significant reduction in levels of economic activity, employment and productivity**, among other indicators, as well as a significant **worsening of regional disparities** in the face of the impacts of climate change.

The economic impacts were projected based on different levels of global warming by the end of the century. The 4 °C scenario assumes that there are no additional efforts to reduce emissions. The 1.5 °C scenario, on the other hand, assumes that there are ambitious and globally coordinated climate action, with an accelerated reduction in emissions. The difference between the indicators projected for these scenarios represents the cost of inaction. That is, the economic damage associated with not responding effectively to climate change, allowing global warming to reach critical levels, such as the 4 °C increase projected by the end of the century.

The accumulated loss in the GDP of the Brazilian economy by 2050, as a result of climate inaction, corresponds to 146% of the national GDP recorded in 2024. The Center-West, North and Northeast regions would be the most impacted, with cumulative costs of inaction equivalent to 126%, 97% and 96% of the GDP projected for 2050, respectively.

The impact of climate inaction on jobs in the macro-regions will increase regional inequalities in the country, which, according to the trend of demographic movements resulting from job losses, should increase rural-urban migration to large cities, especially to those located in the Southeast. When comparing the 4 °C and 1.5 °C scenarios, the Center-West, North and Northeast macro-regions would be the most affected, with a cost of inaction of 7%, 5% and 4% of the total number of jobs projected for 2050, respectively.

In short, **the costs of inaction significantly outweigh the costs associated with action. The urgency is clear. The window of opportunity to avoid severe economic, social and environmental losses, guaranteeing a livable and sustainable future, is rapidly closing**. In this context, we highlight the key role of this National Climate Plan, which, through the national strategy and the Sectoral and Thematic Adaptation Plans, provides guidelines for the coordinated mobilization of society as a whole to develop an effective response to the climate crisis.

Risks and vulnerabilities related to disasters, health and ecosystems

DISASTERS – There has been a worsening of disasters related to climatic and geo-hydrological processes[12] in recent decades in the country (CEPED, 2019), according to the information and data available in the Digital Atlas of Disasters in Brazil (Brasil 2025). The intensification of extreme weather events, when combined with aspects of vulnerability and exposure, causes increasing harm to people (dead, injured, ill, homeless, displaced, isolated, missing or affected people), material damage and environmental damage, as well as high social and economic losses, affecting relationships, security and the well-being of communities.

The increase in the frequency and magnitude of climate extremes interacts with the structural dimensions of vulnerability and with the level of institutional capacity of government actors to deal with climate change. There are some factors that contribute to vulnerability and need to be considered in public policy. Among the main ones are socio-economic inequalities, poverty, unequal access to basic services (such as health and education) and infrastructure (housing, sanitation, socio-spatial segregation, etc.).

These dimensions are intertwined with vulnerabilities related to gender, race, ethnicity, age, nationality and mobility, experienced by social segments such as women, black people, indigenous peoples, traditional communities, children and adolescents, the elderly, people with disabilities, refugees and international migrants, among others. The population's exposure is greater in areas with high population density, especially in urban centers where the most marginalized populations and those living in poverty are at higher risk.

It should be noted that the complex interaction of these multiple factors affects the institutional capacity of government actors to deal with climate change. In the context of Latin America, there is also the issue of corruption in disaster management, due to the allocation of large sums of money, emergency distress, difficulty in monitoring the use of resources, among others (Lacerda *et al.*, 2024).

Projections indicate that the heavy and/or prolonged rainfall events that cause mass movements and landslides are likely to increase even more in the South and Southeast, especially in the coastal zone, where most of Brazil's capital cities and population is concentrated. This increase in heavy rainfall results in a greater occurrence of floods, flash floods and inundations, impacts strongly associated with the weaknesses of urban policy and current patterns of urban development, characterized by precarious and disordered urbanization.

Climate-related events could push up to 3 million Brazilians into extreme poverty by 2030.[13]

In the coastal zone, these events can be exacerbated by sea level rises, such as storm surges. The critical areas for the risk of flooding and landslides are concentrated in the Southeast, Northeast and South regions. Moreover, incorrect generation and disposal of solid urban waste, combined with historical deficiencies in drainage systems, also contribute to worsening disasters such as flooding and inundations.

[12] Listed in the Brazilian Classification and Codification of Disasters (Cobrade, Classificação e Codificação Brasileira de Desastres). Available at: **https://www.gov.br/mdr/pt-br/centrais-de-conteudo/publicacoes/protecao-e-defesa-civil-sedec/DOCU_cobrade2.pdf**. Accessed on: Oct. 01, 2024.

[13] Source: World Bank, 2023.

HEALTH – Rising temperatures, heat waves, and extreme precipitation events (Campbell-Lendrumand; Woodruff, 2007) can intensify the incidence of infectious diseases, such as waterborne diseases (e.g., leptospirosis), because such events cause changes in the environment, such as alterations in ecosystems and biological, hydrological, and geographical cycles. These diseases are associated with urban and socio-territorial factors, such as low-income population agglomeration, inadequate sanitation conditions and infestation of disease transmitters, which are also aggravated by climate change. In this respect, projections indicate an increase in the incidence of diarrhea in children in the North and in the semi-arid northeastern region, which are places characterized by low basic sanitation level.

In addition, the distribution of the incidence of vector-borne diseases is expected to change, especially of dengue, yellow fever, visceral leishmaniosis and malaria, since the climate influences their respective transmission cycles. The increase in temperature, the occurrence of prolonged droughts and heavy rainfall events, together with the lack of basic sanitation, can contribute to the geographical expansion and seasonal abundance of these diseases, including the introduction of new arboviral diseases (IPCC, 2014).

Projections indicate that areas of high climatic suitability for dengue continue to predominate in most of the Northeastern states, with an increase in potential distribution along the coastline towards Bahia and Espírito Santo. With regard to yellow fever, the suitable area will increase significantly in future scenarios, especially in the Center-West and North regions.

As the level of global warming increases, so does the number of deaths and hospitalizations attributable to the temperature. **It is estimated that capital cities in the North and Northeast regions, as well as some in the Southeast, will have more than 90% of the days in the year in a critical condition, in a worst-case scenario**. Considering the risks of death from cardiovascular diseases due to heat stress (WBGT> 28 °C)[14], future climate change scenarios indicate a higher number of deaths, but the impacts differ according to the location and characteristics of the outcomes assessed.

It is noteworthy that some population groups are more affected by cardiovascular diseases caused by heat waves, such as children, the elderly, women, non-white and less educated people, emphasizing the importance of reducing social inequalities (Monteiro Dos Santos *et al.*, 2024; Sousa *et al.*, 2018). For example, future scenarios point to an increase in respiratory and cardiovascular diseases in the elderly population, as well as an increase in the annual mortality rate for this group, which varies between 95 and 149 deaths per 100,000 inhabitants on average. High temperatures lead to a higher number of deaths and hospitalizations due to respiratory diseases, and this situation is critical in the North, Southeast and South of Brazil. In addition, it should be noted that heat stress is especially serious for children in early childhood, as their health and development are severely impacted (NCPI, 2024).

As for the non-white, black and brown populations there has been a historical omission on the part of the states in the development of public policies that prioritize the rights of these populations, making environmental and racial justice effective, which led to a lack of protection and government support in times of climate crisis (Costa, 2023; Dias, 2023). Another relevant issue is the lack of some important data to support the definition of the political agenda. For example, the lack of data stratified by race on the occurrence of cardiovascular diseases during episodes of heat

[14] Wet-Bulb Globe Temperature (WBGT), which represents exposure to climate conditions that influence the body's ability to maintain thermoregulation, i.e., exposure to heat that implies heat stress (WBGT ≥28 °C).

waves is, on average, 10% in the Brazilian Metropolitan Regions, indicating possible underreporting that may affect the understanding of racial vulnerability (Monteiro Dos Santos *et al.*, 2024).

BIODIVERSITY AND ECOSYSTEM SERVICES – Brazilian biodiversity accounts for 10% to 20% of global species diversity (Motta, 2015) and comprises around 30% of the world's tropical forests (Myers *et al.*, 2000). Several factors have been putting pressure on ecosystems and loss of biodiversity, such as changes in land use, population growth, changes in consumption and technological patterns, as well as socio-economic activities.

With climate change, species of animals, plants and other life forms are likely to be impacted in different ways as a result of changes in geographic distribution (Zhang *et al.*, 2017), abundance (Mair *et al.*, 2014), and life cycle (Silva, 2018b). Scenarios indicate changes in the climatic suitability of ecosystems in all biomes, with loss of biodiversity and ecosystem services generated by nature, such as the supply of drinking water, pollination, food and medicinal resources, soil fertility, air quality, tourism among many others.

Furthermore, climate change affects all of humanity, but especially traditional communities, indigenous peoples and family farmers. These populations depend directly on the integrity of natural environments and on their ecosystem services, which makes these groups highly vulnerable to the impacts of environmental degradation and climate change.

In this context, the **Amazon** is highly vulnerable, as the loss of resilience caused by climate change can be aggravated by the changes in land use, such as deforestation, the occurrence of fires and unplanned urbanization. In this respect, future scenarios indicate an increase in tree mortality, reduced forest biomass and a higher incidence of fire episodes, which aggravate the loss of biodiversity and ecosystem services (Anjos; Toledo, 2018; Ometto *et al.*, 2014; Silva *et al.*, 2018).

In addition, the **Cerrado** biome is one of the biodiversity hotspots on the planet, places that are home to thousands of species that only exist there, called endemic species, and which are among the natural areas that are most threatened by the loss of native vegetation. In this respect, projections indicate a major loss of endemic plant and animal species, despite the expansion of some of the Cerrado's characteristics to other regions, but with ecological impoverishment. The biome faces high demand for agriculture and livestock, and has low coverage of protected areas. **An increase in the days of critical fire danger is expected (from 20% to 32%) by the end of the century in Brazil**, which may affect this biome in particular.

In the **Pantanal** biome, the scenarios indicate an increase in exceptional droughts that affect flood pulses, which are natural water cycles that are essential for maintaining life in the largest continental wetland on the planet, making the Pantanal more vulnerable to fires. In addition to these hazards, this biome is particularly affected by the reduction of the Cerrado’s ecosystems, which play an important role in the Pantanal's water pulse (Marques & Rodriguez 2022).

In the Caatinga biome, the range of climatic suitability is very narrow, with a greater trend towards the process of aridization which, together with environmental degradation, can lead to an expansion of areas of desertification. Moreover, under climate change scenarios, the Caatinga biome could expand to the coastal zone, the Southeast and Center-West regions of the country, over the Atlantic Forest and Cerrado biomes.

The high fragmentation of the **Atlantic Forest** reduces its adaptive capacity, since this biome is a biodiversity hotspot but is affected by high population density, low cover of original vegetation (14% remaining) and of protected areas. With regard to changes in this biome, it can be seen that

urbanization along the Brazilian coastal zone, where around 25% of the population lives, has been the major driver of the loss of native vegetation and ecosystem services. With regard to the **Pampa**, the biome loses climatic suitability in all scenarios, with expansion to other areas occupied by the Cerrado, but with a loss of biodiversity, compromising the functionality and provision of its ecosystem services.

Finally, in the **coastal zone and the ocean**, the weaknesses of urban policy to guide the development patterns of cities in compliance with sustainability criteria generate impacts such as the contamination and loss of ecosystems and their ecosystem services, which is accentuated by the lack or inadequacy of city infrastructure planning, urban expansion and tourism. Overfishing and illegal fishing are also pressure factors on fish stocks (Scherer *et al.*, 2024).

Other activities, such as oil and gas exploration, may also have an impact on coastal and marine environments. The resulting loss of provisioning, supporting, regulating and/or cultural ecosystem services, such as food supply, CO2 capture, tidal protection, tourism and recreation, among others, affect human well-being and socio-economic activities in the coastal zone and ocean (Bustamante; Metzger *et al.*, 2019).

Thus, it can be noted that climate change puts additional pressure on cities and coastal and marine ecosystems, impacting ecosystem services, such as those that benefit the fishing sector, as well as leading to impacts on port regions, especially on maritime and river transportation. In addition, changes in water quality are also expected, due to increased temperature and acidification, as well as saturation and salinization of the river basins that flow into the sea (Alfredini *et al.*, 2013; Harari; França; Camargo, 2007; Marengo *et al.*, 2018c). It can also be said that with 2 °C of global warming coral reef and calcareous algae environments are at risk of disappearing (Roy *et al.*, 2018).

In addition, the effects of climate change tend to aggravate flooding and erosion processes caused by rising sea levels and extreme events (Copertino *et al.*, 2017). Thus, areas at lower topographic elevations along the entire coast are more exposed to coastal flooding events, particularly in the southern and southeastern states, where there is a greater influence from frontal systems and the amplitude of meteorological tides. In the North, on the other hand, the tides have a greater astronomical influence, affecting the entire coastal plain and coastline.

Regarding salinization, the locations most affected will be the coastal plains, where the seawater intrusion can have an effect on the extent of the saline wedge, jeopardizing the use of water in cities and the use for crop irrigation, aquaculture/mariculture or even industrial purposes, as well as affecting the structure and distribution of native vegetation.

The Federal Constitution of 1988 included a specific chapter on urban development policy, and established, at the same time, the decentralization of competencies on the subject. In this context, all municipalities were given the same responsibility and autonomy in implementing urban policies, despite the imbalances in terms of technical and financial resources and political and economic forces in the country. This has led to increased inequalities in the territory, due to the lack of adequate infrastructure, the concentration of poverty and the logic of unequal distribution of urban and environmental burdens and benefits. All these factors aggravate the vulnerability of urban communities, especially those living in the outskirts of cities (Paz, Menezes, Branco *et al.*, 2022).

It is worth noting that Latin America is one of the regions that is most vulnerable to the impacts of climate change. Due to its location and diversity in terms of climate, ecosystems, economic profile, population distribution and cultural traditions, this region is exposed to overlapping climate events and has different adaptive capacities between countries (IPCC, 2007), with the Brazilian context reflecting, to a certain extent, the set of regional challenges and circumstances. In this sense, adaptation can also be considered a collective effort in which experiences and strategies for increasing resilience can be shared between countries. The National Climate Plan, therefore, emerges as another platform for international dialog and cooperation with a view to strengthening the region.

The vulnerability of sub-national entities increases due to their low adaptive capacity.

4. General Principles of the Climate Plan

The General Principles represent the values based on which the Climate Plan was developed, fundamentally guiding the development of the elements that make it up in terms of form, content and purpose. These principles were chosen based on the constitutional precepts and international commitments that reflect the importance of a comprehensive and integrated response to climate change.

Thus, the Climate Plan, as an offshoot of the National Policy on Climate Change (PNMC, Política Nacional sobre Mudança do Clima), is based on the precepts of the Brazilian Federal Constitution, particularly Articles 1 to 4, which establish the fundamental principles of the Federative Republic of Brazil; on individual and collective rights, defined in Article 5; social rights, provided for in Articles 6 to 11; and Article 225, the cornerstone of the environmental legal framework, which enshrines the right of all to an ecologically balanced environment, assigning to the public authorities and the community the duty to defend and preserve it for present and future generations.

In addition, Article 227 covers the priority group for constitutional protection of the environment, notably children and adolescents, and Article 231 recognizes the original rights of indigenous peoples. All these points are guiding principles and are inseparable from the Democratic Rule of Law, which ensures the rights of citizens and popular participation, as reflected in the transparent and collaborative process with society for the development of the Climate Plan.

The Climate Plan is also guided by internationally recognized principles derived from multilateral agreements ratified by Brazil. Essential references include:

- The 1992 Rio Declaration on Environment and Development;
- The United Nations Framework Convention on Climate Change (UNFCCC) and its Paris Agreement;
- The Convention on Biological Diversity (CBD);
- The United Nations Convention to Combat Desertification (UNCCD);
- The Sendai Framework for Disaster Risk Reduction 2015-2030; and
- The 2030 Agenda for Sustainable Development, with its 17 Sustainable Development Goals (SDGs).

In view of the national reality, which presents historical socio-economic disparities, the importance of SDG 18 adopted by Brazil, which addresses ethnic-racial equality, is recognized. This approach is considered in the climate justice perspective, which includes tackling environmental racism, one of the guiding cross-cutting themes of this document.

Furthermore, the adaptation agenda is also guided by climate commitments that Brazil has made internationally, such as the Declaration on Climate and Health; Declaration on Sustainable Agriculture, Resilient Food Systems, and Climate Action, as co-leader of the Alliance of Champions for Food Systems Transformation; and also the commitments made during Brazil's presidency of the G20 in 2024, when it signed the Ministerial Declaration on Climate Change, Health and Equity and on One Health and the Rio de Janeiro Declaration of G20 Health Ministers. This agenda is also consistent with the commitments of the New Urban Agenda, which recognizes the strategic role of cities in promoting climate resilience, social justice and sustainable urban development. Finally, it incorporates international human rights guidelines, such as those established by the United Nations Committee on the Rights of the Child, which guides states to adopt inclusive climate adaptation measures with a focus on children and adolescents.

These various instruments form the foundation of principles, among which the following stand out: **precaution, prevention, international cooperation, the promotion of sustainable development, citizen participation, equity and common but differentiated responsibilities**.

Based on the above, the National Climate Change Adaptation Strategy, as established by **Law No. 14.904, of June 27, 2024**, and by **Resolution No. 3/2023 of the Interministerial Committee on Climate Change**, defines clear guidelines for drawing up Sectoral and Thematic Adaptation Plans at national level, as well as state and municipal plans. The principles, guidelines, vision and goals of this Strategy not only guide the development of these plans but also ensure the **integration of adaptation actions** into climate action plans at sub-national level, providing a cohesive and effective response to climate challenges.

It is important to note that **the National Adaptation Strategy's premise is to contribute to climate risk reduction, minimizing loss and damage**. However, specific guidelines for responding to loss and damage (economic and non-economic), when adaptation measures are no longer sufficient, fall under the purview of the National Civil Protection and Defense Policy.

5. Guidelines, Vision and Goals

The Climate Adaptation Plan has a time horizon of twelve years and should support the drafting of three cycles of the Multi-Year Plan (PPA, Plano Plurianual): PPA 2024-2027, PPA 2028-2031 and PPA 2032-2035, and the three NDC review cycles for the years 2025, 2030 and 2035. Nevertheless, it is important to understand adaptation as an iterative, cyclical, and continuous process, which must take into account the current context and long-term scenarios beyond the Plan's time horizon. Adaptation actions have different times of implementation and manifestation of their effects, so it is important to coordinate these different time frames.

Thus, consistency and integration between public policies are fundamental for adaptation. Given the existence of limits to reducing or eliminating risks, the effectiveness of actions depends on taking advantage of synergies, as well as managing any conflicts of choice so that viable adaptation alternatives can be expanded. This Plan is, therefore, based on **intersectorality and multilevel integration**, and it uses methodological and conceptual approaches that are consistent with each other.

5.1. Guidelines

In order to effectively implement the Climate Adaptation Plan, the following guidelines have been established for drawing up and implementing adaptation actions at the federal, state and municipal levels:

1. Promoting sustainable development in its multiple dimensions, considering strategic sectors and themes for the country, with a view to reducing inequalities, promoting equity and ensuring a just transition;

2. Promoting climate justice based on the dimensions of gender, race, ethnicity, age, social class, geographical origin and other factors that influence vulnerability;

3. Promoting environmental protection, conservation and preservation, guided by the principles of precaution and prevention;

4. Multilevel and cross-cutting governance, with a view to having consistency, synergy and complementarity between strategies, taking into account territorial specificities;

5. Promoting transparency and participatory processes with society throughout the iterative adaptation cycle;

6. Integrating adaptation into policies, programs and projects that may be affected by climate change, including structuring initiatives and a long-term perspective;

7. Strengthening institutional capacities at the different levels of government, including those necessary for accessing sources of financing and means of implementation for adaptation measures that are appropriate to each context;

8. Promoting co-benefits between adaptation and mitigation of GHG emissions;

9. Adopting the best available knowledge, based on science, good sectoral and societal practices, traditional knowledge and other sources deemed appropriate;

10. Integrating incremental and transformational actions, based on an understanding of climate-related risks and their multiple conditioning factors, with different time horizons and implementation scales;

11. Promoting public awareness and understanding of climate change, its causes, consequences and approaches to reduce risks;

12. Adopting the Ecosystem-Based Adaptation (EbA) approach, recognizing its potential to reduce climate risks and vulnerabilities in a systemic, flexible, socially just and cost-effective way, and its benefits for mitigation efforts, simultaneously;

13. Ensuring the flexibility and adaptability of the strategies, with reviews of the Plan and changes in context, in order to incorporate updates to the information and knowledge generated, as well as lessons learned.

PRINCIPLES

The Climate Adaptation Plan is guided by the values of the Brazilian Federal Constitution. Its fundamental precepts are individual and collective rights, including the recognition of the original rights of indigenous peoples, social and environmental rights, as well as the prioritization of children and adolescents. It also complies with the climate agreements and commitments assumed by the country, including: the 1992 Rio Declaration on Environment and Development; the United Nations Framework Convention on Climate Change; the Convention on Biological Diversity; the United Nations Convention to Combat Desertification; the Sendai Framework for Disaster Risk Reduction 2015-2030; and the 2030 Agenda for Sustainable Development.

ADAPTATION GUIDELINES

1. Promoting sustainable development in its multiple dimensions, considering strategic sectors and themes for the country, with a view to reducing inequalities, promoting equity and ensuring a just transition.
2. Promoting climate justice based on its dimensions of gender, race, ethnicity, age, social class, geographical origin and other factors that influence vulnerability.
3. Promoting environmental protection, conservation and preservation, guided by the principles of precaution and prevention.
4. Multilevel and cross-cutting governance, with a view to having consistency, synergy and complementarity between strategies, taking into account territorial specificities.
5. Promoting transparency and participatory processes with society throughout the iterative adaptation cycle.
6. Integrating adaptation into policies, programs and projects that may be affected by climate change, including structuring initiatives and a long-term perspective.
7. Strengthening institutional capacities at the different levels of government, including those necessary for accessing sources of financing and means of implementation for adaptation measures that are appropriate to each context.
8. Promoting co-benefits between adaptation and mitigation of GHG emissions.
9. Adopting the best available knowledge, based on science, good sectoral and societal practices, traditional knowledge and other sources deemed appropriate.
10. Integrating incremental and transformational actions, based on an understanding of climate-related risks and their multiple conditioning factors, with different time horizons and implementation scales.
11. Promoting public awareness and understanding of climate change, its causes, consequences and approaches to reduce risks.
12. Adopting the Ecosystem-Based Adaptation (EbA) approach, recognizing its potential to reduce climate risks and vulnerabilities in a systemic, flexible, socially just and cost-effective way, and its benefits for mitigation efforts, simultaneously.
13. Ensuring the flexibility and adaptability of the strategies, with reviews of the Plan and changes in context, in order to incorporate updates to the information and knowledge generated, as well as lessons learned.

In adaptation planning, especially at the local and regional levels, it is recommended that the climate perspective be integrated into territorial and budgetary planning instruments, in order to guarantee an effective and contextualized response, as well as the provision of resources to implement actions. Within the scope of territorial planning, it is essential that adaptation is incorporated into the main instruments. These include:

- The Master Plan (PD, Plano Diretor);
- The Integrated Urban Development Plan (PDUI, Plano de Desenvolvimento Urbano Integrado);
- The Ecological-Economic Zoning (EEZ);
- The Coastal Zoning;
- The River Basin Plans; and
- The National Land Use Planning Policy (PNOT, Política Nacional de Ordenamento Territorial).

These instruments are crucial for guiding land use and occupation, establishing areas of urban expansion, environmental protection zones and places most vulnerable to climate risks. By incorporating adaptation into these plans, it is ensured that local development takes into account the specific climate vulnerabilities of each region, promoting more resilient and sustainable land use planning.

It is also essential that adaptation is included in budgetary planning instruments, such as the Multi-Year Plan (PPA), the Budget Guidelines Law (LDO, Lei de Diretrizes Orçamentárias) and the Annual Budget Law (LOA, Lei Orçamentária Anual). In view of this, the allocation of adequate resources for adaptation actions, such as those provided for in Sectoral and Thematic Plans, will ensure that the strategies developed are viable and implementable, ensuring that governments have the necessary means to implement the planned actions. In this regard, the initiative to draw up and monitor the Cross-Cutting Environmental Agenda stands out. It brings together the main attributes of the PPA and budgetary actions related to the environmental issue, with emphasis on the dimension of "Tackling the climate emergency, risk and disaster management", which includes the federal government's adaptation and mitigation actions that are currently underway.

The challenge of adapting to climate change, however, goes beyond simply integrating climate risks into public policies, as it requires a transition to more equitable, environmentally sustainable and inclusive development models. In this sense, within the scope of the Climate Plan, the National Adaptation Strategy shares the same principles, vision, and general goal as the National Mitigation Strategy, in addition to advocating a combination of incremental and transformational actions at different levels of governance. This integration ensures the consistency and synergy between adaptation and mitigation approaches, promoting a comprehensive and unified response to climate challenges.

5.2. Vision

The Climate Plan sets Brazil on the path to becoming a sustainable, resilient, safe, fair and prosperous country, with governments, civil society, the private sector and the scientific community fully aware, engaged and acting in an integrated manner in the face of climate change.

5.3. General goal

The general goal of the Climate Plan is to guide, promote, implement and monitor coordinated actions aimed at transitioning to a net-zero greenhouse gas emissions economy by 2050 and adapting human and natural systems to climate change, through short-, medium- and long-term strategies, aligned with sustainable development and climate justice principles.

5.4. National adaptation goals

The national goals reflect the integration of local needs and priorities with global commitments, emphasizing that climate change adaptation involves both specific actions in the national context and contributions to broader global goals. Those are:

1. Increase the resilience of populations, cities, territories and infrastructure to the climate emergency.
2. Promote sustainable and resilient production and regular access of the population to healthy food of adequate quality and quantity.
3. Promote water security by ensuring the availability of water, in both sufficient quality and quantity, for multiple uses, such as supply, production, energy and ecosystems.
4. Protect, conserve, restore and strengthen ecosystems and biodiversity, while ensuring the provision of ecosystem services.
5. Promote, protect and recover the health and well-being of populations, while respecting the ways of life of traditional peoples and communities.
6. Ensure energy security in a sustainable and accessible manner.
7. Promote socio-economic development and reduce inequalities.
8. Protect cultural heritage and preserve cultural practices and heritage sites in the face of climate change-related risks.
9. Strengthen the vital role of the ocean and coastal zones in tackling climate change.

VISION OF THE CLIMATE PLAN

O The Climate Plan sets Brazil on the path to becoming a sustainable, resilient, safe, fair and prosperous country, with governments, civil society, the private sector and the scientific community fully aware, engaged and acting in an integrated manner in the face of climate change.

Achieved by

GENERAL GOAL OF THE CLIMATE PLAN

The general goal of the Climate Plan is to guide, promote, implement and monitor coordinated actions aimed at transitioning to a net-zero greenhouse gas emissions economy by 2050 and adapting human and natural systems to climate change, through short-, medium- and long-term strategies, aligned with sustainable development and climate justice principles.

Comprised of

NATIONAL ADAPTATION GOALS

1 

Increase the resilience of populations, cities, territories and infrastructure to the climate emergency.

2 

Promote sustainable and resilient production and regular access of the population to healthy food of adequate quality and quantity.

3 

Promote water security by ensuring the availability of water, in both sufficient quality and quantity, for multiple uses, such as supply, production, energy and ecosystems.

4 

Protect, conserve, restore and strengthen ecosystems and biodiversity, while ensuring the provision of ecosystem services.

5 

Promote, protect and recover the health and well-being of populations, while respecting the ways of life of traditional peoples and communities.

6 

Ensure energy security in a sustainable and accessible manner.

7 

Promote socio-economic development and reduce inequalities.

8 

Protect cultural heritage and preserve cultural practices and heritage sites in the face of climate change-related risks.

9 

Strengthen the vital role of the ocean and coastal zone in tackling climate change.

5.5. National adaptation targets

With a view to reinforcing our commitment to reducing vulnerabilities and strengthening resilience throughout Brazil, the sixteen Sectoral and Thematic Adaptation Plans present **a set of 312 sectoral targets to be achieved through 810 actions**, a milestone in the national climate agenda. However, the challenge of setting comprehensive adaptation targets remains an essential political and strategic process for making the national adaptation agenda more effective and ensuring alignment with the Global Goal on Adaptation (GGA), given the complexity of defining indicators for assessing and monitoring the country's progress in a consistent, transparent, and comparable manner.

In the Brazilian context, this challenge is twofold: on the one hand, there is territorial, social, and economic differences, marked by regional and institutional inequalities; on the other hand, the indicators must reflect the different profiles of existing vulnerabilities and adaptive capacities. In addition, it is necessary to ensure that the data used are of adequate quality, time series, and coverage, recognizing the limitations of national databases. There is an opportunity to make use of established systems, such as the national references found in AdaptaBrasil and in publications by the Brazilian Institute of Geography and Statistics (IBGE, Instituto Brasileiro de Geografia e Estatística), as well as global frameworks, such as the SDGs and the GGA.

In addition to the above-mentioned obstacles, the process of defining national targets and indicators is also faced with a number of structural challenges, such as the difficulty posed by intersectoral integration, which can compromise the cross-cutting approach needed to incorporate adaptation actions. The premise that guides the Adaptation agenda in terms of promoting climate justice and social inclusion also requires that the indicators be disaggregated by vulnerable population groups, such as women, children, the elderly and low-income populations, indigenous peoples and traditional communities.

Despite these difficulties, the process provides strategic opportunities, since the definition of adaptation targets and indicators can foster methodological innovation, strengthen multilevel and multisectoral governance and consolidate adaptation as a structuring axis of public policies. It also brings Brazil in line with international initiatives, boosting its capacity to mobilize resources and cooperate with knowledge networks.

Thus, we sought to develop a set of targets and indicators based on the National Adaptation Goals, providing specific guidance for climate policies whenever possible. The aim is to guide initiatives at Federal Government level and indicate to sub-national entities, as well as private actors, actions that should be strengthened through the coordination of efforts.

It should be noted that potential future refinements of the targets and indicators should be understood as a process of natural continuation of the work that begun with the Climate Adaptation Plan, which will increasingly transform qualitative commitments into measurable parameters that can inform decision-making and deliver concrete results for Brazilian society and the international community.

In this respect, the periodic review of national adaptation targets and indicators is also necessary in order to assess the effectiveness of their achievement and identify the need to include new targets, in line with the country's vulnerabilities and reality. This process reflects the dynamic nature of the iterative adaptation cycle.

In line with international initiatives, the continued development and refinement of national adaptation indicators should consider the three main dimensions that guide the development of indicators for global adaptation targets: Reducing the vulnerability of people, ecosystems, and economic sectors; Increasing socioeconomic, institutional, and environmental resilience; Improving adaptive capacity at multiple levels of governance.

To this end, Brazil intends to establish a robust Monitoring, Evaluation, and Learning (MEL) system that will inform national reports, strengthen transparency, and enable the country to consistently fulfill its commitments under the UNFCCC and within the framework of the Paris Agreement.

The definition of targets and indicators for the Climate Adaptation Plan is more than just a technical requirement, it is a political and strategic process that is essential for consolidating the national adaptation agenda in a context of climate emergency.

Therefore, although it is challenging, this process represents a unique opportunity to consolidate adaptation as a priority for sustainable development in Brazil, strengthening national resilience and contributing to the global effort to tackle the climate crisis. Thus, this Plan presents the National Targets and their respective indicators (Table 3).

Table 3 – National targets and indicators of the Climate Adaptation Plan

Targets	Indicators
1 ➡ By **2035**, ensure that **all states and at least 35% of Brazilian municipalities have Adaptation Plans**.	**1.** Number of states and percentage of municipalities with published Adaptation Plans.
2 ➡ By **2035**, provide **structural disaster risk reduction measures** to at least **4 million people** exposed to geohydrogeological disaster risk.	**1.** Number of people benefiting from structural disaster risk reduction measures and urban drainage and slope containment infrastructure.
3 ➡ By **2035**, expand **vegetation cover in urban areas by 180,000 hectares**, prioritizing municipalities at greater climate risk.	**1.** Number of hectares of vegetation cover expanded in urban census sectors.
4 ➡ By **2035**, **reduce to 7.5%** the total number of municipalities with the **minimum level of water security**.	**1.** Percentage of municipalities with a minimum level of water security.[15]
5 ➡ By **2035**, ensure that **100% of the projects for infrastructure works** to be supported by the Federal Government **consider climate risks**.	**1.** Percentage of the projects for infrastructure works to be supported by the Federal Government that include climate risks.[16]

[15] Baseline: 13% (2025)

[16] **Verification criterion:** Affirmative answer to the following question: Have climate risks been addressed in the Basic and Executive Project for investment in infrastructure?

Targets	Indicators
6 ➡ By **2035, reduce, by at least 30%, operational interruptions in federal transportation infrastructure** caused by climate events.	1. Percentage of operational interruptions in federal transportation infrastructure caused by climate events.
7 ➡ By **2030, expand the extension of Marine Protected Areas to 30%**, with specific strategies for climate change included in the management plans.	1. Percentage of the extension of Marine Protected Areas in the Exclusive Economic Zone (EEZ), including specific strategies for climate change.[17]
8 ➡ By **2035, connect 30% of the national territory through ecological corridors** between protected areas and Other Effective Area-Based Conservation Measures - OMECs, prioritizing territories at greater risk from climate change and climate refuge areas.	1. Percentage of national territory connected by ecological corridors.[18]
9 ➡ By **2030**, expand the **adoption of diversified, sustainable and resilient agricultural production systems** to **72.68 million hectares**.	1. Number of hectares adopting Sustainable Production Systems, Practices, Products, and Processes (SPSabc), with the exception of Intensive Finishing (number of animals) and Animal Manure Management. 2. Number of hectares of family farming units engaged in agroecological farming.[19]
10 ➡ By **2035, eradicate severe food and nutrition insecurity**.	1. Number of households with severe food insecurity.

[17] **Baseline:** 26.39% of the Exclusive Economic Zone (EEZ)

[18] **Connectivity parameters:** Maximum distances between fragments, width of ecological corridors, fragments' vegetation cover index.
Baseline: It is being developed within the framework of the National Biodiversity Strategy and Action Plan (EPANB, Estratégia e Plano de Ação Nacionais para a Biodiversidade), which is expected to be defined in early 2026.

[19] Obtained by reconciling the hectares of the farming units of the families registered in the National Family Farming Register that indicated they were engaged in agroecological farming.

Targets	Indicators
11 → By **2035**, have **100% of the health departments of the states and municipalities that are priority areas** for climate emergency **mobilized to adapt the SUS** – Unified Health System (Sistema Único de Saúde) to climate change.	**1**. Percentage of state departments of health mobilized to adapt the SUS to climate change. **2**. Percentage of priority municipal departments of health mobilized and with a diagnosis of impacts, vulnerabilities and adaptation to climate change in the SUS. **3**. Percentage of DSEI (Special Indigenous Health District) included in the diagnoses made by the State Departments of Health.
12 → By **2035**, ensure that **100% of power planning studies take climate risks into account**.	**1**. Percentage of power planning studies and plans that incorporate risk analysis and climate resilience.[20]

Source: Own elaboration.

When setting national and sectoral adaptation targets, climate risk is defined as: *The potential for the occurrence of climate-related adverse consequences (or impacts) for human or ecological systems. Climate risks result from dynamic interactions between climate-related hazards and the exposure and vulnerability of affected human or ecological systems. (IPCC,2022)*

It should be noted that the methodology used to develop the national targets and the 16 Sectoral and Thematic Adaptation Plans was based on the identification of the climate risks in each context, from which the adaptation actions to be implemented were defined. As risk factors evolve and interact over time, the iterative adaptation cycle must guide the entire process, from the definition of plans, the drawing up of projects and budgets, to the implementation of works.

5.6. Climate justice: guiding principle for adaptation

The Climate Plan should prioritize people-centered adaptation, focusing on reducing vulnerabilities and eradicating inequalities that perpetuate poverty and aggravate the risks associated with climate change. To this end, the pursuit for **transformative adaptation** is essential, not only to respond to climate change, but also to reconfigure the fundamental attributes of natural and human systems.

Considering Brazil's diversity and the unequal reality that permeates society, **climate justice is seen as the guiding principle of this Plan throughout the iterative adaptation cycle**, seeking to identify how climate risks affect different populations and territories. With regard to the means of implementation, priority should be given to resources and information that are essential for the resilience of vulnerable populations, especially those at risk of climate disasters, guaranteeing the

[20] **Indicator Details:**
(Number of studies and plans that include climate risk analysis ÷ Main* power expansion studies and plans) × 100
*note: Main expansion planning instruments to be considered in the analysis: PDE – Ten-Year Energy Plan (Plano Decenal de Energia), R1 Reports, and Sisol (Isolated Systems) Planning Cycle.

non-transfer of vulnerabilities, i.e., not passing on to others the propensity or predisposition to be adversely affected, **nor increasing inequalities** in the adaptation measures implemented.

When the necessary measures may cause negative socio-environmental impacts, **socio-environmental safeguards** to avoid and minimize impacts should be implemented, including free, prior and informed consultation, if they affect the territories or rights of traditional peoples or communities. Furthermore, when carrying out adaptation work, it is recommended to prioritize local labor and suppliers, strengthening regional economies and improving living conditions.

Additionally, the distribution of burdens and benefits should take into account that the most affected populations are those that contribute the least to causing climate risks, requiring policies that guarantee a fair distribution of the effects of climate action. Thus, in participation and governance, it is crucial to establish the inclusion of vulnerable populations in decision-making and monitoring spaces, including children and adolescents, ensuring that their voices are heard in appropriate and sensitive settings. Finally, when generating and making data available, it is essential to break it down by race, gender, class, age, among others, in order to build a foundation of knowledge for more inclusive and effective policies.

6. Plan Management

The National Adaptation Strategy and its respective Sectoral and Thematic Plans will be complemented by the Climate Plan's Cross-Cutting Strategies for Climate Action. They will cover topics that are common to both mitigation and adaptation, including: Just Transition and Climate Justice; Women and Climate; Education, Research, Development, and Innovation; Means of Implementation; and Governance Arrangements and Mechanisms for Monitoring, Evaluation, and Transparency.

The cross-cutting strategies will, therefore, play a key role for the ENA and for the Climate Plan as a whole, as they will identify the main challenges and solutions for Brazil to have a climate plan that: (i) integrates mitigation and adaptation measures in a coordinated manner, exploiting their co-benefits; (ii) promotes a just climate transition with gender perspective, fostering positive social, economic, and environmental impacts throughout its implementation; (iii) defines an agenda for education, science, technology, and innovation that enables a knowledge-based transformation of society and the economy; (iv) is based on effective financial, economic, regulatory, and legal means of implementation; and (v) has an institutional governance arrangement equipped with mechanisms for data collection, processing, and analysis for its continuous monitoring, evaluation, review and learning to promote its transparency before Brazilian society.

This section presents the elements most directly related to the ENA and its respective Sectoral and Thematic Plans, with the Cross-Cutting Strategies for Climate Action consolidating a more complete and coordinated framework of mechanisms that will support the management and implementation of the Climate Plan's various agendas, integrating the mitigation and adaptation dimensions.

6.1. Means of implementation

The implementation of the actions provided for in this Strategy and in the Sectoral and Thematic Adaptation Plans, as established in the guidelines, seeks to promote sustainable development in its multiple dimensions, considering strategic sectors and themes, with a view to reducing inequalities, achieving equity and a just transition.

Thus, implementation will largely take place by incorporating climate change adaptation into the planning of policies and programs of federal, state and municipal bodies, as well as into the initiatives of the private sector and civil society. This will be made possible by defining parameters and criteria for prioritizing actions, considering, for example, the assessment of climate risks and vulnerabilities. This process requires the review, re-direction, and re-dimensioning of these policies, programs, and their respective instruments. In addition, given the magnitude of the adaptation challenges, it will be necessary to implement new actions specifically aimed at meeting the goals and targets of this Strategy and of the Sectoral and Thematic Plans.

To guide the implementation of adaptation actions at the federal level, this ENA considers the actual possibilities for financing and resources from the public budget and from funds established specifically for this purpose, in line with the government's Multi-Year Plan, already allocated to the ministries responsible for implementing these actions. In addition to the Multi-Year Plan, the National Adaptation Strategy should strategically support other fiscal and budgetary instruments to ensure the implementation and monitoring of initiatives that promote climate resilience.

The details of the sources of funding and means of implementation for each priority action listed by the sectoral and thematic ministries will be provided with the necessary breakdown within the scope of the Sectoral and Thematic Plans. To this end, the specificities and context of each of the sectors and themes involved in the ENA, as well as the Cross-Cutting Strategy for Means of Implementation, whose elements and flows will underpin the monitoring of its implementation, should be considered.

Given the complexity of making Brazil less vulnerable to the adverse impacts of climate change, it is clear that the actions provided for in the federal public budget will not be sufficient to meet the country's existing needs. In this regard, in line with the international debate on adaptation financing, it is essential to increase the mobilization of private financing at the domestic and international levels, as well as to encourage the adoption of innovative financial mechanisms for the implementation of the actions outlined in the Sectoral and Thematic Plans. To this end, adaptation actions should be included in a portfolio of potential projects, considering the scale of needs in order to strengthen political support for seeking new investments in adaptation.

Public funds already allocated to the agenda should be supplemented and assist in mobilizing and leveraging private funds, international cooperation, and climate finance funds for the agenda. The use of these funds must also be designed to take into account the wide range of financial instruments available, in addition to budget resources and traditional financing operations, using mechanisms such as insurance, equity[21] and guarantees, to broaden the scope and effectiveness of the actions.

Considering ENA guidelines and the competencies and co-responsibilities of sub-national entities in the agenda, it is understood that states and municipalities will also seek the means to finance actions that contribute to achieving the goals. In this context, there is a need to encourage the allocation of public funds to adaptation policies and initiatives that may not be attractive to the private sector, but which are essential for tackling inequalities.

In accordance with **Law 14.904, of June 27, 2024**, the National Adaptation Strategy should promote international cooperation at the bilateral, regional and multilateral levels for the financing, capacity-building, development, transfer and dissemination of technologies and processes for the implementation of adaptation actions, including scientific research, monitoring and systematic evaluation of the impacts of climate change and the exchange of information (Art. 8, Law 14.904/2024).

Under the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, the means of implementation (MoI) refer to the forms of support that are indispensable for countries to effectively implement their climate initiatives. These means involve three main pillars - financing, technology transfer and capacity building - which complement each other to enable the planning, implementation and monitoring of adaptation and mitigation actions.

[21] Equity refers to shareholding in ventures, whereby investors contribute capital in exchange for a share of ownership in the business, taking on risks and also sharing the profits.

Thus, technology transfer is also considered one of the key elements of the means of implementation for adaptation. The aim is to promote access to environmentally- appropriate technologies that contribute to increasing the resilience of natural and human systems to climate change, involving both the provision of equipment and infrastructure and the sharing of knowledge, processes, and innovations. In the Brazilian context, the National Adaptation Strategy recognizes that technology transfer needs to be integrated into public policies and international cooperation, in order to enable the adoption of effective solutions, especially in the most vulnerable sectors.

In the same way, capacity building is essential to ensure the effectiveness and sustainability of adaptive actions. According to the UNFCCC, capacity building should take place at three levels: individual (through training and education), institutional (by strengthening governance and technical and intersectoral structures) and systemic (by creating environments conducive to the development and implementation of policies). In this regard, the Cross-cutting Strategy for Education, Capacity Building, Research, Development, and Innovation stands out, aiming to foster a culture of capacity building and innovation in the country. This strategy contributes to the development of technical and scientific skills, promotes social engagement and supports the implementation of national policies related to tackling climate change.

It is incumbent upon governments to develop integrated initiatives to strengthen the institutional capacities of states and municipalities, with a view to improving diagnostics and taking concrete measures to reduce the risks and impacts of climate change, including those necessary for accessing sources of financing for adaptation and other means of implementation. Finally, the financing mechanisms for the Climate Plan's adaptation and mitigation actions will be detailed in the Cross-Cutting Strategy for the Climate Plan's Means of Implementation.

6.2. Federative governance

Brazil's federal structure presents a set of complex elements for the coordination of public policies within the national territory, especially those related to tackling climate change, which has been severely impacting all regions of the country. This reinforces the need to strengthen **Climate Federalism** as a key to the multisectoral and multilevel implementation of the Climate Plan, considering the territory as the basis of social demands and where public policies actually materialize.

For the effective integration of state and municipal entities around the national adaptation agenda, efforts will be made to establish federal dialogue in various forums, especially those indicated in the **Cross-Cutting Strategy for Monitoring, Management, Evaluation, and Transparency of the Climate Plan**. These include the Federal Coordination Chamber, a body established by **Decree No. 12,040, of June 05, 2024**, with the aim of promoting the participation of states, the Federal District, and municipalities in the development, improvement, and implementation of climate change mitigation and adaptation measures.

At the same time, the goals and guidelines of the Climate Adaptation Plan should be incorporated into policies and initiatives at sub-national level, with institutional flows and channels that allow them to be monitored and evaluated. The synergies and possible dilemmas (trade-offs) between actions at different levels of governance should be noted, as well as the current gaps. This information is relevant for recommending adjustments and/or additions to both the national plan and the policies and initiatives under the responsibility of state and municipal governments.

This federal coordination is referenced in **Law No. 14.904, dated June 27, 2024**, which highlights, in its Article 6, that it is incumbent upon the National Adaptation Plan to define guidelines for state and municipal plans, prioritize support for the most vulnerable municipalities that are exposed to

climate-related hazards, and foster inter-municipal consortia and regional arrangements for the implementation of the measures provided for therein.

The same law also establishes that the NAP should provide for federal coordination and governance mechanisms in order to ensure: (I) representation of civil society and broad cooperation among federal entities; (II) harmonization of methodologies for identifying impacts, assessing and managing climate risk, analyzing climate vulnerabilities and hazards, and identifying, assessing, and prioritizing adaptation measures; and (III) provision of support for the development, implementation, monitoring, and review of the National Adaptation Plan.

The guidelines, vision, general goal, and national adaptation goals presented in this Plan should, therefore, guide multisectoral policies and programs at different federal levels, taking into account territorial specificities and different institutional and financial capacities.

In addition, Sectoral and Thematic Adaptation Plans may make use of specific sectoral forums for federal coordination, whether new or existing ones, for the vertical integration of sectoral policies for adaptation to climate change.

6.3. Participation of civil society, the business sector and the scientific community

Similarly to the federal coordination, the participation of civil society, the business sector, and the scientific community in monitoring the Climate Adaptation Plan will take place in the forums indicated in the **Cross-Cutting Strategy for Monitoring, Management, Evaluation and Transparency of the Climate Plan**. The importance of participatory processes is stressed if adaptation policies are to be effective, ensuring that there is a balance of interests, credibility and representativeness.

Under the CIM – Interministerial Committee on Climate Change (Comitê Interministerial sobre Mudança do Clima), the Social Participation and Scientific Advisory Chambers stand out. These bodies aim to promote the participation of civil society and the business sector in public policies on climate change, and to inform climate policy with the best available science. These chambers should be informed periodically about the status of the plan's implementation and, thus, provide recommendations and evaluations by entities representing these segments, with a view to improving, drawing up and implementing sectoral, thematic and cross-cutting instruments and policies on climate change adaptation strategies.

Social participation makes it possible for government bodies to better understand the needs of the population. In addition, it allows the representation of vulnerable populations to have their voices heard and contributes to public awareness and understanding about climate change, its causes, consequences and approaches to risk reduction.

The implementation of the Sectoral and Thematic Adaptation Plans may be complemented by new or existing social participation forums. These forums allow for social debate and the promotion of transparency in the implementation of sectoral climate change adaptation policies, the results of which will be reported by representatives of each sector or theme to the monitoring body.

As an additional forum for promoting social participation in the implementation and execution of the Climate Plan, there is the Brazilian Forum on Climate Change (FBMC, Fórum Brasileiro de Mudança do Clima). The FBMC aims to raise awareness and mobilize society, as well as contributing to the discussion of the actions needed to tackle climate change. As a member of CIM, FBMC is also responsible for creating channels and encouraging debate in various groups within society.

The Brazilian Research Network on Global Climate Change (Rede Clima, Rede Brasileira de Pesquisas sobre Mudanças Climáticas Globais), which is also a member of the CIM, is a fundamental pillar of support for the development and monitoring of public policies related to climate change. Rede Clima is responsible for carrying out research and development activities to meet national knowledge needs, including sectoral analysis through thematic sub-networks.

In addition, from a multi-level integration perspective, it is essential to recognize the instruments of social participation established by sub-national governments, such as councils, forums and state committees, which bring together relevant actors to discuss issues related to climate change. These instruments should guarantee the effective participation of the most vulnerable local communities. To this end, it is essential to provide meeting options in different forums, with accessible days and times, as well as forms of participation that are appropriate to the types of audience, so as to make it possible to include these populations in the debate.

6.4. Monitoring, evaluation and learning

The Interministerial Committee on Climate Change (CIM), established by **Decree No. 11.550, of June 05, 2023**, is a permanent forum for promoting and monitoring actions and public policies within the Federal Executive Branch relating to the National Policy on Climate Change (PNMC). The monitoring and evaluation of adaptation policies will be conducted in an integrated manner with mitigation, connecting actions with specific targets and indicators to support the monitoring of progress, the evaluation of the achievement of proposed targets, and the periodic review of the Climate Plan, which is scheduled to be updated at least every four years, as established by **CIM's Resolution No. 3, of 2023**.

As part of the monitoring and evaluation system, Brazil recognizes the importance of adaptive management, which means the provision for continuous improvement and adjustment to respond to new needs and challenges. Adaptive management will allow the country to monitor the evolution of the climate scenario, adjust its policies and ensure the effectiveness of adaptation actions.

Although they complement each other, monitoring and evaluation refer to different activities. While the former involves the systematic collection and analysis of information on the progress of a given policy, evaluation seeks to measure the results achieved, comparing them with the targets and goals that were initially set (GVses, 2016).

The monitoring of the Climate Adaptation Plan should involve the systematic collection of information that makes it possible to verify whether the National Strategy and the Sectoral and Thematic Adaptation Plans are in fact being implemented, as the evaluation seeks to measure whether and how the Climate Adaptation Plan is contributing to reducing vulnerability and strengthening the adaptive capacity of natural and human systems. It is important that this process is continuous so that the efforts and learning generated feed back into the iterative adaptation cycle.

To ensure its accuracy, the Climate Adaptation Plan should be monitored periodically for various purposes. Monitoring sectoral and thematic policies is the responsibility of the bodies responsible for developing and implementing them, verifying the progress of the actions defined in each plan, for the following purposes:

- Analyzing the indicators of sectoral and thematic actions;
- Identifying obstacles to the implementation of sectoral and thematic actions and proposing solutions to overcome them;
- Adjusting the activities to ensure alignment with the goals of the sectoral or thematic plan, if necessary; and
- Recording the progress of the implementation of the Sectoral and Thematic Plan in the defined channels and formats.

Within the CIM, the monitoring body must be made up of the bodies responsible for developing and implementing the policy. This body should analyze the progress made in achieving the sectoral and thematic targets, with a view to:

- Analyzing the indicators linked to the sectoral or thematic targets and the planned and actual deliveries;
- Checking the effectiveness of sectoral or thematic plans and making potential adjustments;
- Drawing up recommendations for strategic, tactical and operational adjustments aimed at achieving the targets; and
- Supporting the preparation of reports, consolidating the status of implementation and proposed recommendations.

Also within the purview of the CIM, an assessment should be made of the global implementation and impacts of the National Adaptation Strategy of the Climate Plan, seeking to ensure that long-term goals are pursued in a consistent and integrated manner across sectors. The purpose of this monitoring is to:

- Comprehensively review the annual indicators with a focus on the results and impacts obtained in each sector/theme and on the national strategy;
- Analyze the global impact of national and sectoral/thematic goals, discussing consistency and intersectoral synergy, as well as sectoral and thematic contributions to the national goals of the Climate Adaptation Plan;
- Plan implementation activities and adjustments to the Climate Adaptation Plan based on lessons learned and emerging needs; and
- Support the preparation of a periodic report consolidating the analyses and strategic recommendations for the implementation of the Climate Adaptation Plan.

The procedures for monitoring, analyzing, evaluating, reviewing and updating the Climate Plan will be detailed in the **Cross-cutting Strategy for Monitoring, Management, Evaluation and Transparency**.

6.5. Knowledge management and transparency

Knowledge management in the Climate Adaptation Plan is a strategic pillar to ensure the circulation, sharing and continuous improvement of information and practices related to climate adaptation. This process involves systematizing scientific data, traditional knowledge and best sectoral and thematic practices, ensuring that decisions are based on up-to-date evidence and local experience. Through collaborative tools and digital platforms, knowledge management seeks to strengthen the technical capacity of the institutions involved, promote the exchange of knowledge between different actors and regions, and support the effective implementation of adaptation actions at all levels of governance.

In addition, knowledge management aims to fill some information gaps that have already been identified, such as a broader understanding of how climate change impacts infrastructure, cities and human settlements, energy, food and water security, among other strategic themes and sectors for the country. The need for data and risk analyses, both in the present and in the future, with a focus on vulnerable populations, is another important gap for monitoring the progress of adaptation in the country and for the effectiveness of the Climate Adaptation Plan's actions. In particular, the peripheral populations living in slums and urban communities, traditional peoples and communities, indigenous peoples, black and brown populations, women, the elderly and children need to be considered.

The reports and information generated during the monitoring and evaluation of the Climate Adaptation Plan, as well as the periodic updating of its indicators, will be made available in a Climate Plan monitoring and evaluation system. This system aims to structure the monitoring of the plan and ensure society's full and transparent access to information.

The information can be viewed on management screens in the Climate Plan monitoring and evaluation system and in DataClima+.[22] Scientific evidence and evidence from other sources can be mobilized through the participation of the scientific community and Rede Clima, with the aim of supporting climate policy planning based on the best available knowledge.

In this context, for the management of data and knowledge for the development of the Climate Adaptation Plan, local mappings and databases that include indicators such as income, gender, and race will also be considered, since the impacts of climate change are felt most acutely in these dimensions, especially by vulnerable populations. The data and results will also be aligned and coordinated with international documents and reports, such as those of the UNFCCC.

[22] A Project that is underway aimed at strengthening the national transparency framework in Brazil in order to support the development of national policies and meet the requirements of the Enhanced Transparency Framework (ETF) under the Paris Agreement.

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Glossary

AdaptaBrasil – AdaptaBrasil is an interactive platform presenting climate risk indices for the present and the future, based on their dimensions – climate-related hazards, vulnerability and exposure - for different sectors and themes. AdaptaBrasil was established through Ordinance No. 3,896, of October 16, 2020, and was developed through cooperation between the National Institute for Space Research (INPE, Instituto Nacional de Pesquisas Espaciais) and the National Research and Education Network (RNP, Rede Nacional de Pesquisa e Ensino), sponsored by the Ministry of Science, Technology and Innovation (MCTI, Ministério da Ciência, Tecnologia e Inovação) and with the collaboration of several partner institutions, which play key roles in climate risk assessment and in the development and improvement of the platform (Brasil, 2024).

Adaptation to climate change – The process of adjustment of natural and human systems to the present and future climate and its effects. It includes changes in actions and measures to moderate or avoid potential harm or exploit beneficial opportunities (IPCC, 2022).

Adaptation limits – The point at which an actor's objectives (or system needs) cannot be secured from intolerable risks through adaptative actions. They can be hard or soft. Hard adaptation limit is when no adaptive actions are possible to avoid intolerable risks. Soft adaptation limit is when options may exist but are currently not available to avoid intolerable risks through adaptive action (IPCC, 2022).

Ecosystem-based adaptation (EbA) – The use of ecosystem management activities to increase the resilience and reduce the vulnerability of people and ecosystems to climate change (IPCC, 2022).

Incremental adaptation – It refers to small improvements or changes, usually in the short term (UNFCCC, 2019).

Maladaptation – Actions that may lead to increased risk of adverse climate-related outcomes in other sectors, themes, territories or populations, including increased greenhouse gas (GHG) emissions, increased vulnerability to climate change, more unequal outcomes or diminished welfare, now or in the future. Most of the time, maladaptation is an unintended consequence (based on IPCC, 2022).

Transformational adaptation – It alters the essential properties of a system (social, ecological, economic, etc.) in anticipation of climate change and its impacts, and refers to broad and deeper adaptation, with a long-term perspective. It can also extend beyond political cycles to become part of the way communities operate (UNFCCC, 2019).

Adaptive capacity – The ability of systems, institutions, people and other organisms to adjust to potential harm, take advantage of opportunities or respond to consequences (IPCC, 2022).

Adaptive management – A process of iteratively planning, implementing and modifying strategies to manage resources in the face of uncertainty and change. It involves adjusting approaches in response to observations of their effects and to changes in the system caused by the resulting feedback effects and other variables (IPCC, 2022).

Climate justice – A human-centered approach to addressing climate change, safeguarding the rights of the most vulnerable people to the climate crisis (considering factors such as social inequality, gender, race, ability, age and geographical origin) and sharing the burdens and benefits of climate change and its impacts equitably and fairly (based on IPCC, 2022 and MRFCJ, 2011).

Climate refugees – Areas relatively protected from climate change, which maintain stable environmental conditions for longer, offering support to biodiversity even when the surrounding environment becomes more hostile. (DARROW *et al.*, 2024).

Climate Resilient Development – An inclusive process that integrates climate adaptation measures and mitigation of greenhouse gas emissions with sustainable development, guided by climate justice and respect for planetary boundaries (adapted from IPCC, 2022).

Climate risk – The potential for adverse consequences (or impacts) on human or ecological systems. Climate risks result from dynamic interactions between climate-related-related hazards and the exposure and vulnerability of affected human or ecological systems (IPCC, 2022).

Co-benefit – A positive effect that a policy or measure aimed at a certain objective has on another objective, thereby increasing the total benefit to society or the environment. Co-benefits are also referred to as ancillary benefits (IPCC, 2022).

Critical infrastructures – Are facilities, services, goods and systems whose interruption or destruction, in whole or in part, would have a serious social, environmental, economic, political, international or security impact on the State and on society (see Decree No. 9.573, of 11.22.2018). This includes not only facilities and buildings (built infrastructure), but also intangible assets and systems on which essential services depend. In some jurisdictions, this covers, for example, food production and distribution systems (see, for example, the definition provided by the USA CISA, as well as Directive 2022/2557 of the European Union).

Displacement – The movement of people who have been forced or obliged to leave their homes or places of habitual residence as a result of a disaster or to avoid the impact of an immediate and foreseeable natural hazard (UNFCCC, 2011).

Ecosystem Services – Relevant benefits to society generated by ecosystems, in terms of maintaining, restoring or improving environmental conditions. According to Law No. 14,119, of January 13, 2021, which establishes the National Policy for Payment for Environmental Services, they can be classified into the following modalities: provisioning, supporting, regulating and cultural services.

Environmental racism – The disproportionate environmental and climate impacts on the black population, traditional peoples and communities and indigenous peoples, increasing their historical, social, environmental, economic and political vulnerability.

Exposure – The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC, 2022).

Food deserts – Geographical areas in which the availability and affordability of healthy food are limited (Ares *et al.*, 2024).

Global Goal on Adaptation (GGA) – A key commitment set out in Article 7 of the Paris Agreement, which aims to increase resilience, strengthen adaptive capacities and reduce vulnerability to climate change, contributing to sustainable development and ensuring an adequate global response to climate impacts. It focuses on seven themes (water, agriculture, health, ecosystems, infrastructure, human settlements, cultural heritage) and four dimensions of the iterative adaptation cycle (impacts/risk, planning, implementation and monitoring) (UNFCCC, 2023).

Hazard (climate-related) – The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage to and loss of property, infrastructure, livelihoods, service provision, ecosystems and environmental resources (IPCC, 2022).

Heat islands – Considered to be one of the basic attributes of the urban climate (Monteiro, 1990), characterized as a thermal anomaly, which has horizontal (extension), vertical and temporal dimensions, this effect is closely related to the size of the city, the number of buildings, land use, the climate and the meteorological conditions of that given place (Oke, 1982). Thus, a heat island is a "phenomenon that associates the conditioning factors derived from anthropogenic actions on the urban environment, in terms of land use and the conditioning factors of the physical environment and its geoecological attributes" (Lombardo, 1985).

Heat waves – A period of abnormally hot weather, often defined with reference to a relative temperature threshold, lasting from two days to several months (IPCC, 2022).

Impacts – The consequences of climate change on natural and human systems. Impacts generally refer to adverse effects on lives, livelihoods, health and wellbeing, ecosystems and species, economic, social and cultural assets, services (including ecosystem services) and infrastructure. The corresponding impacts can be direct or indirect (IPCC, 2022).

Internally displaced persons – Internally displaced persons are those persons or groups of persons who have been forced or obliged to flee their home or habitual place of residence, in particular as a result of or in order to avoid the effects of disasters, and who have not crossed an internationally recognized border (UN, 1998).

IPCC – The Intergovernmental Panel on Climate Change is a scientific-political organization of the United Nations (UN) whose main objective is to summarize and disseminate knowledge about climate change.

Livelihoods – The resources used and the activities carried out to guarantee people's livelihoods. Livelihoods are generally determined by the rights and assets to which people have access. These assets can be classified as human, social, natural, physical or financial.

Losses and Damages – Refer to the negative effects of climate change, which occur despite mitigation and adaptation efforts. These impacts can include loss of life, assets, crops, infrastructure, biodiversity, cultural heritage, livelihoods and health (IPCC, 2022; Mechler *et al.*, 2020).

Low-regret or no-regret measures – Measures that bring benefits regardless of future climate conditions. These measures are designed to be effective under a wide range of possible climate scenarios, helping to reduce the negative impacts of climate change, even in the face of an uncertain future climate.

Mesoscale Convective Systems – Complex clusters of organized storms, with typical horizontal scales of 100 to 1,000 km, which produce intense rainfall and strong winds, often associated with extreme weather events, especially in southern Brazil (CAVALCANTI *et al.*, 2009). They can last several hours and develop in different regions of the world, significantly influencing the local and regional climate (HOUZE, 2004).

Migration (in the context of climate change) – The movement of a person or groups of persons who, predominantly for reasons of sudden or progressive change in the environment due to climate change, are obliged to leave their habitual place of residence, or choose to do so, temporarily or permanently, within a State or across an international border (UNFCCC, 2011).

Mitigation (of climate change) – Human intervention to reduce emissions and concentrations of greenhouse gases in the atmosphere, thereby reducing global warming (IPCC, 2022).

Nature-based solutions (NBS) – Actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits (IPCC, 2022).

Other Effective Area-based Conservation Measure (OECM) – A geographically defined area other than a Protected Area, which is governed and managed in ways that achieve positive and sustained long-term outcomes for the in situ conservation of biodiversity, with associated ecosystem functions and services and where applicable, cultural, spiritual, socio-economic, and other locally relevant values (CDB, 2018).

Planned relocation – A process in which people or groups of people move, voluntarily, and are assisted to move from their homes or temporary places of residence and settle in a new location, in a planned way, where they are offered the necessary conditions to rebuild their lives, including infrastructure, public services, housing and livelihood. It should be a last resort solution, with government support, in a participatory manner and implemented before the disaster or event that is still unfolding occurs, respecting the culture and rights of the relocated communities. It occurs in the context of disaster risk or environmental degradation, including when due to the effects of climate change (UNFCCC, 2011).

Rede Clima – The Brazilian Research Network on Global Climate Change (Rede Clima) is an institutional instrument of the National Policy on Climate Change provided for in Law No. 12.187, of December 29, 2009, linked to the Ministry of Science, Technology and Innovation (MCTI). Its purpose is to boost the generation of knowledge and scientific and technological progress in the area of climate change, resulting from the exchange of information and the integration of skills of experts, researchers, research groups and scientific, technological and innovation institutions that have recognized competence in the areas of knowledge relevant to the theme.

Right to the city – The right to urban land, housing, environmental sanitation, urban infrastructure, transportation and public services, work and leisure, for present and future generations. The right to the city is a diffuse and collective right, indivisible in nature, held by all the city's inhabitants, from present and future generations. The right to inhabit, use and participate in the creation of fair, inclusive, democratic and sustainable cities (Costa, Thadeu, Favarão, 2012).

Sensitivity – Degree to which a system or species is adversely or beneficially affected by climate change or variability (IPCC, 2022).

Slums and urban communities – Popular territories originating from the various strategies used by the population to meet, generally independently and collectively, their housing needs and associated uses (businesses, services, leisure, culture, among others), in the face of insufficient and inadequate public policies and private investments aimed at guaranteeing the right to the city (IBGE – Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística, 2024).

Social inequality – It occurs when there are significant differences between groups in society. The differences can cover aspects such as race/ethnicity, gender, sexuality, income, age, disability and schooling. In general, these differences mean that certain groups are more or less privileged depending on their cultural, social and economic characteristics (Brasil, 2021).

Socio-spatial inequality – It occurs when social inequalities are also evident in the territory. Groups with fewer privileges due to social inequality usually occupy lower quality spaces such as: (1) risk areas; or (2) areas where the State or the market does not yet offer essential services to have a dignified life. Examples of essential services: public transport, health center, school, water and sanitation, electricity, connectivity network, public square, neighborhood shops, cultural facilities, Social Welfare Reference Center (CRAS, Centro de Referência de Assistência Social), Specialized Social Welfare Reference Center (CREAS, Centro de Referência Especializado de Assistência Social), etc. Socio-spatial inequality occurs in many ways and at many levels in the territory: (a) within neighborhoods (e.g. risk areas); (b) between neighborhoods and regions within a city (e.g., peripheral neighborhoods and peripheral regions); and (c) between cities (e.g., commuter towns) (Brazilian Charter for Smart Cities) (Brasil, 2021).

Sustainable Urban Development – The process of urban occupation aimed at the common good and the reduction of inequalities, which balances social needs, fosters culture, values and strengthens identities, uses natural, technological, urban and financial resources responsibly, and promotes local economic development, boosting the creation of opportunities for diversity and social inclusion, productive and spatial inclusion of all people, from present and future generations, through the equitable distribution of infrastructure, public spaces, urban goods and services and the appropriate planning of land use and occupation in different contexts and territorial scales, in accordance with socio-political agreements established in democratic arenas of collaborative governance (BRASIL, 2020).

Synergies – Actions that are enhanced because they aim at the same goal, resulting in a better outcome than isolated actions (IPCC, 2022).

Trade-offs – A situation that arises when a policy or measure aimed at one objective reduces the results of other objective(s) due to adverse side effects, thus potentially reducing the net benefit to society or the environment (IPCC, 2022).

Traditional Peoples and Communities – culturally differentiated groups who recognize themselves as such, who have their own forms of social organization, who occupy and use territories and natural resources as a condition for their cultural, social, religious, ancestral and economic reproduction, using knowledge, innovations and practices generated and transmitted through tradition (Brasil, 2007).

UNFCCC Adaptation Committee – A technical body of the United Nations Framework Convention on Climate Change (UNFCCC) with the aim of promoting more effective and coordinated climate adaptation action, especially in developing countries. It was established under the Cancun Adaptation Framework (2010).

Uncertainty – A state of incomplete knowledge that can result from a lack of information sources, imprecision in data or ambiguity of concepts or terminology, or uncertain projections of human behavior. Uncertainty can be represented by quantitative measures or by qualitative statements (for example, reflecting the judgment of a team of experts) (IPCC, 2022).

Urban climate – Climate resulting from the interference of all the factors that take place on the urban boundary layer and that act to alter the climate on an urban and local scale. Its most direct effects are perceived by the population through manifestations linked to thermal comfort, air quality, rainfall impacts and other manifestations capable of disrupting city life and deteriorating the quality of life of its inhabitants (Monteiro, 1975).

Vulnerability – The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (or adaptive capacity) (IPCC, 2022).

Appendices

APPENDIX A – Method for the analysis of observed and future changes in Brazil

This analysis was based on the method of Mastrandrea *et al.* (2011), which is used to deal with uncertainties in IPCC reports. The level of uncertainty, or confidence, of the key messages is based on the level of agreement between the conclusions of various data sources and references, as well as the degree of evidence associated with each one of them.

Sixteen sources of data and references were considered, including analyses by the National Institute for Space Research (INPE), information from the National Institute of Meteorology (INMET, Instituto Nacional de Meteorologia) website, the IPCC's sixth report, the IPCC's climate atlas and peer-reviewed scientific articles published in relevant journals (Tables 4 and 5). In this approach, each source is given a score, +1 being for an increase conclusion and -1 for a decrease conclusion. If the source indicates some uncertainty (e.g., low agreement between models), the conclusion value is equal to +0.5 or -0.5, for increase and decrease respectively. If more than half of the sources agree with an increase (or decrease), then there is a lot of evidence, i.e., a sign of change equal to ▲ (or ▼ for a decrease). Otherwise, the result is equal to some evidence, i.e., a sign of change equal to ▲(or ▼ for a decrease). If at least one source concludes a change with a sign that is the opposite of the sign of the other sources, or all sources show no change (sign = 0), then, the sign of change is undefined, i.e., —.

In addition, the plausibility of a given future scenario was estimated, i.e., the level of confidence. If both the observed and future time periods agree on the sign of change and show *a lot of evidence*, then the future scenario is ***plausible*** (high confidence), otherwise the future scenario is ***possible*** (medium confidence). If there is disagreement on the sign of change between the time periods, then the future scenario is ***uncertain***. This confidence analysis of key messages helps prioritize risks associated with climate-related hazards with ***plausible*** or ***possible*** futures, and define adaptation actions (e.g., prioritizing no-regret actions for risks associated with ***possible*** or ***uncertain*** futures).

Table 4 – List of climate-related hazards considered by each data source and reference

Climate-related hazards	Data sources and references															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Average temperature	■			■	■	■		■								
Maximum temperature	■	■		■	■		■	■	■					■		
Minimum temperature	■	■		■	■			■						■		
Heat waves[a]	■	■	■	■	■		■	■	■					■		
Annual rainfall	■	■	■	■	■	■	■	■						■	■	
Extreme rainfall[b]	■	■	■	■	■			■	■					■		
Extreme persistent rainfall [c]	■		■	■	■		■	■	■					■		
Frequency of drought [d]				■	■			■							■	
Duration of drought [e]	■		■	■	■		■	■						■		
Severe wind [f]		■		■	■			■				■	■			
Mean sea level				■				■		■						■
Sea surface temperature				■				■		■	■					
Marine heatwaves				■				■			■					
Ocean acidification				■				■								

[a] warm spell duration index (WSDI); percentage of days in the year when the maximum temperature is greater than the 90th percentile (TX90);

[b] maximum annual precipitation for 1 day (Rx1day);

[c] maximum consecutive precipitation over a 5-day period in the year (Rx5day);

[d] standardized precipitation index (SPI);

[e] maximum duration of the dry period in the year (CDD);

[f] maximum annual extreme wind; surface wind; percentage of days in the year when surface wind is greater than the 90th percentile; 50-year return period.

Source: Own elaboration.

Table 5 – Description of the data sources and references used

No.	Reference
1	AVILA-DIAZ, A. *et al. Assessing current and future trends of climate extremes across Brazil based on reanalyses and earth system model projections*. Climate Dynamics, v. 55, n. 5–6, p. 1403–1426, set. 2020.
2	BALLARIN, A. S. *et al. CLIMBra - Climate Change Dataset for Brazil*. Scientific Data, v. 10, n. 1, p. 47, 20 jan. 2023.
3	DUNN, R. J. H. *et al. Development of an Updated Global Land In Situ-Based Data Set of Temperature and Precipitation Extremes: HadEX3*. Journal of Geophysical Research: Atmospheres, v. 125, n. 16, p. e2019JD032263, 27 ago. 2020.
4	GUTIÉRREZ, J. M. *et al. IPCC WGI Interactive Atlas: Regional information (Advanced)*. Dataset: CMIP6. Available at: **http://interactive-atlas.ipcc.ch/**. Accessed on: Apr. 01, 2024.
5	GUTIÉRREZ, J. M. *et al. IPCC WGI Interactive Atlas: Regional information (Advanced).* Dataset: CORDEX South America. Available at: **http://interactive-atlas.ipcc.ch/**. Accessed on: Apr. 01, 2024.
6	INMET. *Normais climatológicas do Brasil: Variações Climática*s. Available at: **https://clima.inmet.gov.br/VariacoesClimaticas/1961-1990/diferenca_precipitacao**. Accessed on: Apr. 01, 2024.
7	INPE. *Análise de mudanças observadas para o período de 1961 a 2020. Contribuição para a estratégia geral do Plano Clima Adaptação*. 2023. Available at: **https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/noticias/2023/11/numeros-de-dias-com-ondas-de-calor-passaram-de-7-para-52-em-30-anos**. Accessed on: Apr. 01, 2024.
8	IPCC. *Climate Change 2021 – The Physical Science Basis: Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. 1. ed. [s.l.] Cambridge University Press, 2023.
9	LI, C. *et al. Changes in Annual Extremes of Daily Temperature and Precipitation in CMIP6 Models*. Journal of Climate, v. 34, n. 9, p. 3441–3460, maio 2021.
10	NASA/JPL. NASA Sea Level Portal. *Data Analysis Tool 2.0.* Available at: **https://sealevel.nasa.gov/data-analysis-tool/**. Accessed on: Apr. 04, 2024.
11	OLIVER, E. C. J. *et al. Longer and more frequent marine heatwaves over the past century*. Nature Communications, v. 9, n. 1, p. 1324, 10 abr. 2018.
12	PES, M. P. *et al. Climate trends on the extreme winds in Brazil*. Renewable Energy, v. 109, p. 110–120, ago. 2017.
13	PIRES, A. V. *et al. Updated Design Wind Map for Brazil and Impacts on the Reliability of Built Structures*. ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering, v. 7, n. 4, p. 04021058, dez. 2021.
14	REGOTO, P. *et al. Observed changes in air temperature and precipitation extremes over Brazil*. International Journal of Climatology, v. 41, n. 11, p. 5125–5142, set. 2021.
15	TOMASELLA, J. *et al. Assessment of trends, variability and impacts of droughts across Brazil over the period 1980–2019*. Natural Hazards, 16 dez. 2022.
16	VOUSDOUKAS, M. I. *et al. Global probabilistic projections of extreme sea levels show intensification of coastal flood hazard*. Nature Communications, v. 9, n. 1, p. 2360, 18 jun. 2018.

Source: Own elaboration.

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