

FIFTH NATIONAL COMMUNICATION AND SECOND BIENNIAL TRANSPARENCY REPORT

OF BRAZIL TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE



MINISTRY OF SCIENCE, TECHNOLOGY AND INNOVATION

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OF BRAZIL TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

Brazil 2026

FEDERATIVE REPUBLIC OF BRAZIL

PRESIDENT OF THE FEDERATIVE REPUBLIC OF BRAZIL

Luiz Inácio Lula da Silva

MINISTER OF STATE OF SCIENCE, TECHNOLOGY AND INNOVATION

Luciana Barbosa de Oliveira Santos

EXECUTIVE SECRETARY

Luis Manuel Rebelo Fernandes

SECRETARY OF STRATEGIC POLICIES AND PROGRAMS

Andrea Brito Latgé

DIRECTOR OF THE DEPARTMENT FOR CLIMATE AND SUSTAINABILITY

Osvaldo Luiz Leal de Moraes

GENERAL COORDINATOR OF CLIMATE SCIENCE

Márcio Rojas da Cruz

CONTRIBUTION OF THE FOLLOWING REPRESENTATIVES OF THE INTERMINISTERIAL COMMITTEE ON CLIMATE CHANGE (CIM, Comitê Interministerial sobre Mudança do Clima):

Office of the President's Chief of Staff; Attorney General's Office; Ministry of Agriculture and Livestock; Ministry of Cities; Ministry of Agrarian Development and Family Farming; Ministry of Development and Social Assistance, Family and Fight against Hunger; Ministry of Development, Industry, Trade and Services; Ministry of Education; Ministry of Finance; Ministry of Racial Equality; Ministry of Integration and Regional Development; Ministry of the Environment and Climate Change; Ministry of Mines and Energy; Ministry of Women; Ministry of Planning and Budget; Ministry of Indigenous Peoples; Ministry of Foreign Affairs; Ministry of Health; Ministry of Labor and Employment; Ministry of Transport; and the General Secretariat of the Presidency of the Republic and the Secretariat of Institutional Relations of the Presidency of the Republic.

PREPARATION, TECHNICAL REVIEW AND GENERAL EDITING OF THE REPORT

Team of the General Coordination of Climate Science of the Ministry of Science, Technology and Innovation

Márcio Rojas da Cruz
Ricardo Vieira Araujo
Sávio Túlio Oselieri Raeder
Antônio Marcos Mendonça
Andréa Nascimento de Araújo
Leonardo Salema
Marcelo da Silva Castro
Pablo Rafael Lopes de Medeiros
Sonia Regina M. de Bittencourt
Vitor Vasconcelos

Team of the Ciência&Clima Project (BRA/23/G31 - Fifth National Communication, Biennial Update Report and Biennial Transparency Reports to the United Nations Framework Convention on Climate Change)

Bruna Ribeiro
Danielly Godiva Santana Molleta
Eliana Furlaneto de Macedo
George Vasconcelos Goes
Iris Roitman
Juliana Leroy Davis
Jussara Peccini
Mariana Gutierres Arteiro da Paz
Natalia Torres D'Alessandro
Nayana Machado
Raphael Camargo
Régis Rathmann
Renata Patricia Soares Grisoli
Tamar Bakman

Graphic project: REC Design
Design: CT Comunicação

AUTHORS AND CONTRIBUTORS BY CHAPTER

CHAPTER 1.
NATIONAL CONTEXT

Authors:

Eduardo Canina

Jussara Peccini (UNDP)

Mariana Gutierres Arteiro da Paz (UNDP)

Natalia Torres D'Alessandro (UNDP)

Renata Patricia Soares Grisoli (UNDP)

Contributors:

Marcelo da Silva Castro (MCTI – Ministry of Science, Technology and Innovation)

Márcio Rojas da Cruz (MCTI)

Ricardo Vieira Araujo (MCTI)

CHAPTER 2.
NATIONAL INVENTORY OF ANTHROPOGENIC EMISSIONS BY SOURCES AND REMOVALS BY SINKS OF GREENHOUSE GASES

The list of authors and contributors is included in the National Inventory Report (NIR 2026).

CHAPTER 3.
INFORMATION NECESSARY TO TRACK PROGRESS IN IMPLEMENTING AND ACHIEVING NATIONALLY DETERMINED CONTRIBUTIONS

Authors:

Eduardo Canina

Renata Patricia Soares Grisoli (UNDP)

Ricardo Vieira Araujo (MCTI)

Contributors:

Alberto da Rocha Neto (MMA – Ministry of the Environment and Climate Change)

Anamaria de Aragão C. Martins (Ministry of Cities)

Bárbara Bressan Rocha (MME – Ministry of Mines and Energy)

Bruno Carvalho Arruda (MRE – Ministry of Foreign Affairs)

Camila Marques Viana da Silva (MDA - Ministry of Agrarian Development and Family Farming)

Cibele Dutra de França (Ministry of Cities)

Cloves Eduardo Benevides (MT - Ministry of Transport)

Demetrio Florentino de Toledo Filho (MDIC - Ministry of Development, Industry, Trade, and Services)

Fani Mamede (MT)

George Yun (MT)

Laura Esmeraldo Arraes de Lavor (Ministry of Cities)

Leandro Gomes Cardoso (MMA)

Leonardo Feldman de Mattos (MRE)

Lidiane Rocha de Oliveira Melo (MMA)

Maria Rosa Tesser Rodrigues de Lima (Ministry of Cities)

Poliana Marcolino Corrêa (MME)

Rafael Martins Dias (Office of the President's Chief of Staff)

Rafaela C. G. Gomes Siqueira Moreira (MME)

Ronaldo Carneiro Teixeira (MAPA – Ministry of Agriculture and Livestock)

Sílvia Helena de Souza Ferrari (MMA)

Thiago Olante Casagrande (MT)

Vívian Maria de Faria Nasser Vilela (MMA)

CHAPTER 4.
INFORMATION RELATED TO THE IMPACTS OF CLIMATE CHANGE AND ADAPTATION

Authors:

Beatriz Fátima Alves de Oliveira (Fiocruz - Oswaldo Cruz Foundation)

Eliseu Afonso (INPE – National Institute for Space Research)

Fábio T. F. da Silva (COPPE - Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering/UFRJ - Federal University of Rio de Janeiro)

Gilvan Sampaio (INPE/ AdaptaBrasil MCTI)

Glícia Garcia (INPE)

Gustavo Felipe Balué Arcoverde (INPE/AdaptaBrasil MCTI)

Ismael Henrique da Silveira (ISC/ UFBA - Institute of Collective Health of the Federal University of Bahia)

Julliana Larise (Itaipu Parquetec)

Leonardo Salema (MCTI)

Marcos Sanches (WRI)

Mariana Gutierres Arteiro da Paz (UNDP)

Marilia Harumi Shimizu (INPE/ AdaptaBrasil MCTI)

Matheus Bonifácio Pamplona

Moacir Schmengler (Itaipu Parquetec)

Natalia Torres D'Alessandro (UNDP)

Patrícia Pinho

Renata Patricia Soares Grisoli (UNDP)

Rosaria Rodrigues Ferreira

Sávio Túlio Oselieri Raeder (MCTI)

Talita Cruz (COPPE/UFRJ)

Contributors:

Adalberto Luis Val (INPA – National Institute for Amazonian Research)

Alberto Santos (COPPE/UFRJ)

Alexandre Ferreira (GIZ)

Alexandre Szklo (COPPE/UFRJ)

Alisson Flávio Barbieri (Cedeplar – Center for Development and Regional Planning/UFMG - Federal University of Minas Gerais)

Ana Carolina Oliveira Fiorini (COPPE/UFRJ)

Anamaria de Aragão C. Martins (Ministry of Cities)

André Frossard Pereira de Lucena (COPPE/UFRJ)

Artur Malecha Teixeira (IIS - International Institute for Sustainability/UFRJ)

Beatriz Nunes Garcia (COPPE/UFRJ)

Bianca Hammerschmidt (MPI - Ministry of Indigenous Peoples)

Bibiana Waquil Campana (UNHCR - United Nations High Commissioner for Refugees)

Carolina Burle Schmidt Dubeux (COPPE/UFRJ)

Carolina Di Lello Jordão Silva (IPHAN - National Institute of Historical and Artistic Heritage)

Cassia Maria Gama Lemos (INPE/AdaptaBrasil MCTI)

Daniel Andres Rodriguez (UFRJ)

Débora de Pina Castiglione (IOM - International Organization for Migration)

Eduardo Müller-Casseres (COPPE/UFRJ)

Fabio A. Diuana (COPPE/UFRJ)

Felipe Husadel Poyer (INPE)

Francieli Lisboa de Almeida (MPI)

Francinelli de Angeli Francisco (INPE/AdaptaBrasil MCTI)

Gabriela do Couto e Silva Fichtner (COPPE/UFRJ)

Gerd Angelkorte (COPPE/UFRJ)

Gustavo Cretton-Souza (COPPE/UFRJ)

Iorrana Lisboa Camboim (MDA)

Izabela Penha de Oliveira Santos (USP - University of São Paulo)

Jacqueline Rogéria Bringhenti (IFES - Federal Institute of Education, Science, and Technology of Espírito Santo)

Janaína de Holanda Camilo (Ministry of Cities)

Javier Tomasella (INPE)

Jean Pierre Henry Balbaud Ometto (INPE)

Joana Portugal-Pereira (COPPE/UFRJ)

Júlia Alves Menezes (INPE)

Jussara Peccini (UNDP)

Laura Bahiense (COPPE/UFRJ)

Letícia Rodrigues (COPPE/UFRJ)

Luiz Bernardo Baptista (COPPE/UFRJ)

Luiza Bezerra Ribeiro (Rede Clima)

Maiara Batista Dourado (MIR - Ministry of Racial Equality)

Márcia Muchagata (SESAN - National Department of Food and Nutritional Security/MDS - Ministry of Development and Social Assistance, Family and Fight against Hunger)

Marcos del Fabbro (SESAN/MDS)

Maria Carolina Chalegre (DOceano - Department of Ocean and Coastal Management/ SMC - National Department of Climate Change/MMA)

Maria Elisa Costa (Ministry of Cities)

Mariana Império (COPPE/UFRJ)

Mariana Marques Wolf (INPE/ AdaptaBrasil MCTI)

Marina Valverde Briant (GIZ)

Otávio Grassi Gonçalves (COPPE/UFRJ)

Paulo Horta (UFSC - Federal University of Santa Catarina)

Raquel Furtado (Ministry of Cities)

Régis Rathmann (UNDP)

Ricardo Medeiros Coelho de Souza (IPHAN)

Roberto Schaeffer (COPPE/UFRJ)

Saulo Rodrigues Pereira Filho (UnB - University of Brasília)

Taísa Nogueira Morais (COPPE/UFRJ)

Tamar Bakman (UNDP)

Tamara Zambiasi (RNP - National Education and Research Network/USP)

Thales Vaz Penha (INPE/ AdaptaBrasil MCTI)

Vanessa de Souza Hacon (MS - Ministry of Health)

Wanda Maria Risso Günther (USP)

CHAPTER 5.

INFORMATION ON FINANCIAL, TECHNOLOGY DEVELOPMENT AND TRANSFER AND CAPACITY-BUILDING SUPPORT NEEDED AND RECEIVED

Authors:

Danielly Godiva Santana Molleta (UNDP)

Eduardo Canina

Sonia Regina Mudrovitsch de Bittencourt (MCTI)

Contributors:

Alda Alves da Silva (ABC - Brazilian Cooperation Agency)

Alessandra Ambrosio (ABC)

Alessandra Jacobovski (Ministry of Women)

Carolina Grottera (MF - Ministry of Finance)

Daniela Ramos Guimarães de Faria (MF)

Eron Costa (ABC)

Flavio Daniel Baran (MF)

Josue Neto (ABC)

Livia Farias Ferreira de Oliveira (MF)

Luana Magalhães Duarte de Araujo (MF)

Marguerite Marque (ABC)

Moema Vieira Gomes Corrêa (MMA)

Pablo Rafael Lopes de Medeiros (MCTI)

Régis Rathmann (UNDP)

Renata Patricia Soares Grisoli (UNDP)

Ricardo Vieira Araujo (MCTI)

Ronaldo Carneiro Teixeira (MAPA)

Vinicius Barbosa Salles de Azeredo (MF)

CHAPTER 7.

ADDITIONAL INFORMATION

SUBCHAPTER 7.1.

RESEARCH AND SYSTEMATIC OBSERVATION

Authors:

Giovana Mira de Espindola

Renata Patricia Soares Grisoli (UNDP)

Contributors:

Andrea Cancela da Cruz (MCTI)

Andréa Nascimento de Araujo (MCTI)

Antônio Marcos Mendonça (MCTI)

Gilvan Sampaio (INPE)

Jussara Peccini (UNDP)

Márcio Rojas da Cruz (MCTI)

Pablo Rafael Lopes de Medeiros (MCTI)

SUBCHAPTER 7.2.

EDUCATION, TRAINING, AND PUBLIC AWARENESS REGARDING CLIMATE CHANGE

Authors:

Jussara Peccini (UNDP)

Renata Patricia Soares Grisoli (UNDP).

Contributors:

Andréa Nascimento de Araujo (MCTI)

Maíra Correia Cavalcanti Dantas (MMA)

Moema Vieira Gomes Corrêa (MMA)



MINISTRY OF SCIENCE, TECHNOLOGY AND INNOVATION

ESPLANADA DOS MINISTÉRIOS, BLOCO E
WEBSITE: https://www.gov.br/mcti
CEP: 70.067-900 – Brasília – DF

B823f Brazil. Ministry of Science, Technology and Innovation.

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Foreword

Transparency is one of the pillars of climate action and is a fundamental tool for tracking results, identifying challenges, and guiding decisions based on scientific evidence. In this context, by submitting its Fifth National Communication and Second Biennial Transparency Report to the United Nations Framework Convention on Climate Change, Brazil reaffirms its commitment to producing and disseminating consistent information on the national climate agenda.

This publication marks a new stage in Brazil's history of international reporting. By submitting its First Biennial Transparency Report in 2024, within the internationally established deadline, the country began its participation in the Enhanced Transparency Framework of the Paris Agreement. The report underwent a technical expert review by international experts in 2025 and was submitted to the Facilitative, Multilateral Consideration of Progress in 2026. With the completion of the first transparency cycle, Brazil gained valuable experience and learned important lessons to improve national climate monitoring and reporting processes.

This year, Brazil submits its Fifth National Communication and Second Biennial Transparency Report together, in a single document, for the first time. This approach demonstrates the integration of the reporting commitments undertaken under the UNFCCC and its Paris Agreement. The publication reflects Brazil's institutional trajectory, built over approximately three decades of preparing different types of transparency reports, during which the country has developed technical and scientific capacities, improved methodologies, and strengthened coordination among public institutions, research centers, and experts from different fields of knowledge.

This document presents updated information on greenhouse gas emissions and removals, progress in implementing and achieving the targets of the Nationally Determined Contribution (NDC), the impacts of climate change and adaptation initiatives, as well as needs and support received in capacity-building, finance, and technology development and transfer. It also includes information on research, systematic climate observation, education, and public awareness, providing a comprehensive overview of the actions undertaken by the country to address climate change.

It is important to note that the preparation of this document involved collaboration among various Federal Government agencies, research institutions, universities, and experts from different fields, under the coordination of the Ministry of Science, Technology and Innovation. This work, carried out under the Ciência&Clima[1] (Science&Climate) international technical cooperation project, is financed with resources from the Global Environment Facility and implemented with support from the United Nations Development Programme.

Finally, by bringing together scientific knowledge, official information, and the results of public policies, Brazil reaffirms the importance of science, technology, and innovation in developing responses to the challenges posed by climate change. The information compiled in this publication contributes to tracking the climate commitments undertaken by the country and provides inputs for planning and improving national public policies.

Luciana Santos

Minister of State for Science, Technology and Innovation

1 BRA/23/G31 – Fifth National Communication, Biennial Update Report, and Biennial Transparency Reports to the United Nations Framework Convention on Climate Change (UNFCCC).

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CHAPTER 1

National context



1.1 Characterization of Brazil's territory

The Federative Republic of Brazil is located in South America and occupies nearly half of the continent's territory, between the parallels 5°16'20" north latitude and 33°45'03" south latitude, and the meridians 34°47'30" and 73°59'32" west (Brasil, 2016b). It ranks fifth among the world's largest countries by land area, after the Russian Federation, Canada, the People's Republic of China, and the United States of America. It is bounded by the Atlantic Ocean along approximately 10,900 km of its eastern coastline and shares more than 16,900 km of land borders with all South American countries, except the Republic of Chile and the Republic of Ecuador. Specifically, it borders the Oriental Republic of Uruguay to the south; the Argentine Republic, the Republic of Paraguay, and the Plurinational State of Bolivia to the southwest; the Republic of Peru to the west; the Republic of Colombia to the northwest; and the Bolivarian Republic of Venezuela, the Co-operative Republic of Guyana, the Republic of Suriname, and French Guiana to the north (IBGE, 2021, 2024a; Brasil, 2016b). It encompasses a wide range of tropical and subtropical landscapes, including wetlands, savannas, and plateaus, besides containing most of the Amazon River basin, which has the world's largest river system and the world's most extensive rainforest (IBGE, 2024a). Dataframe 1.1 summarizes Brazil's territorial, demographic, environmental, and energy characteristics.

Dataframe 1.1 Relevant information about Brazil

Parameter	Characteristics
Territory	A total area of 8.509 million km², divided into five political-administrative regions (North, Northeast, Central-West, South, and Southeast) and comprising 26 states and the Federal District (IBGE, 2026e).
Population	213,421,037 inhabitants in 2025 (IBGE, 2025a)
Climate	Wide climatic diversity, with predominantly equatorial conditions in the Amazon, tropical conditions across much of the territory, and temperate conditions in the South Region (IBGE, 2002).
Biodiversity	Six biomes[1]: Amazon (49.5% of the national territory), Cerrado (23.3%), Atlantic Forest (13%), Caatinga (10.1%), Pampa (2.3%), and Pantanal (1.8%) (IBGE, 2019a).
Protected areas	Terrestrial conservation units account for approximately 19% of the continental area, while marine conservation units cover around 27% of the marine ecosystem. In total, there are 3,421 conservation units across the three levels of government (Brasil, 2026q). Indigenous Lands account for 14.6% of the national territory, comprising a total of 657 territories (FUNAI, 2026).

1 A biome is defined as a collection of life (plant and animal life) constituted by the grouping of contiguous vegetation types identifiable on a regional scale, with similar geoclimatic conditions and a shared history of changes, which results in a unique biological diversity (IBGE, 2004).

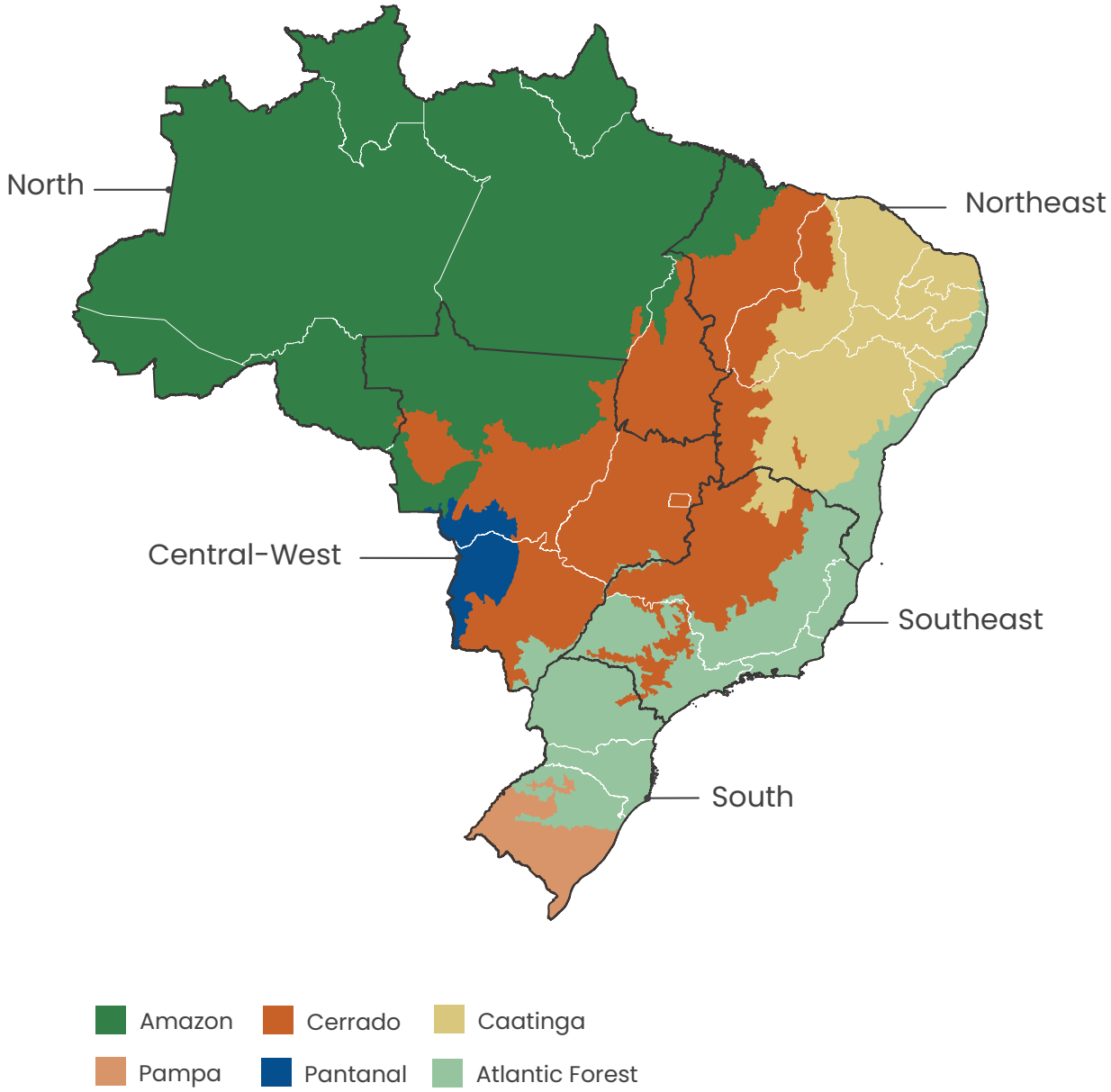
Parameter	Characteristics
Traditional Peoples and Communities[2]	Brazil is home to a wide diversity of Traditional Peoples and Communities, present across all biomes. The 2022 Demographic Census provided specific national data on Indigenous Peoples (1,694,836 people) and Quilombolas (1,330,186 people) (IBGE, 2023c).
Water resources	The country holds approximately 12% of the planet's freshwater, unevenly distributed across 12 river basins. Irrigation for agricultural production is the primary use of water in the country (ANA, 2019, 2026).
Energy matrix	In 2025, the share of renewable sources reached 86.8% in Brazil's electricity matrix and 49.5% in its energy matrix (EPE, 2026a).

Brazil is a country of continental dimensions, with a wide diversity of climate regimes, a variety of natural features (soil, relief, vegetation, and fauna), and one of the largest coastal zones in the world. These factors form a unique environmental composition responsible for the formation of six major biomes (biogeographic zones), which together encompass one of the greatest levels of biodiversity on the planet, including the Amazon Rainforest, the world's largest tropical moist forest; the Pantanal, the largest floodplain; the Cerrado, with its savannas and woodlands; the Caatinga, comprising semiarid forests; the grasslands of the Pampas; and the tropical rainforest of the Atlantic Forest (Brasil, 2026j) (Figure 1.1).

Much of Brazil's territory is covered by forests and grasslands. Tropical moist and seasonal forests are particularly common in the Amazon and in the Atlantic Forest. Savanna formations predominate in the Cerrado, although they also occur in other regions of the country, including in the Amazon. Savanna-steppe formations occur mainly in the Caatinga of northeastern Brazil, while steppe formations correspond primarily to the plateau and Campanha grasslands in the far south of Brazil, in the Pampa biome, due to the temperate climate. Campinaranas, on the other hand, can be found mainly in the Amazon, in the Rio Negro watershed. Finally, in the Pantanal, open grassland vegetation formations predominate, with their characteristics influenced by the periodic flooding regime (IBGE, 2004).

2 Although Brazil recognizes the expression "local communities and indigenous peoples" (LC&IP) in international contexts, such as UNFCCC discussions, domestically the country uses the expression "traditional peoples and communities" to refer to the groups that will be discussed in section 1.2, Population and socioeconomic characterization.

Figure 1.1 Distribution of Brazilian biomes and Brazil's political-administrative regions



Source: Adapted from IBGE (2004).

Brazil occupies almost half of South America and, as previously noted, is the country with the greatest biodiversity in the world, accounting for 10% to 15% of global species diversity (Brasil, 2020a), in addition to containing approximately 30% of the planet's tropical forests (Myers *et al.*, 2000). Currently, more than 50,000 plant species, more than 125,000 animal species (IBGE, 2023b), and more than 8,000 fungal species (IPJBRJ, 2026) are recognized in Brazil, distributed across the six terrestrial biomes and the coastal-marine system. According to the Biodiversity

Extinction Risk Assessment System (SALVE, Sistema de Avaliação do Risco de Extinção da Biodiversidade), of the 15,875 fauna species assessed, 1,268 are threatened with extinction (ICMBio, 2026). In another assessment, conducted in 2022, of the 7,517 flora species assessed, 3,207 (42.7%) are threatened with extinction, that is, classified in the "Critically Endangered," "Endangered," or "Vulnerable" categories, according to the methodological criteria established by the International Union for Conservation of Nature (IBGE, 2023b).

In addition, Brazil has an extensive coastal and marine zone, which includes ecosystems such as coral reefs, dunes, mangroves, salt marshes, lagoons, and estuaries (Brasil, 2026j). It is one of the largest coastal regions in the world and represents a particularly valuable part of Brazilian territory in terms of natural, economic, and human resources. The reefs extend from the state of Maranhão, located in the Northeast, to Santa Catarina, in the South, and are home to more than 400 fish species and approximately 20 coral species, 30% of which are found exclusively on Brazilian reefs (Bender *et al.*, 2023). Mangrove forests cover 1.23 million hectares, spread across 11,142 patches along the Brazilian coast. Approximately 82% of this total area is located within Conservation Units, such as Environmental Protection Areas (APAs, Áreas de Proteção Ambiental) and Extractive Reserves (Resex, Reservas Extrativistas), whose importance lies in protecting biodiversity and supporting the livelihoods of traditional communities. The highest concentration is found on the country's northern coast, particularly in the states of Amapá, Pará, and Maranhão, which together account for approximately 78% of the country's mangrove forest cover (Brasil, 2026k).

The main sources of water in Brazil are rainfall and river flows from other countries, which are concentrated in the Amazon biome. Vegetation cover plays an extremely important role in water retention across various ecosystems. The country holds approximately 12% of the Earth's surface freshwater, unevenly distributed across its territory in twelve river basins. The basins are used for various purposes, such as irrigation, human and animal water supply, industrial use, energy generation, mining, aquaculture, navigation, tourism and leisure (ANA, 2019).

Although Brazil is widely recognized for its water availability, there are significant differences among its regions. The Amazon Hydrographic Region accounts for approximately 80% of this resource and for less than 7% of water demand. On the other hand, the São Francisco Region, which begins in the Southeast and extends through the Northeast, accounts for 17% of water demand and 1.3% of water availability (ANA, 2025).

In contrast, the semiarid region of northeastern Brazil, where the Caatinga biome is located, faces water scarcity, accounting for 30% of the population, but having access to only 4% of water resources. In this region, the intermittent nature of rivers, which dry up during the dry season, makes the use of reservoirs essential to ensure continuous water supply (Souza Filho *et al.*, 2018). Some of these areas are classified as having high water risk, with annual rainfall below 500 mm and prolonged droughts, a predominance of crystalline rocks and intermittent rivers, and extensive use of reservoirs to ensure water availability (Brasil, 2021).

The Cerrado, a biome that spans several states in the central region of the country and occupies 23.3% of the national territory (IBGE, 2019a), plays a strategic role in water security, as it is home to the headwaters of the three largest river basins in South America (Amazon/Tocantins, São Francisco, and La Plata) and the Guarani, Bambuí, and Urucuia aquifers, making it essential for water storage and biodiversity protection (Brasil, 2021). The biome is also recognized as one of the world's 34 biodiversity hotspots (IUCN, 2025) and is of great importance to Brazil's agricultural production.

Finally, the Southeast Region, which is predominantly home to the Atlantic Forest and Cerrado biomes, and accounts for 60% of Gross Domestic Product (GDP) and 40% of the population, has only 6% of water availability. To meet growing demands, primarily for hydroelectric power generation and urban and industrial water supply, large reservoirs are used. In addition to these characteristics, anthropogenic pressures have a significant impact on water quality in the region (Souza Filho *et al.*, 2018).

Differences in water distribution reflect Brazil's wide climatic diversity, associated with its territorial extent, geographical location, and variety of environmental conditions. Generally speaking, the country has three major climate types: equatorial, tropical, and temperate.

The Amazon region has a predominantly equatorial climate, characterized by high temperatures and high humidity throughout the year. A tropical climate prevails across much of the country, with regional variations in temperature and precipitation regimes. In the South Region, temperate climate conditions predominate, with lower temperatures in winter and the possibility of occasional frost and snowfall in higher-altitude areas (IBGE, 2002).

The seasonal rainfall cycle in Brazil is affected by interannual variations, which can alter its dynamics, causing, for example, droughts during the rainy season or even an exceptionally wet rainy season. *El Niño* and *La Niña* are significant sources of interannual variability, as they affect precipitation regimes, the occurrence of droughts and wildfires, and influence the impacts of climate change across various sectors (Brasil, 2021). Further information on Brazil's climate context, such as the influences of atmospheric and oceanic systems and observed trends in changes in climate variables, is presented in **Chapter 4, Information related to climate change impacts and adaptation.**

Regarding the distribution of mean annual temperature (ºC) in Brazil, the highest temperatures were recorded in the North and Northeast regions, averaging more than 28 ºC. Across most of the North and Northeast regions and in the state of Mato Grosso, temperatures ranged from 26 ºC to 30 ºC. Mean temperatures ranged from 22 ºC to 26 ºC across most of the Southeast Region and in the states of Bahia, Mato Grosso do Sul, and Goiás, and the Federal District, with the lowest values occurring in the high-altitude areas of the states of Minas Gerais and São Paulo, where temperatures ranged from 18 ºC to 20 ºC. Across most of southern Brazil, mean temperatures ranged from 14 ºC to 20 ºC, with lower temperatures in mountainous areas (INMET, 2018).

1.2 Population and socioeconomic characterization

The most recent IBGE data estimate that Brazil's resident population in 2025 was 213,421,037 people, representing a 5% increase compared to the population recorded in the 2022 Census (203,080,756 people) (IBGE, 2025a).

The Brazilian population is predominantly female, mixed race, young, and concentrated in large urban centers. However, this profile varies considerably across the country. Among the observed and future trends of the 2022 Census[3], there is the prospect of a rapidly aging population, a reduction in the general growth rate, and changes in the population concentration pattern, with greater population movement toward inland areas and more pronounced growth in medium-

3 The Demographic Census is the most complex statistical operation carried out in the country, through which the characteristics of the entire population and households of the National Territory are surveyed.

sized municipalities (between 100,000 and 500,000 inhabitants) than in large municipalities (over 500,000 inhabitants) (IBGE, 2023c).

The distribution of the population is heterogeneous across the country, with the Southeast Region being the most populous region (41.6% of the population), followed by the Northeast region (26.8%), the South (14.7%), the North (8.8%), and Central-West (8.1%) (IBGE, 2025a). The country's average population density is 25.08 inhabitants/km², with the highest concentration in the Southeast Region (96.07 inhabitants/km²) and the lowest in the North Region (4.88 inhabitants/km²).

Women make up the majority of the population, with 94 men for every 100 women. Starting with the 25- to 29-year-old age group, women make up the majority of the population in all regions of the country, and this gap widens among older age groups, reflecting higher male mortality rates throughout the life cycle (IBGE, 2023c). This pattern is linked, among other factors, to the higher rate of male deaths from external causes, especially among adolescents and young adults, a situation exacerbated by factors such as socioeconomic inequalities and racism.

According to the *2022 Census*, the Black population[4], which includes Black and mixed-race people, accounts for 55.5% of Brazilians. Among the categories of color or race surveyed by the IBGE, the mixed-race population is the largest, accounting for 45.3% of the total, followed by the white (43.5%), Black (10.2%), Indigenous (0.6%), and Asian (0.4%) populations. The North Region has the highest percentage of mixed-race people (67.2%), the South has the highest proportion of white people (72.6%), and the Northeast has the highest percentage of Black people in its population (13.0%) (IBGE, 2024b).

According to the 2022 Census, 12,348 *favelas* and urban communities were identified in Brazil, home to 16.4 million people, representing 8.1% of the country's population. These territories contained 5.6 million occupied permanent private households. *Favelas* and urban communities reflect socio-spatial inequalities related, among other factors, to access to infrastructure and urban services. In 2022, 86.5% of households were connected to the general water supply network, while 74.6% had access to sanitation through a general sewerage network, stormwater drainage network, septic tank, or filter. Waste collection by cleaning services, either directly from households or via dumpsters, reached 96.7% of households. However, significant territorial inequalities persist: the percentage of households connected to the general water supply network ranged from 23.3% in Rondônia to 98.1% in Bahia, while access to the aforementioned forms of sanitation ranged from 28.1% in Amapá to 89.3% in Bahia (IBGE, 2024b).

In addition to regional inequalities and specificities, sociocultural diversity is a central characteristic of Brazil. The country is home to diverse peoples and communities, each with their own ways of life, knowledge systems, cultural values, and traditions. In this context, Traditional Peoples and Communities (TPC) are defined as culturally distinct groups that recognize themselves as such, have their own forms of social organization, and maintain specific relationships with the territories and natural resources on which they depend for their cultural, social, religious, ancestral, and economic reproduction. Their knowledge, practices, and innovations are developed and transmitted across generations.

4 According to the Racial Equality Statute (Brasil, 2010), the Black population consists of all people who self-identify as Black or mixed-race, as per the color or race category used by the Brazilian Institute of Geography and Statistics (IBGE, Instituto Brasileiro de Geografia e Estatística), or who use a similar self-definition.

In many of these groups, activities such as fishing, hunting, extractive activities, and natural resource management play an important role in food security, income generation, and the maintenance of their ways of life. These practices and knowledge can also contribute to the conservation of biodiversity and the sustainable use of Brazilian ecosystems (Brasil, 2026l).

In Brazil, 29 groups[5] are represented on the National Council of Traditional Peoples and Communities (CNPCT, Conselho Nacional de Povos e Comunidades Tradicionais), including some of the categories of Traditional Peoples and Communities, as well as Indigenous Peoples and youth groups from these populations. This recognition is based on the principle of self-identification, which is why the diversity of Traditional Peoples and Communities (TPC) groups is considered potentially even greater, given the dynamic nature of processes of identity affirmation and recognition.

Some traditional peoples and communities have specific legal recognition and territorial rights, as is the case of Quilombola communities[6] and Roma peoples[7]. For this reason, conducting research and making data available for these specific groups is more feasible. Similarly, Indigenous Peoples, who are the original peoples of Brazil, have rights guaranteed by the Federal Constitution[8]. Thus, Indigenous Peoples and Quilombolas stand out due to the recent data and detailed population profile collected through the *2022 Census*.

The Indigenous population residing in Brazil nearly doubled over 12 years, increasing by 88.96% to a total of 1,694,836 people in 2022, concentrated mainly in the North and Northeast regions, where 75.70% of this population is located (IBGE, 2023d). On the other hand, self-identified Quilombola individuals, identified for the first time in a demographic census, total 1,330,186 people distributed across 1,700 municipalities, 24 states, and the Federal District. Most of them live in the Northeast (68.1%), followed by the Southeast (13.7%), the North (12.6%), the Central-West (3.4%), and the South (2.2%) (IBGE, 2023a). In addition, the 2022 Census identified 495 Quilombola Territories (IBGE, 2023a), of which 37% are located in the Amazon biome, 28% in the Atlantic Forest, 19% in the Caatinga, 13% in the Cerrado, and 4% in the Pampa.

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5 Members of the National Council of Traditional Peoples and Communities (CNPCT), as established by Decree No. 8,750/2016: 1. Indigenous Peoples; 2. Quilombola communities; 3. *Terreiro* peoples and communities/peoples and communities of African origin; 4. Roma peoples; 5. artisanal fishers; 6. extractivist communities; 7. coastal and marine extractivist communities; 8. *caiçaras* (traditional coastal communities of southeastern and southern Brazil); 9. *faxinalenses* (traditional communities of southern Brazil that practice communal land use and agroforestry); 10. *benzedeiros* (traditional healers); 11. *ilhéus* (traditional island-dwelling communities); 12. *raizeiros* (traditional herbal medicine practitioners); 13. *geraizeiros* (traditional communities of the Cerrado region of northern Minas Gerais and western Bahia); 14. *caatingueiros* (traditional communities of the Caatinga biome); 15. *vazanteiros* (traditional floodplain farming communities of the Cerrado); 16. *veredeiros* (traditional communities associated with the palm wetlands of the Cerrado); 17. everlasting flower gatherers; 18. *pantaneiros* (traditional communities of the Pantanal wetlands); 19. *morroquianos* (descendants of rural workers, immigrants, and refugees); 20. Pomeranian people; 21. mangaba fruit gatherers; 22. women babassu coconut breakers; 23. *retireiros do Araguaia* (traditional Araguaia floodplain cattle herders); 24. *fundos e fechos de pasto* communities (traditional communities practicing communal livestock grazing and land management); 25. *ribeirinhos* (traditional riverine communities); 26. *cipozeiros* (traditional vine-gathering communities); 27. *andirobeiros* (traditional andiroba seed-gathering communities of the Amazon region); 28. *caboclos* (small-scale family farmers of the Amazon region); and 29. youth from Traditional Peoples and Communities.

6 According to Decree No. 4,887 of November 20, 2003, ethnic-racial groups that self-identify as such, have their own historical trajectory and specific territorial relationships, and who are presumed to have Black ancestry associated with resistance to the historical oppression they have suffered are considered to be remaining members of *quilombo* communities.

7 Roma peoples are recognized as traditional peoples and communities under Decree No. 12,128/2024, which acknowledges their ethnic identity and their distinct forms of social, linguistic, cultural, family, and territorial organization.

8 The Federal Constitution, through Articles 231 and 232, guarantees Indigenous Peoples rights aimed at protecting their ways of life, recognizing their social organization, customs, languages, beliefs, and traditions, as well as their original rights to the lands they have traditionally occupied. These lands constitute the material, cultural, and spiritual foundation of their existence and are essential for their physical and cultural reproduction, which is why the Constitution guarantees them permanent possession of these lands and exclusive usufruct of the natural resources found therein.

Indigenous Peoples and traditional peoples and communities contribute to the conservation of protected areas, which increases the resilience of biomes and helps mitigate climate change. Studies indicate that Indigenous Lands help protect against deforestation and have rates that are up to 20 times lower than those of unprotected areas (Qin *et al.*, 2023). The preservation of these territories, in addition to maintaining the forest and ensuring the various services provided by nature, is also important for preserving the cultural values and ways of life of these peoples (Nogueira *et al.*, 2018; Pinho *et al.*, 2012) (see **Box 1.1**).

BOX 1.1. INDIGENOUS LANDS, TERRITORIAL SECURITY, AND CLIMATE ACTION

Indigenous Lands are territories traditionally occupied by Indigenous Peoples and constitute Federal property designated for their permanent possession and exclusive use of the natural resources of the soil, rivers, and lakes located therein, as established by Articles 231 and 232 of the Federal Constitution of 1988 (see footnote 8). Demarcation is an administrative procedure governed by Decree No. 1,775/1996 and MJSP - Ministry of Justice and Public Security (Ministério da Justiça e Segurança Pública) Ordinance No. 14/1996, which comprises successive stages of identification studies, a declaratory ordinance issued by the Minister of Justice, physical demarcation, ratification by presidential decree, and registration. It is a declaratory act recognizing a pre-existing original right, rather than a constitutive act. This framework also includes the National Policy on Territorial and Environmental Management of Indigenous Lands (PNGATI, Política Nacional de Gestão Territorial e Ambiental de Terras Indígenas), established by Decree No. 7,747/2012, whose governance structure includes a Management Committee with equal representation from the Federal government and Indigenous organizations, and Convention No. 169 of the International Labour Organization (ILO), promulgated by Decree No. 10,088/2019, which guarantees the right to free, prior, and informed consultation.

According to data from the National Foundation for Indigenous Peoples (FUNAI, 2026), Brazil has 657 Indigenous Lands, corresponding to 14.6% of the national territory, in addition to another 171 areas under study and areas subject to restriction orders, accounted for separately. The 2022 Demographic Census recorded 1,694,836 Indigenous people, 75.7% of whom resided in the North and Northeast regions (IBGE, 2023d).

Indigenous Lands have deforestation rates up to 20 times lower than those of unprotected areas (QIN *et al.*, 2023) and hold significant carbon stocks in the Brazilian Amazon (NOGUEIRA *et al.*, 2018). Their preservation is considered essential for water and food security across much of the country, given the dependence of agricultural income and hydropower generation on rainfall patterns in the Amazon system (MATTOS *et al.*, 2024). The protective effect, however, is associated with progress in land tenure regularization: Indigenous Lands at advanced stages of demarcation have lower deforestation rates than those in the initial stages of recognition (ALMEIDA; CARVALHO *et al.*, 2025, p. 31). In addition to being demarcated, full possession of these territories must be guaranteed, which involves the removal of non-Indigenous occupants.

Given this importance, the issue of land tenure regularization and demarcation of Indigenous Lands has gained recognition both nationally and internationally. In a cross-cutting manner, CNPI - National Council for Indigenous Policy (Conselho Nacional de Política Indigenista) Resolution No. 4, of October 25, 2024, recommended that the Federal Government include

the demarcation of Indigenous Lands as a key pillar of the Climate Plan, reflecting a formal position adopted by the National Council for Indigenous Policy. Program 1617 of the 2024–2027 Multi-Year Plan, "Demarcation and Management of Indigenous Territories for Good Living, Sustainability, and Addressing the Climate Emergency," finances most of the actions under the Thematic Adaptation Plan for Indigenous Peoples, which includes a target to increase the land tenure regularization rate of Indigenous Lands to 72% by 2027 (BRASIL, 2025i). At the international level, the preamble to the Paris Agreement states that Parties should, when taking action to address climate change, respect, promote and consider their respective obligations concerning the rights of Indigenous Peoples (UNFCCC, 2015), while target 9(g) of the UAE Framework for Global Climate Resilience calls for the protection of cultural heritage through strategies guided by the knowledge of these Peoples (UNFCCC, 2023).

With regard to socioeconomic aspects, the Human Development Index (HDI) does not provide all the necessary elements for analyzing the country's complex socioeconomic structure, given the high level of income concentration, as well as the pronounced regional, gender, and racial disparities, among others. In any case, Brazil's HDI rose from 0.780 in 2022 to 0.786 in 2023, a figure slightly above the global average (UNDP, 2025b). Brazil moved from 89th to 84th place among 193 countries, rising five positions compared to the previous year's ranking and remaining in the high human development category. Between 1990 and 2023, the country's HDI increased by 22.6% (UNDP, 2025b).

According to the Municipal Human Development Index (MHDI)[9], Brazil improved from 0.744 in 2012 to 0.805 in 2024 — an increase of 8.2%, marking a new level of development and reaching the very high human development category. The MHDI is a composite measure designed to assess long-term progress in the three fundamental dimensions of human development: Longevity, which reflects a long and healthy life; Education, related to access to knowledge; and Income, measured by a decent standard of living (UNDP, 2026).

9 The Municipal Human Development Index (MHDI), which uses the same methodology as the global HDI, was developed by UNDP Brazil in partnership with Ipea - Institute of Applied Economic Research (Instituto de Pesquisa Econômica Aplicada) and the João Pinheiro Foundation (Fundação João Pinheiro) to enable the calculation of human development across a wide range of territorial units, such as macroregions, states, metropolitan regions, municipalities, and intramunicipal human development units. At the national level, the tool established a metric capable of capturing the impact and progress of public policies at different levels of government (UNDP, 2026).

Table 1.1 presents the evolution of selected economic and social indicators since 2012, updated based on national references.

Table 1.1 Socioeconomic indicators for Brazil

Socioeconomic indicators	2012	2014	2016	2018	2020	2022	2024
GDP (BRL trillion, current values)	4.80	5.80	6.30	7.00	7.60	10.08	11.74
Agriculture GDP at current prices (%GDP)	4.90	5.03	5.66	5.15	6.59	6.65	6.47
Industry GDP at current prices (%GDP)	26.03	23.79	21.23	21.85	22.51	26.33	24.74
Services GDP at current prices (%GDP)	69.07	71.18	73.11	73.00	70.90	67.02	68.79
GDP *per capita* (BRL thousand)	24.70	29.10	31.10	34.40	37.30	49.60	57.33
GDP *per capita* (USD thousand)	12.60	12.30	8.90	9.40	7.20	9.60	10.64
HDI	0.758	0.765	0.765	0.774	0.770	0.780	0.786*
MHDI	0.744	0.760	0.767	0.777	0.776	0.788	0.805
Gini Index[10]	0.54	0.53	0.54	0.55	0.52	0.52	0.51
Life expectancy at birth (years)	74.48	75.11	75.68	76.22	76.21	75.50	76.60
Infant mortality rate (deaths of children under 1 year of age per 1,000 births)	15.7	14.4	13.3	12.4	11.4	12.4	12.3
National poverty rate[11]	34.70	30.80	33.70	33.30	31.00	31.60	23.1
International poverty rate[12]	6.60	5.20	6.70	7.40	6.00	5.90	3.5

*Refers to 2023, the most recent data available as of April 2026.

Source: IBGE (2025e, 2025f), IPEA (2026), UNDP (2025b, 2026).

In Brazil, poverty is analyzed from a monetary perspective, that is, based on a threshold used to distinguish between poor and non-poor individuals. In 2022, 31.6% of the population lived in poverty and 5.9% lived in extreme poverty[13]. In 2024, these rates fell to 23.1% and 3.5%, respectively — the lowest levels since 2012, when the IBGE time series began. Poverty and extreme poverty rates varied across different groups and regions, declining in all of them, particularly in the North and Northeast, where poverty and extreme poverty fell more sharply (IBGE, 2025c).

Education in Brazil has made significant progress over the years, as indicated by the most recent data. In 2022, the country had a population of 163 million people aged 15 and older, of whom 151.5 million were literate, representing a literacy rate of 93%. This is remarkable progress

10 It measures the degree of inequality in the distribution of individuals according to *per capita* household income. Its value is 0 when there is no inequality (the *per capita* household income of all individuals is the same) and approaches 1 as inequality increases.

11 Proportion of the population living below the national poverty line. National poverty line (for monitoring the Sustainable Development Goals - SDGs/IBGE) of USD 5.50 a day, converted at purchasing power parity (PPP-2011) of BRL 1.66 per dollar.

12 Proportion of the population living below the international poverty line. Line of USD 1.90 per day, converted at purchasing power parity (PPP-2011) of BRL 1.66 per dollar.

13 Poverty: up to USD 6.85 per day; Extreme poverty: USD 2.15 per day. *Per capita* household income values according to World Bank criteria (IBGE, 2025f).

compared to 1940, when only 44% of this age group could read and write. The decline in illiteracy is evident over the decades, with the rate falling from 9.6% in 2010 to 7% in 2022, according to the *Census*. The most recent data from the Continuous *PNAD - National Household Sample Survey (Pesquisa Nacional por Amostra de Domicílios)* - Education - estimate that the illiteracy rate fell from 6.7% in 2016 to 4.9% in 2025, the lowest in the time series that began in 2016 (IBGE, 2025d, 2026d). Although the methodologies differ, both sources indicate a downward trend in the illiteracy rate. However, significant inequalities persist, especially among different regions and racial groups. The Northeast Region accounted for 55.6% of the country's illiterate population (5.1 million people), followed by the Southeast Region, with 22.5% (2.1 million people). The analysis by race or color, in turn, showed that in 2024, 3.1% of white people aged 15 or older were illiterate, while that rate was 6.9% among Black or mixed-race people in that same age group (IBGE, 2025d).

The importance of social programs to mitigate poverty and extreme poverty is evident in Brazil. Government social programs contributed 67% of the household income of people living in extreme poverty in 2022. Among poor households, social benefits made up 20.5% of their income. The absence of these social programs would have significantly exacerbated the situation, increasing the proportion of people living in poverty and increasing extreme poverty. Furthermore, income inequality, as measured by the Gini Index, would have been higher, underscoring the importance of these social policies in reducing poverty and promoting a more equitable society (IBGE, 2023c).

Access to these social programs is administered through the Single Registry for Federal Government Social Programs (CadÚnico, Cadastro Único), a tool used to identify and characterize low-income families throughout the country. The database compiles socioeconomic and household information, including family composition, housing conditions, education level, employment, income, and disability, among other dimensions relevant to the characterization of social vulnerability. CadÚnico is the Brazilian government's primary mechanism for guiding the selection and inclusion of low-income families in federal social policies and programs, such as the *Bolsa Família* (Family Allowance) Program, the Social Electricity Rate (Tarifa Social de Energia Elétrica), and housing programs, for example (Brasil, 2026m).

By consolidating information on who these families are, where they live, and their living conditions, the registry supports the planning, targeting, and coordination of public policies at different levels of government, contributing to the organization of the provision of social programs and services (Brasil, 2026m). Aspects regarding the population's vulnerabilities will be discussed in more detail in **Chapter 4, Information related to climate change impacts and adaptation.**

Finally, the health of the Brazilian population also reflects a history of significant institutional and public health advances. The *Federal Constitution* of 1988 established the Brazilian National Health System (SUS, Sistema Único de Saúde), guaranteeing full, universal, and free access to healthcare for the entire population of the country. The SUS is organized with shared responsibilities among the Federal government, states, and municipalities, and includes mechanisms for social participation, encompassing primary healthcare, medium- and high-complexity services, urgent and emergency care, hospital care, health surveillance, and pharmaceutical services (Brasil, 2026n). For 76% of the Brazilian population, the SUS is the primary healthcare provider (Brasil, 2025h).

Since the establishment of the SUS, the country has made significant progress in health indicators, including reductions in infant mortality, the control of preventable diseases, and increased life expectancy, among others. Despite these advances, challenges related to socioeconomic,

racial, and territorial inequalities persist, affecting equitable access to healthcare services, particularly among Indigenous and Black populations. Challenges also persist regarding declining vaccination coverage and environmental determinants of health, such as air pollution and insufficient access to safe basic sanitation (Brasil, 2024b).

1.3 Economy and infrastructure

Brazil is a developing country with a complex and dynamic economy. It is characterized as an urban-industrial country, with an agriculture sector that plays a prominent role in the national and global economies. In addition, it has a clean electricity matrix and an energy matrix that is transitioning toward a predominance of renewable energy sources.

In 2025, Brazil's GDP was BRL 12.7 trillion, with a growth of 2.3% compared to 2024, placing the country among the 10 largest economies in the world, according to estimates by the International Monetary Fund (IMF). Brazil's *per capita* GDP was BRL 59,687.49 in 2025, a real increase of 1.9% compared to the previous year (IBGE, 2026b). With regard to the labor market, the country's annual unemployment rate in 2025 was 5.6%, 1 percentage point lower than the rate recorded in 2024 (IBGE, 2026c).

Since 2000, Brazilian agribusiness has played a crucial role in both supplying the domestic market and expanding into the international market, with coffee, sugarcane, soybeans, maize, cotton, and meat production standing out. This progress was driven by the adoption of modern technologies, efficient production systems, and innovations, which have transformed the country's agriculture and livestock systems (Contini *et al.*, 2022).

In 2025, Brazil's agribusiness GDP, which encompasses the production of inputs for agriculture, agro-industrial processing, distribution, and other services necessary for its products to reach the end consumer, accounted for 25.1% of the country's total GDP (CEPEA/CNA, 2026b)[14]. In addition to its contribution to GDP, the sector plays a significant role in the trade balance, accounting for approximately 49% of total exports, and in the labor market, employing 26.3% of Brazil's total employed population. This figure represents 28.4 million people, of whom 38.2% are women and 16.8% have a university degree. The sector shows a trend toward an increase in the average level of education among workers and a rise in the formalization of employment (CEPEA/CNA, 2026a).

Additionally, family farming[15] constitutes an important segment of Brazilian agriculture, playing a strategic role in food production, food and nutrition security, and the supply of local and regional markets (Castro, 2024; Brasil, 2025a). The sector stands out for its diverse production, including cassava, maize, beans, rice, coffee, bananas, vegetables, and fruit, as well as livestock activities. In 2017, it accounted for 23% of the value of national agricultural production, equivalent to BRL 107 billion, and accounted for 67% of the workforce engaged in agricultural activities, totaling approximately 10.1 million people (IBGE, 2019b).

14 The shares of industry and agribusiness in GDP are not directly additive, as they are based on different methodological approaches. The agribusiness aggregate includes agro-industrial activities that are also classified under the industrial sector.

15 Law No. 11,326/2006 establishes guidelines for the formulation of the National Policy on Family Farming and Rural Family Enterprises and recognizes the broad range of groups involved in family farming, including family farmers, foresters, aquaculture producers, fishers, communities engaged in extractive activities, Indigenous Peoples, and traditional communities, ensuring recognition of the diversity of their ways of life and their distinct production systems.

Despite its economic and social importance, family farming faces historical and structural barriers to land access. The segment accounts for 77% of the country's agricultural and aquaculture establishments (3.9 million), but occupies 23% of the area (80.9 million hectares) devoted to agricultural activities (IBGE, 2019b). In 2017, establishments with less than 50 ha accounted for 81.4% of the total and occupied 12.8% of the area; those with 50 to 500 ha represented 15% of establishments and 28.8% of the area; and establishments with more than 500 ha accounted for 2.1% of the total and occupied 58.4% of the area. Among these, establishments with more than 2,500 ha accounted for 0.3% of the total and occupied 32.8% of the total area of establishments in the country (IBGE, 2020).

Family farming is addressed in the Climate Plan through the sectoral mitigation and adaptation plans, which together provide the framework for the country's approach to climate change in relation to food security and agriculture. The topic is addressed in the mitigation plans for Agriculture and Livestock, Land-Use Change in Private Rural Areas, and Land-Use Change in Public Areas and Collective Territories, as well as in the sectoral adaptation plans for Family Farming, Agriculture and Livestock, and Food and Nutrition Security. Information on the Climate Plan will be presented under section **1.4 Institutional arrangements and political dimensions**.

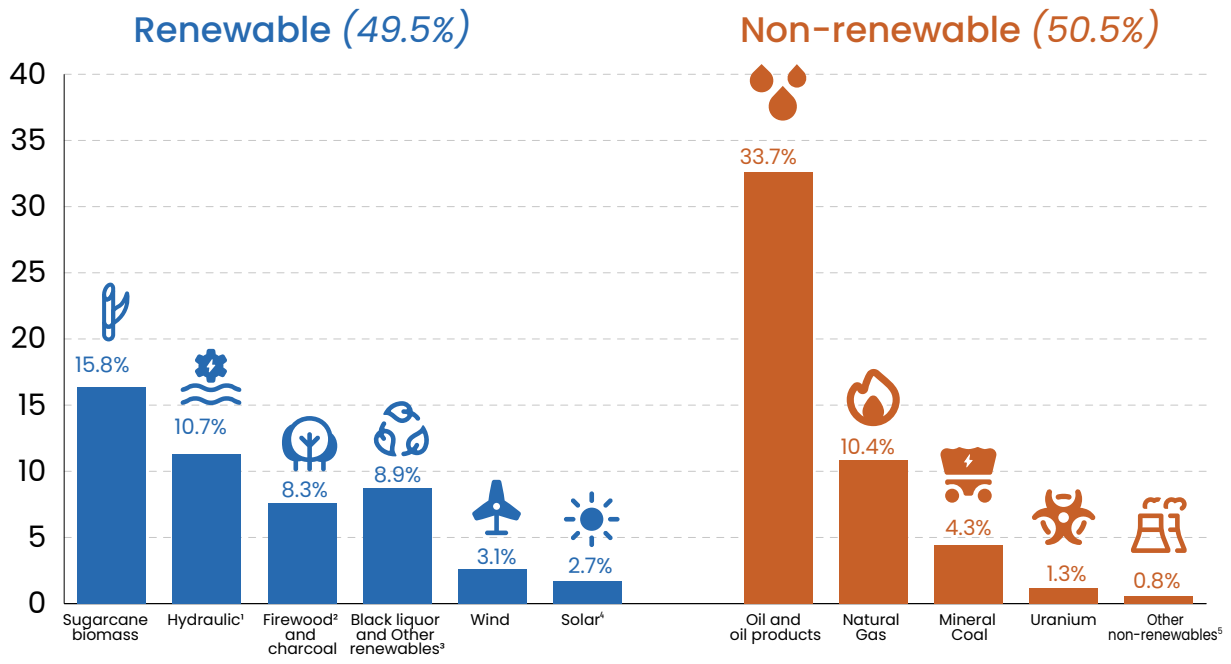
Property titling is an important factor for productive development and the stability of family farmers. Legal documentation of land ownership enhances legal certainty, facilitates access to rural credit, and reduces the risks of conflicts and uncertainty regarding continued possession of the land. In Brazil, 19% of family farming establishments were not classified as owned by the farmers, a proportion that reaches 20.3% in Areas Susceptible to Desertification (ASD) and Surrounding Areas, which may represent an additional source of vulnerability (Brasil, 2025b).

Brazilian industry is an important component of the national economy, accounting for 20.2% of total value added in the economy in 2025, according to the IBGE National Accounts. The industry aggregate encompasses extractive and manufacturing industries, construction, and electricity, gas, water, sewage, and waste management activities (IBGE, 2026b)[16]. Industry also has the most significant share in the trade balance among all economic sectors, accounting for 67.7% of exports of goods and services. From a global point of view, Brazil accounts for 1.5% of the world's industrial production. In 2025, the industry sector's share of formal employment was 20% (CNI, 2026).

With regard to the Brazilian energy matrix, the high share of renewable sources stands out, being well above the global average. In 2025, Domestic Energy Supply (DES) reached 327.9 Mtoe, an increase of 1.7% compared to the previous year (Figure 1.2). Over the past 20 years, the share of renewable sources in Brazil's Domestic Energy Supply (DES) has remained high, reflecting the diversification of the country's energy matrix and the utilization of different renewable resources (EPE, 2026a).

16 This economic classification does not correspond directly to the sectoral categories (1.A.2 and 2.A–2.G) adopted in the National GHG Inventory.

Figure 1.2 Domestic Energy Supply (DES) in Brazil in 2025, disaggregated by source



¹Includes electricity imports; ²Includes wood chips; ³Includes black liquor, biodiesel, other biomass, biogas, and industrial gas from charcoal; ⁴Includes solar photovoltaic (MMDG and centralized generation) and solar thermal sources; ⁵Other non-renewables include natural gas liquids, blast furnace gas, steelworks gas, sulfur gas, and others.

Source: EPE, 2026a.

In 2025, the supply of renewable energy sources reached 162.4 Mtoe, an increase of 0.8% compared to 2024, accounting for 49.5% of the total. The largest increases were recorded in solar energy, at 22.0%, black liquor and other renewable sources, at 9.2%, and wind energy, at 8.2%. Over the same period, hydropower supply decreased by 5.7%, and sugarcane biomass supply by 3.2%. The supply of non-renewable energy sources grew by 2.6%, with a notable 9.5% increase in natural gas (EPE, 2026a).

The share of renewable energy sources in Brazil's electricity matrix reached 86.8% in 2025. Over the past decade, the expansion of wind and solar photovoltaic energy sources has changed the operation of the Brazilian electric power system. Together, these sources accounted for 26.4% of total electricity generation in 2025, up from 5.7% in 2016. With this expansion, dispatchable generation came to account for a smaller share of the load, particularly during periods of peak solar irradiance (EPE, 2026a, 2026b).

The Brazilian Interconnected System (SIN, Sistema Interligado Nacional) connects electricity generation and transmission facilities and consists of four subsystems: South, Southeast/Central-West, Northeast, and North. Its transmission network enables the transfer of energy between subsystems, the achievement of synergistic benefits, and the utilization of the diversity in the hydrological regimes of the basins. The National Electric System Operator (ONS, Operador Nacional do Sistema Elétrico) coordinates and controls the operation of the generation and transmission facilities that make up the SIN, under the supervision and regulation of the National Electric Energy Agency (Aneel, Agência Nacional de Energia Elétrica) (ONS, 2026a). In addition

to the SIN, the Brazilian electric energy system includes isolated systems and self-generation facilities, which are accounted for separately in the national electricity supply and consumption. In 2025, approximately 5,600 km of transmission lines were added, bringing the total length of the basic grid to more than 181,800 kilometers (EPE, 2026b).

This interconnection provides the country with significant operational flexibility, contributing to energy security and the optimization of dispatch from the different available energy sources. On the other hand, the SIN is heavily influenced by weather conditions, and forced outages in the transmission system may occur due to tower collapses, breaks in overhead power lines, or equipment failure or defects caused by adverse weather conditions (Brasil, 2025c).

Access to electricity is nearly universal: in 2022, 99.8% of Brazilian households had access to this service (IBGE, 2023c). The Southeast region accounted for 47.3% of national consumption, followed by the South and Northeast regions, with 18.8% and 17.9%, respectively. Among the consumption sectors, the industrial sector accounted for the largest share, at 35.2%, followed by the residential sector, at 31.7%, and the commercial sector, at 18.4% (EPE, 2026b).

Brazil is the world's second-largest producer of ethanol and third-largest producer of biodiesel, with large-scale production of vehicle fuel and generation of bioelectricity for the SIN using surplus sugarcane bagasse from distilleries. In recent years, sugarcane products have stood out, accounting for 15.8% of the share of the sources of Brazil's domestic energy supply in 2025. The growing share of maize as a feedstock for ethanol production is also noteworthy. In 2025, maize-based ethanol production reached 9.4 billion liters, accounting for about 25% of the country's total ethanol production (EPE, 2026a).

In that same year, the shares of ethanol and biodiesel in the transport sector increased: final ethanol consumption reached approximately 38.5 million m³, up 3.6%, while final biodiesel consumption reached 9.5 million m³, an increase of 9.5%, both compared to 2024. It should be noted that the mandatory percentage of biodiesel blended into diesel was increased to 15% (in volume) in August 2025 (EPE, 2026a).

Brazil's transport infrastructure encompasses five modes: road, rail, air, waterway, and pipeline transport. The country has more than 73,000 kilometers of federal highways (Brasil, 2026h), which connect the national territory and serve as a strategic tool for economic and regional development. Its logistics matrix is highly structured around road transportation, which, in addition to playing a considerable role in the transportation of large volumes (65.7% of useful ton-kilometers), is also responsible for transporting high added-value goods (Brasil, 2020b). This mode of transport also plays a leading role in the transportation of people, accounting for a total of 89.2% of passengers transported (Brasil, 2020b).

The Civil Aviation sector accounts for 1.4% of Brazil's GDP and generates 1.5 million jobs. In 2025, the sector recorded the transportation of 129.6 million passengers, 101.2 million in Brazil and 28.4 million internationally (Brasil, 2026i). This activity accounts for 6% of Brazil's passenger modal split (115 billion passenger-kilometers). With regard to cargo transportation, the subsector accounted for 0.1% of the modal split (1.1 billion ton-kilometers) (ANAC, 2024).

A large portion of cargo related to international trade is transported through ports. In 2021, 1.2 billion metric tons of cargo were handled at Brazilian ports. Of this total, the majority is related to long-haul shipping and foreign trade. In terms of ton-kilometers, the share of long-haul maritime transport reached 98% (17.5 trillion ton-kilometers) in 2021 (ANTAQ, 2024). Additionally,

with 8,500 km of coastline and 19,500 km of active waterways, Brazil has a high potential for navigation (CNT, 2022). This category (cabotage and inland waterways) accounted for 17% of Brazil's cargo modal split in 2022 (260 billion ton-kilometers) (ANTAQ, 2024).

Lastly, railways have been increasing their share of Brazil's freight transportation matrix. With approximately 31,000 kilometers of network, they accounted for 24% of the modal split (371 billion ton-kilometers) in 2022 (ANTF, 2022).

In the context of urban mobility, data from the 2022 Census show that individual transport accounts for approximately 49% of trips, driven by the use of private cars, motorcycles, and taxis, while public transport accounts for approximately 23% of trips and has been declining in recent years. Among public transport modes, urban buses remain the main means of transport, although the system has been losing ground and passengers since 2018. Walking and cycling, in turn, account for approximately 24% of urban trips, with variations according to municipality size. These characteristics of the infrastructure and transport systems are relevant for understanding national circumstances and their relationship to climate impacts and risks (IBGE, 2024b). Additional information on the Brazilian context can be found in the sections addressing specific aspects of national circumstances, such as sections **3.1** and **4.1**.

1.4 Institutional arrangements and political dimensions

Brazil plays an important role in global climate change governance. At the international level, this leading role was marked by the United Nations Conference on Environment and Development (Rio-92). Brazil was the first country to sign the Convention, which was ratified by the National Congress on February 28, 1994. In 2012, Brazil's central role in this area was consolidated through its hosting of Rio+20. In 2025, Brazil hosted the first COP in the Amazon region, on an occasion marked by great symbolic significance: the holding of COP30 in Belém contributed to further consolidating Brazil's central role in the climate regime. Furthermore, as a Party to the UNFCCC, Brazil fulfills its obligation to prepare and publish its National Communications (NCs), Biennial Update Reports (BURs), and, under the Paris Agreement, the Biennial Transparency Reports (BTRs).

The Brazilian Government has developed a set of regulatory frameworks and management instruments aimed at implementing the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement in the country. The main instrument is the **National Policy on Climate Change (PNMC, Política Nacional sobre Mudança do Clima)**, established in 2009, which provides the legal and institutional foundations for addressing climate change and fulfilling Brazil's international commitments. Through the PNMC, the federal government seeks to coordinate mitigation and adaptation efforts at all levels of government, promoting the integration of the climate agenda into public policies. Its key principles include precaution, prevention, citizen participation, sustainable development, and common but differentiated responsibilities (Brasil, 2009).

The PNMC has the following goals: promote sustainable development while protecting the climate system; reduce greenhouse gas emissions from different sources, and strengthen removals of these gases by sinks; implement climate change adaptation measures; preserve, conserve, and restore natural resources; consolidate and expand legally protected areas; and foster the development of the Brazilian Greenhouse Gas Emissions Trading System (SBCE,

Sistema Brasileiro de Comércio de Emissões de Gases de Efeito Estufa)[17]. These goals shall be consistent with sustainable development, with a view to pursuing economic growth, poverty eradication, and the reduction of social inequalities. The instruments provided for in the PNMC include the National Climate Change Plan; the National Climate Change Fund; the Action Plans for the Prevention and Control of Deforestation in the biomes; as well as Brazil's National Communication to the UNFCCC. In addition, policy instruments include the use of fiscal and tax measures, credit and financing lines, research lines by funding agencies, and financial and economic measures relating to climate change mitigation and adaptation, among others. The PNMC's institutional mechanisms include the Interministerial Committee on Climate Change (CIM, Comitê Interministerial sobre Mudança do Clima), the Commission for the Coordination of Meteorological, Climatological, and Hydrological Activities (CMCH, Comissão de Coordenação das Atividades de Meteorologia, Climatologia e Hidrologia), the Brazilian Climate Change Forum (FBMC, Fórum Brasileiro de Mudança do Clima), and the Brazilian Research Network on Global Climate Change (Rede Clima, Rede Brasileira de Pesquisas sobre Mudanças Climáticas Globais).

The revision of the PNMC, which began in 2023 under the CIM, aims to update the main national legislation on climate change and align it with the commitments made by Brazil under the Paris Agreement (Brasil, 2023b). The proposed revision is currently being consolidated by the technical group within the CIM, taking into account contributions received through social participation and federative coordination processes, including those submitted during the public consultation on the preliminary draft held on the *Brasil Participativo*[18] platform between October and December 2025.

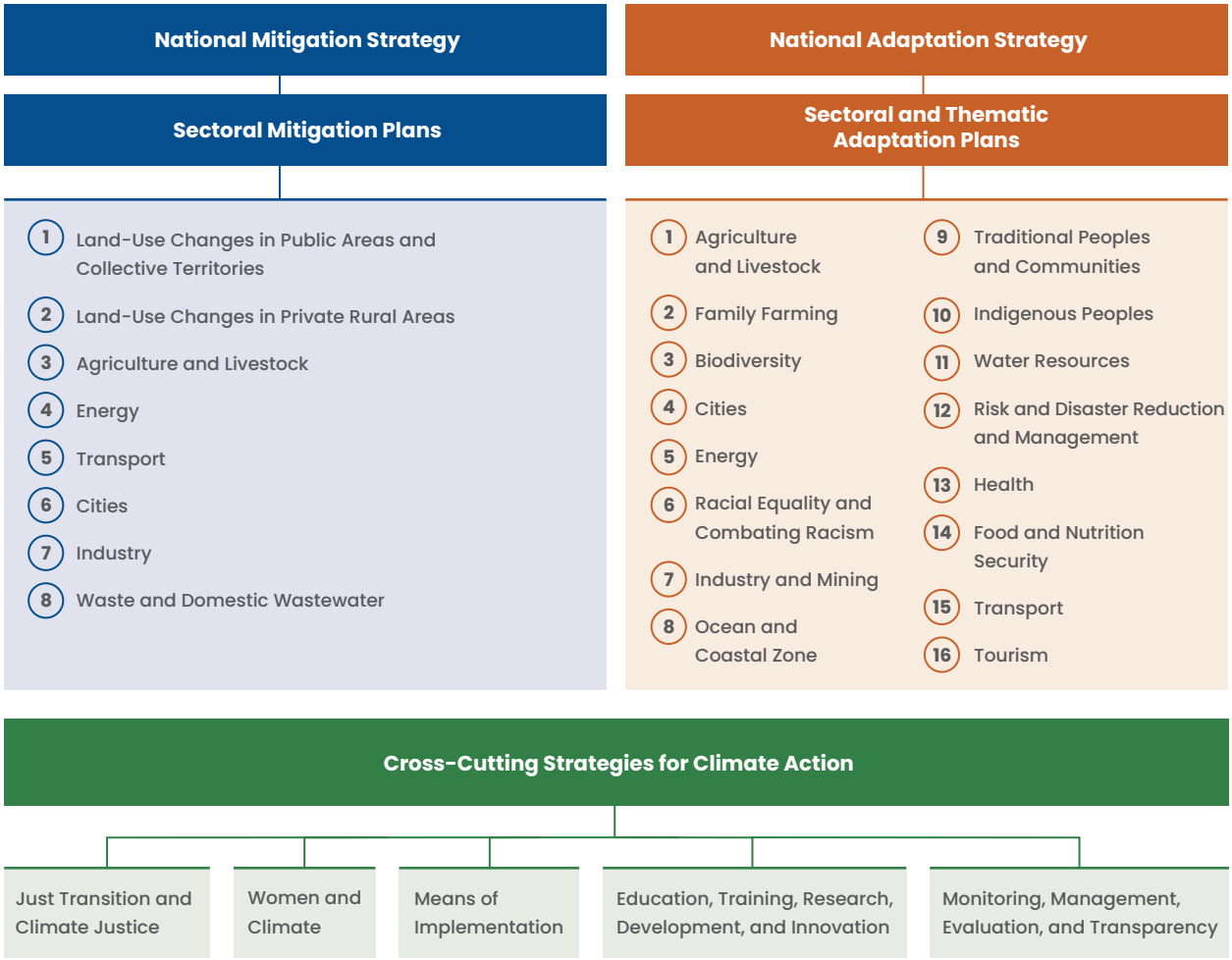
The **National Climate Change Plan** (known as the Climate Plan) is the instrument that consolidates the strategies, plans, and targets of the federal executive branch to achieve the goals of the PNMC and to reach the targets of the Nationally Determined Contribution (NDC). The result of more than two years of interministerial and intersectoral coordination – under the general coordination of the Ministry of the Environment and Climate Change (MMA, Ministério do Meio Ambiente e Mudança do Clima) and the technical and scientific coordination of the Ministry of Science, Technology and Innovation (MCTI, Ministério da Ciência, Tecnologia e Inovação), demonstrating the cross-cutting nature of the climate agenda – the 2024–2035 Climate Plan establishes short-, medium-, and long-term targets and guidelines aimed at transitioning to a net-zero greenhouse gas emissions economy by 2050 and adapting human and natural systems to climate change (Brasil, 2025d).

The Plan is structured around three complementary pillars: Adaptation, Mitigation, and Cross-Cutting Strategies for Climate Action (Figure 1.3). This structure makes it possible to address the problems arising from climate change in an integrated manner, aiming to reduce the causes of global warming while preparing society and territories to become more resilient to its impacts, from the perspective of sustainable development and climate justice. The cross-cutting strategies also incorporate key themes such as a just transition, gender equality, financing, capacity building, innovation, monitoring, and transparency (Brasil, 2026o). The mitigation and adaptation pillars and the cross-cutting strategy of the Climate Plan will be detailed in **chapters 3**, **4**, and **7**.

17 As amended by Law No. 15,042, of December 11, 2024.

18 *Brasil Participativo* is a digital platform (https://brasilparticipativo.presidencia.gov.br) developed by the Federal Government to enable the public to contribute to the development and improvement of public policies.

Figure 1.3 Structure of the National Climate Change Plan (Climate Plan)



Source: Brasil, 2026a.

The development of the Climate Plan involved representatives from the federal and subnational governments, the private sector, civil society, and the scientific community. Public consultations were held through the *Brasil Participativo* platform, along with dozens of workshops and technical meetings, as well as territorial plenary sessions that mobilized the population from all regions of the country. In 2024, between June 5 and September 17, a digital phase was launched through the platform, during which the public was able to submit proposals for addressing climate change and reducing its impacts in Brazil. A total of 298,000 visits, 23,009 participants, 1,296 proposals, more than 47,000 votes, and 2,000 comments were recorded. Seven in-person plenary sessions, organized by biome (Coastal-Marine System, Caatinga, Pantanal, Atlantic Forest, Cerrado, Amazon, and Pampa), brought together 4,161 participants, while recordings of the meetings received more than 2,000 views (Brasil, 2025d). Additionally, several broad participatory processes generated direct contributions from society to the Climate Plan, such as the 5th National Conference on the Environment[19] in 2025 (Brasil, 2025d).

19 At the end of the conference, 104 proposals were selected, organized into five thematic pillars: Mitigation, Adaptation and Disaster Preparedness, Climate Justice, Ecological Transformation, and Governance and Environmental Education (Brasil, 2025f).

During the development of the *National Mitigation Strategy* (ENM, *Estratégia Nacional de Mitigação*), a number of seminars, workshops, and technical meetings were held with federal agencies and representatives of organizations from the sectors covered by the ENM, to present and discuss the assumptions and results of the modeling of mitigation pathways (Brasil, 2026b), details of which are provided in **Chapter 3.**

The development of the Climate Adaptation Plan also involved various listening forums. 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 the Sectoral and Thematic Plans. In total, these activities involved 871 participants, with the involvement of 25 federal ministries (Brasil, 2025d).

The Cross-Cutting Strategies for Climate Action (ETACs, Estratégias Transversais para Ação Climática) also emphasized the collaborative development process. They were developed by Technical Groups established under the Executive Subcommittee of the Interministerial Committee on Climate Change (SUBEX/CIM), composed of representatives from various sectoral ministries, who were responsible for drafting the documents. In total, the five ETACs included 25 meetings, 9 workshops, and the participation of more than 19 ministries. All ETACs underwent public consultation through the *Brasil Participativo* platform during different periods between October 13, 2025, and January 15, 2026 (Brasil, 2026p). Dataframe 1.2 provides a brief description of each strategy.

Dataframe 1.2 Cross-Cutting Strategies of the Climate Plan

Cross-Cutting Strategy	Description
Cross-Cutting Strategy for a Just Transition and Climate Justice (ETTJ, Estratégia Transversal de Transição Justa e Justiça Climática)	It addresses the theoretical framework on the topic and its challenges, seeking to highlight structural and territorial inequalities and their effects on the distribution of transition risks and opportunities. The general objective of the ETTJ is broken down into 11 national goals, each accompanied by a specific set of guidelines intended to guide the implementation of the public policies required for their effective achievement (Brasil, 2026d).
Cross-Cutting Strategy on Women and Climate (ETMC, Estratégia Transversal de Mulheres e Clima)	It seeks to consolidate a systemic approach that integrates gender equality, social justice, and climate justice, with the aim of supporting managers at all three levels of government and strengthening intersectoral and institutional governance. The strategy provides an overview of gender inequalities, identifies and analyzes the priority climate risks affecting women and girls using an intersectional approach, and presents an action plan with six goals and their respective guidelines. In total, it establishes 64 targets (Brasil, 2026e), further details of which are provided in **Chapter 4.**
Cross-Cutting Strategy on Means of Implementation (ETMI, Estratégia Transversal de Meios de Implementação)	It addresses the means of implementation and the context of climate finance at the national and international levels and in the public and private sectors. It presents programs and instruments available to finance Climate Plan actions and brings together guidelines and recommendations aimed at operationalizing the financial means of implementation of Brazil's climate agenda. The ETMI addresses five topics identified as priorities in detail and maps the main financial instruments related to the sectoral adaptation and mitigation plans (Brasil, 2026f).
Cross-Cutting Strategy for Education, Capacity-Building, Research, Development, and Innovation (ET-ECAPI, Estratégia Transversal de Educação, Capacitação, Pesquisa, Desenvolvimento e Inovação)	It is organized around five key pillars: (i) formal education; (ii) non-formal education integrated with the knowledge of Indigenous Peoples and traditional peoples and communities; (iii) vocational and technological training; (iv) research, technological development, and innovation; and (v) awareness-raising and combating misinformation. For each pillar, it presents an assessment and goals that are further broken down into actions, targets, indicators, and key stakeholders (Brasil, 2026g).
Cross-Cutting Strategy for Monitoring, Management, Evaluation, and Transparency (ET-MGAT, Estratégia Transversal de Monitoramento, Gestão, Avaliação e Transparência)	It is organized into two complementary sections. The first section outlines the goals, management and governance structure, and the modalities and procedures for conducting annual monitoring cycles, biennial impact evaluation, and quadrennial updates of the Climate Plan. The second section details the elements of the Plan that will be monitored and evaluated, organized into dataframes and tables, and presents the operational aspects of these cycles (Brasil, 2026c), the details of which can be found in section **4.6**.

BOX 1.2 STRENGTHENING OF BRAZILIAN CLIMATE GOVERNANCE

Starting in 2023, Brazil underwent a process of updating and reorganizing the governance, planning, and implementation instruments of its national climate policy. This process involved the restructuring of the Interministerial Committee on Climate Change (CIM), the updating of the Climate Plan (2024–2035), and the consolidation of new instruments aimed at integrating the climate agenda with sectoral policies, economic mechanisms, and medium- and long-term planning processes.

In the context of economic and development planning, the Ecological Transformation Plan was launched in 2023, coordinated by the Ministry of Finance, with the aim of guiding a vision of economic growth, social inclusion, and environmental preservation through the mobilization of investments based on decarbonization and resilience. In 2024, the Pact for Ecological Transformation was signed by the Executive, Legislative, and Judicial Branches, with a view to promoting greater coordination among legislative, administrative, and judicial measures related to this topic. The Commitment to Climate Federalism was also established, aimed at strengthening coordination among the Federal government, states, the Federal District, and municipalities in the implementation of climate actions (Brasil, 2024c).

Also in 2024, the development of national long-term planning[20] began, coordinated by the National Planning Secretariat of the Ministry of Planning and Budget (SEPLAN/MPO, Secretaria Nacional de Planejamento/Ministério do Planejamento e Orçamento), in coordination with various ministries (Brasil, 2024d). The initiative takes into account key megatrends and critical uncertainties, potential development scenarios, and incorporates aspects related to climate change. The development process involved 130 entities and more than 5,000 people (including citizens, experts, public officials, business leaders, civil society representatives, and members of academia), who were consulted through public consultations, technical workshops, state-level events, interviews, and meetings (Brasil, 2025g)[21].

Actions in the areas of biome protection, biodiversity, and land use stand out, particularly with the resumption of the action plans for the prevention and control of deforestation in the Amazon (5th phase of the PPAmazônia - Action Plan for the Prevention and Control of Deforestation and Fires in the Amazon) and in the Cerrado (4th phase of the PPCerrado – Action Plan for the Prevention and Control of Deforestation and Fires in the Cerrado) in 2023, and the launch of the first phase for all other biomes in 2024 and 2025; the development of the National Biodiversity Strategy and Action Plan (EPANB, Estratégia e Plano de Ação Nacionais para a Biodiversidade, 2025-2030); the resumption of Planaveg – National Plan for the Restoration of Native Vegetation (Plano Nacional de Recuperação da Vegetação Nativa) to restore 12 million hectares of native vegetation; the launch of the Amazon Restoration Arc[22] (Arco da Restauração na Amazônia) initiative; the establishment of new protected areas; the launch of the National Program for the Conservation and Sustainable Use of

20 Long-term planning was conducted by SEPLAN within the scope of the Brazil 2050 Strategy project and will inform the development of the strategic dimension of the 10th Multi-Year Plan (PPA, Plano Plurianual, 2028–2031).

21 Available at: https://www.gov.br/planejamento/pt-br/assuntos/noticias/2025/outubro/secretaria-nacional-de-planejamento-entrega-a-estrategia-brasil-2050. Accessed on: Feb. 16, 2026.

22 The initiative aims to restore 6 million hectares of forest by 2030 and 24 million hectares by 2050. It is estimated that approximately BRL 200 billion in investments will be needed, with the potential to create up to 10 million jobs in the region.

Brazil's Mangroves (*ProManguezal*); and the National Integrated Fire Management Policy. More details on these actions will be discussed in **Chapter 3**.

With regard to economic and financial instruments, the Amazon Fund and the Climate Fund were reinstated, and other mechanisms were created, such as:

- Brazilian Sustainable Taxonomy – TSB (Taxonomia Sustentável Brasileira) (Decree No. 12,705/2025): official classification of sustainable activities;
- Brazilian Climate Investment Platform – BIP (Plataforma Brasil de Investimentos Climáticos) (Joint Ordinance MF - Ministry of Finance (Ministério da Fazenda)/MDIC - Ministry of Development, Industry, Trade and Services (Ministério do Desenvolvimento, Indústria, Comércio e Serviços)/MMA – Ministry of the Environment and Climate Change (Ministério do Meio Ambiente e Mudança do Clima)/MME – Ministry of Mines and Energy (Ministério de Minas e Energia)/BNDES – Brazilian Development Bank (Banco Nacional de Desenvolvimento Econômico e Social) No. 20/2025);
- Sustainable Sovereign Bonds;
- Brazilian Greenhouse Gas Emissions Trading System – SBCE (Sistema Brasileiro de Comércio de Emissões de Gases de Efeito Estufa) (Law No. 15,042/2024): a regulated market subject to a GHG emissions cap-and-trade system involving the trading of assets representing GHG emissions, emission reductions, or removals, with gradual implementation. In 2025, the Extraordinary Secretariat for the Carbon Market of the Ministry of Finance, which temporarily exercises the responsibilities of the SBCE managing body (Decree No. 12,677/2025), and the SBCE Standing Technical Advisory Committee (Decree No. 12,768/2025) were established. It should be noted that its implementation depends on mobilizing resources for investments in mitigation technologies and measures in the regulated sectors; and
- Eco Invest Brasil (Law No. 14,995/2024): Incentives for investments that promote ecological transformation.

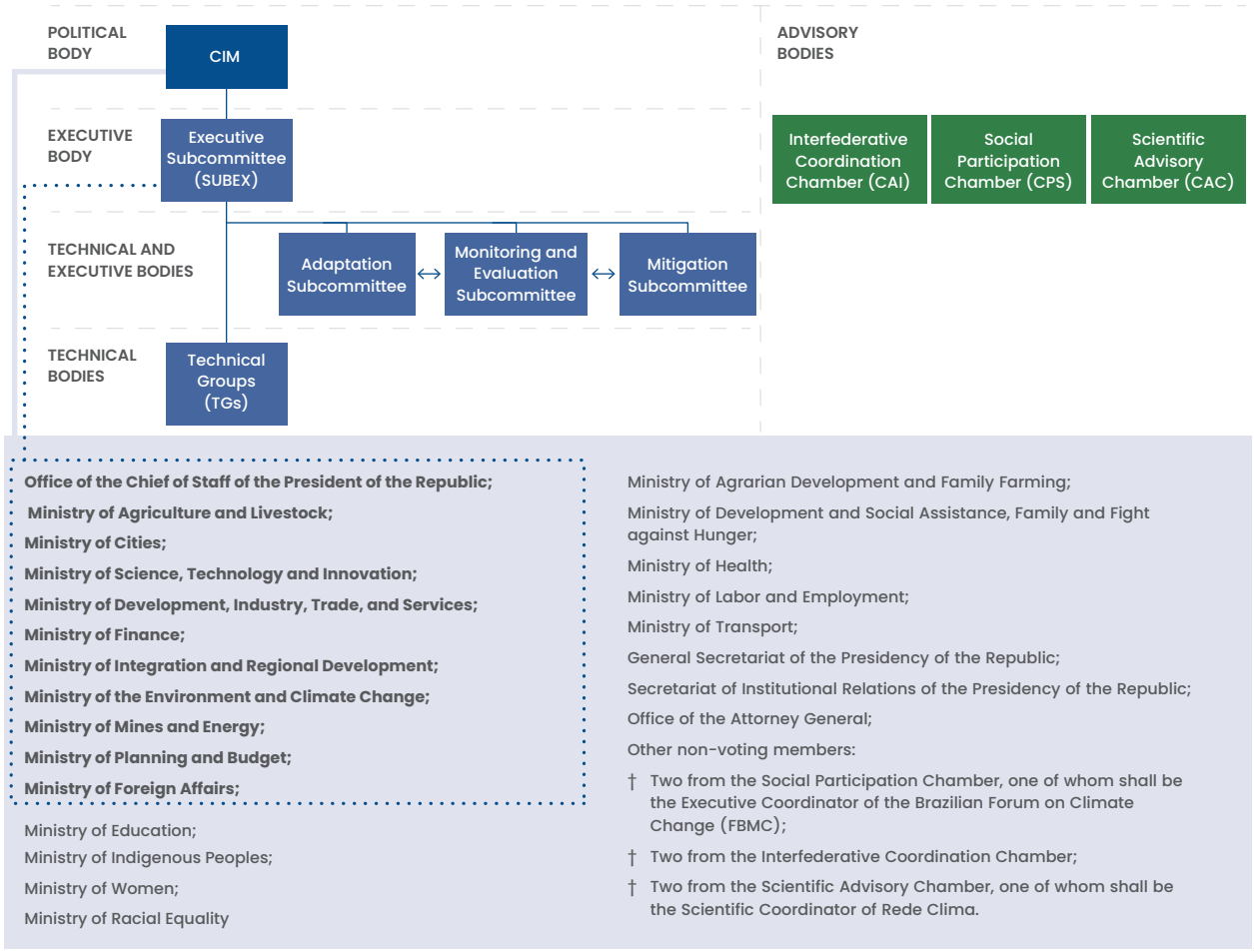
In the areas of adaptation, risk management, and resilience, initiatives aimed at generating and disseminating information on climate risks and providing support to subnational entities have been expanded. The AdaptaBrasil MCTI platform, a tool for analyzing integrated and updated information on climate risks, has begun to incorporate new strategic sectors. As part of the commitment to climate federalism, *AdaptaCidades* was launched in 2025 to support states and municipalities in developing local or regional climate change adaptation strategies and plans, linked to the Green Resilient Cities Program *(Programa Cidades Verdes Resilientes).*

The National Strategy for Food and Nutrition Security in Cities was also established; the National Civil Protection and Defense Plan (PN-PDC, Plano Nacional de Proteção e Defesa Civil, 2025–2035) was developed, incorporating the challenges posed by climate change; and Conama – National Environment Council (Conselho Nacional do Meio Ambiente) Resolution No. 511/2025 on climate justice was adopted. Other adaptation initiatives are presented in **Chapter 4**.

During this period, several national and international meetings hosted by Brazil also stand out, as they strengthened the resumption of the climate agenda: the meeting of the Amazon Cooperation Treaty Organization (ACTO), held in Belém in 2023, an organization dedicated to strengthening regional cooperation and promoting the sustainable development of the Amazon and its peoples; Brazil's presidency of the G20 from December 1, 2023, to November 30, 2024, during which combating climate change was one of its priorities; the Municipal and State Environmental Conferences held between 2024 and 2025 as preparatory stages for the 5th National Conference on the Environment (which had not been held for 11 years), aimed at discussing the climate emergency and the challenge of ecological transformation, consolidating proposals and discussions from across the country; and, finally, the 30th Conference of the Parties (COP30) to the UNFCCC and the Leaders' Summit, held in Belém, in the state of Pará, in November 2025.

Regarding institutional arrangements, the **CIM**, the country's main permanent climate governance body, has, among its responsibilities, the task of promoting, integrating, and monitoring the implementation of climate change-related actions and public policies, as well as deliberating on strategies for the development, implementation, financing, monitoring, evaluation, and updating of policies, plans, and actions related to climate change in the country (Brasil, 2024a). Figure 1.4 shows the structure of the CIM.

Figure 1.4 Structure of the Interministerial Committee on Climate Change (CIM)



Source: Adapted from Brasil (2026o), with additions regarding the structure of the CIM and SUBEX.

At the political level, the CIM is chaired by the Minister of the Office of the Chief of Staff of the President of the Republic (CC/PR, Casa Civil da Presidência da República) and is comprised of 23 Ministers of State. The CIM deliberates on and defines climate change policies, programs, and actions. The CIM also includes non-voting members appointed by the Social Participation Chamber, the Interfederative Coordination Chamber, and the Scientific Advisory Chamber.

The Office of the Chief of Staff of the President of the Republic (CC/PR) is also responsible for coordinating the CIM, while the National Secretariat for Climate Change (SMC, Secretaria Nacional de Mudança do Clima) of the Ministry of the Environment and Climate Change (MMA) serves as its Executive Secretariat. The SMC/MMA also serves as the Designated National Authority and performs other duties related to the instruments established in Article 6 of the Paris Agreement under the United Nations Framework Convention on Climate Change, in coordination with the Ministry of Foreign Affairs (MRE, Ministério das Relações Exteriores).

At the technical and executive level, there are bodies dedicated to tracking the implementation, monitoring, evaluation, and updating of the Climate Plan:

- Adaptation Subcommittee, whose main purpose is to track the implementation and updating of the Climate Adaptation Plan;
- Mitigation Subcommittee, whose main purpose is to track the implementation and updating of the Climate Mitigation Plan; and
- Monitoring and Evaluation Subcommittee, dedicated to managing and facilitating the processes of monitoring, evaluation, updating, and transparency of the Climate Plan, including the Adaptation, Mitigation, and Cross-Cutting Strategies pillars.

At the advisory level, the CIM has three advisory chambers: the Social Participation Chamber (CPS, Câmara de Participação Social), the Scientific Advisory Chamber (CAC, Câmara de Assessoramento Científico), and the Interfederative Coordination Chamber (CAI, Câmara de Articulação Interfederativa). This structure assists the committee in developing proposals, tracking actions, and coordinating with different sectors. Through these Advisory Chambers, the CIM receives contributions from civil society, representatives of subnational governments, and academia in the form of recommendations, analyses, and scientific input (Brasil, 2026p).

The Scientific Advisory Chamber (CAC) aims to support climate policy with the best available science, and is responsible for proposing to the CIM scientific data, information, and evidence to inform the formulation, implementation, tracking, and evaluation of public climate policies, and contributing to public awareness and scientific dissemination related to climate change, its causes, consequences, and mitigation and adaptation options. One of the representatives of the Scientific Advisory Chamber is the scientific coordinator of Rede Clima.

Established by the MCTI in 2007 as an instrument of the PNMC – National Policy on Climate Change (Política Nacional sobre Mudança do Clima), Rede Clima is the country's main national research network dedicated to the theme of climate change. Rede Clima brings together experts and research institutions from different fields of knowledge to promote the generation and integration of scientific evidence on climate change, providing input for the formulation, implementation, and evaluation of public policies.

The Social Participation Chamber (CPS) aims to promote civil society participation in public policies on climate change by fostering dialogue with organized civil society, collecting proposals and successful experiences, sharing information on public policies, and disseminating knowledge, thereby increasing the transparency of climate policies. The CPS has 50 participants selected according to criteria of diversity across civil society segments (NGOs, social movements, trade unions, and the private sector), regional balance, capacity for political engagement, and territorial reach, as well as gender and ethnic-racial representativeness. In its first year of activities, it was coordinated by the Brazilian Climate Change Forum (FBMC, Fórum Brasileiro de Mudança do Clima), which is a permanent member of the CPS.

The FBMC, established in 2017 (Brasil, 2017), aims to mobilize the public and serves as a channel for interaction between the Federal Government and organized civil society, business, and non-governmental sectors. The FBMC is organized into thematic chambers and sectoral committees: Adaptation and green infrastructure; Carbon economy, Circular economy; Environmental and climate education; National climate change policy; Sustainable finance; Green cities; and Energy transition.

The Interfederative Coordination Chamber (CAI) is an advisory body whose objective is to promote the participation of subnational governments — which, in Brazil, comprise the states, the Federal District, and municipalities — in the development, improvement, and implementation of

climate change mitigation and adaptation measures. It also aims to contribute to the alignment between national, sectoral, and cross-cutting policies and regional and local policies and contexts, in addition to fostering the development of plans and monitoring the implementation of climate policy at the subnational level.

The Ministry of Science, Technology and Innovation (MCTI), through the General Coordination of Climate Science (CGCL, Coordenação-Geral de Ciência do Clima), under the Secretariat for Strategic Policies and Programs (SEPPE, Secretaria de Políticas e Programas Estratégicos), serves as the National Designated Entity (NDE) for the UNFCCC Technology Mechanism and the Designated National Authority (DNA) for the Clean Development Mechanism (CDM).

The MCTI also coordinates, in consultation with other relevant ministries and bodies, the preparation of Brazil's National Communications (NCs), Biennial Update Reports (BURs), and the Biennial Transparency Reports (BTRs), including the National Inventory of Anthropogenic Greenhouse Gas Emissions by Sources and Removals by Sinks (Brasil, 2023a).

Established in 1994, the CGCL is one of the oldest administrative units of the Federal Government working on the climate agenda and serves as the executive secretariat of the Rede Clima Steering Committee, contributing to coordination between the scientific community and government decision-making processes. The General Coordination is responsible for the National Emissions Registry System (SIRENE, Sistema de Registro Nacional de Emissões), the Federal Government's official instrument for the measurement, reporting, and verification of GHG emissions and removals, as well as for SIRENE Organizacionais (Organizational SIRENE), the AdaptaBrasil MCTI platform, and the National Climate Transparency System (DataClima+).

BOX 1.3 STRENGTHENING OF THE NATIONAL CLIMATE TRANSPARENCY SYSTEM (DATACLIMA+)

DataClima+ is an initiative coordinated by the Ministry of Science, Technology and Innovation (MCTI) to strengthen the national climate transparency system. Its objective is to structure and institutionalize the governance of the data used in the formulation, tracking, and evaluation of climate policies and in the preparation of national reports submitted under the UNFCCC and the Paris Agreement.

The initiative aims to advance the development of technology platforms to consolidate a governed database, supported by clearly defined institutional responsibilities, regular flows of information provision and validation, documented procedures, and common quality standards. To this end, policies, processes, and institutional roles will need to be established to ensure the quality, consistency, security, accessibility, and traceability of data, as well as interoperability among systems.

DataClima+ is being designed as a modular and integrated system, with modules for Mitigation, Adaptation, Public Policy, NDC Tracking, and Means of Implementation. The project also provides for the updating and gradual integration of existing platforms and tools, such as AdaptaBrasil MCTI, the National Emissions Registry System (SIRENE), SIRENE Organizacionais, and the National Simulator of Sectoral Policies and Emissions (SINAPSE, Simulador Nacional de Políticas Setoriais e Emissões). At the same time, institutional arrangements will be established to ensure the periodic and timely collection of data, the definition of responsibilities throughout the information cycle, and capacity-building of participating institutions.

The project was approved in August 2024, officially launched on June 25, 2026, and is scheduled to be implemented until August 2028. Following institutional formalization and the completion of the initial deliverables defining the scope, the technological modules, governance processes, and integration mechanisms are currently under development. The launch also marked the beginning of engagement with institutions that may be involved in data provision and management.

The platform receives financial support from the Global Environment Facility (GEF) under the Capacity-building Initiative for Transparency (CBIT). Its implementation is carried out in partnership with the United Nations Environment Programme (UNEP), with support from the Brazilian Biodiversity Fund (Funbio, Fundo Brasileiro para a Biodiversidade), the National Education and Research Network (RNP, Rede Nacional de Ensino e Pesquisa), and the Brazilian Cooperation Agency (ABC, Agência Brasileira de Cooperação).

DataClima+ is expected to help reduce the fragmentation of information flows, institutionalize data collection and management processes, and increase the availability of consistent, comparable, traceable, and timely information. These advances will support compliance with the requirements of the Enhanced Transparency Framework and the Modalities, Procedures and Guidelines under Article 13 of the Paris Agreement.

The Ministry of Foreign Affairs (MRE), through the Department of Climate (DECLIMA, Departamento de Clima), under the Secretariat for Climate, Energy and the Environment (SECLIMA, Secretaria de Clima, Energia e Meio Ambiente), is responsible for coordinating Brazil's international participation within the framework of the UNFCCC and of other forums where climate change is discussed. DECLIMA serves as Brazil's focal point for the UNFCCC, the Intergovernmental Panel on Climate Change (IPCC), and the Montreal Protocol. The Ministry of Finance (MF), in turn, serves as the National Designated Authority for the Green Climate Fund (GCF), the Operational Focal Point for the Global Environment Facility (GEF), and as the designated member for the Climate Investment Funds (CIF) Committees. Additionally, the Ministry of Finance (MF), through the Extraordinary Secretariat for the Carbon Market (SEMC, Secretaria Extraordinária do Mercado de Carbono), temporarily exercises the responsibilities of the managing body of the Brazilian Greenhouse Gas Emissions Trading System (Decree No. 12,677/2025) and chairs the SBCE Standing Technical Advisory Committee (Decree No. 12,768/2025).

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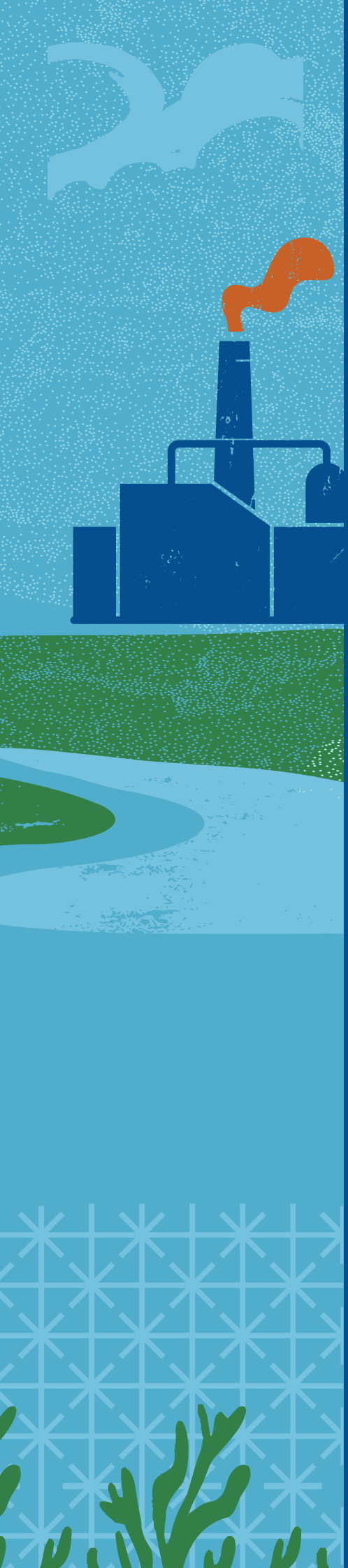
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CHAPTER 2

National Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases

As part of the submission of the Fifth National Communication and the Second Biennial Transparency Report (BTR2), Brazil has prepared, in a separate document, the National Inventory Report (NIR 2026).

The Paris Agreement represents a crucial global commitment to tackling climate change and limiting global warming. The active participation of countries in this agreement is fundamental for the reduction of greenhouse gas emissions and the promotion of joint actions for a more sustainable future, reconciling economic and social development with environmental protection.

Joining the Paris Agreement brings significant economic and environmental benefits to Brazil, with access to sustainable financing, increased international competitiveness and job creation for a low-carbon economy. With regard to the environment, it can help preserve ecosystems, reduce vulnerability to extreme weather events and promote the use of clean technologies. In this scenario, National GHG Inventories are essential to ensure transparency, monitor progress towards the achievement of climate targets and support decision-making.

In this context, Brazil reaffirms its commitment to prepare and submit, in accordance with its national capabilities, the National Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases (GHG). This effort is part of the Second Biennial Transparency Report (BTR2), covering the time series from 1990 to 2024, in accordance with the requirements of the Enhanced Transparency Framework (ETF), reinforcing the country's role in terms of transparency and global responsibility in the face of climate change.

The estimated GHGs were carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). Other GHG precursors, such as carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2) and other non-methane volatile organic compounds (NMVOC) have been included whenever possible.

Given the various sources of anthropogenic GHG emissions, the Inventory is organized according to the activities included in the following sectors: Energy (CRT 1); Industrial Processes and Product Use (IPPU) (CRT 2); Agriculture (CRT 3); Land Use, Land-Use Change and Forestry (LULUCF) (CRT 4); and Waste (CRT 5). On the other hand, GHG removals are only accounted for in the LULUCF sector, as a result of the increase in carbon stock, for example through vegetation growth.

The estimates were based on the same methodological approach as the one used in the Inventory presented in Brazil's National Inventory Document of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases, submitted in 2024 together with the BTR1, as well as updates to the country's Inventory covering the period from 1990 to 2024 (BRASIL, 2024a; 2024b).

In order to update the activity data, mainly public and official references were consulted. Data that were not available in publications or other media were requested from the institutions responsible for such data, or experts were consulted. The collection of data and the preparation of the inventory of GHG emissions and removals pose a number of challenges, such as the need for detailed, up-to-date data and the lack of specific data for some categories of emissions. The

integration of data from multiple sources and the need for the extrapolation and interpolation of historical data also introduce uncertainties into the estimates. All the technical details, such as activity data, methodologies, equations, parameters and emission factors used can be found in the **National Inventory Report (NIR 2026),** which is part of this submission, and is available at the National Emissions Registry System (SIRENE, Sistema de Registro Nacional de Emissões).[1]

The key categories were identified using the Tier 1 level and trend assessments from 1990 to 2024, as recommended in the IPCC Guidelines (2006) and adopted by the MPGs. This approach identified the sources that, when combined, contribute to 95% of total emissions, or 95% of the inventory trend in absolute terms.

A quantitative assessment of uncertainties in activity data and emission factors was conducted at the national level using the error propagation method (Type 1 Approach) for the Energy, Industrial Processes and Product Use (IPPU), Agriculture, and Land Use, Land-Use Change, and Forestry (LULUCF) sectors. For the Waste sector, the Monte Carlo method (Type 2 Approach) was used, which allowed for the propagation of the probability distributions associated with the various parameters involved in the estimates.

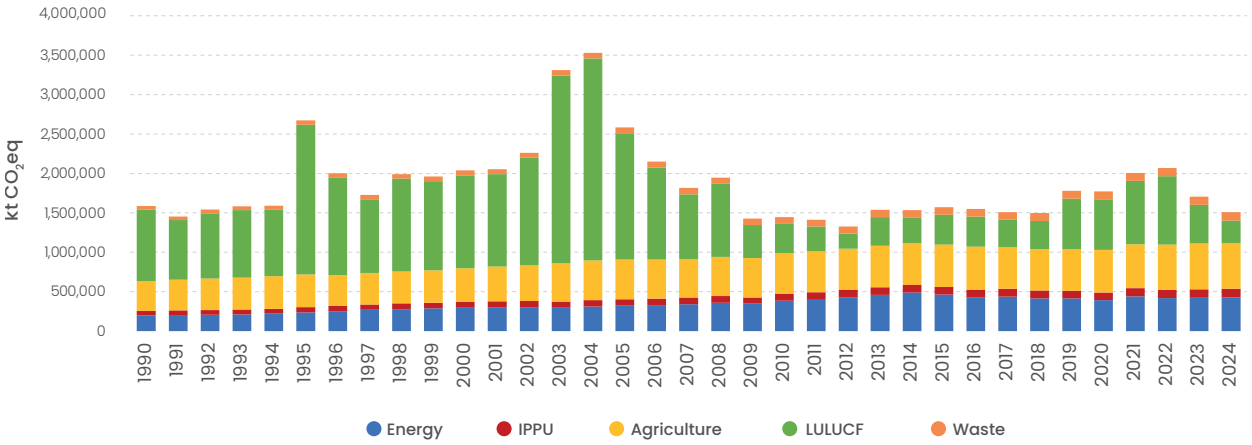
It should be noted that, in accordance with Decision 18/CMA.1, all the Inventory's analyses and results are presented in kt CO_2 eq, using the Global Warming Potential (GWP) metric for a 100-year time horizon contained in the IPCC's Fifth Assessment Report (GWP AR5) (IPCC, 2013). In addition, in accordance with Decision 18/CMA.1, Brazil also presents the emissions of gases aggregated in terms of global temperature potential over a 100-year time horizon (GTP 100) in the National Inventory of Emissions and Removals of Greenhouse Gases (see NIR 2026, section 2.8, Information on the metrics used).

2.1 Results of Brazil's GHG emissions and removals

Brazil's total net emissions were 1,509,791 kt CO_2 eq in 2024. This represents a 41.6% decrease in total emissions (or -1,074,162 kt CO_2 eq) compared with 2005. Compared with 2022, there was a reduction of 27% (-557,517 kt CO_2 eq), as shown in Table 2.1 and Figure 2.1.

1 Available at: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/sirene/publicacoes/relatorios-bienais-de-transparencia-btrs. Accessed on: Aug 29, 2026.

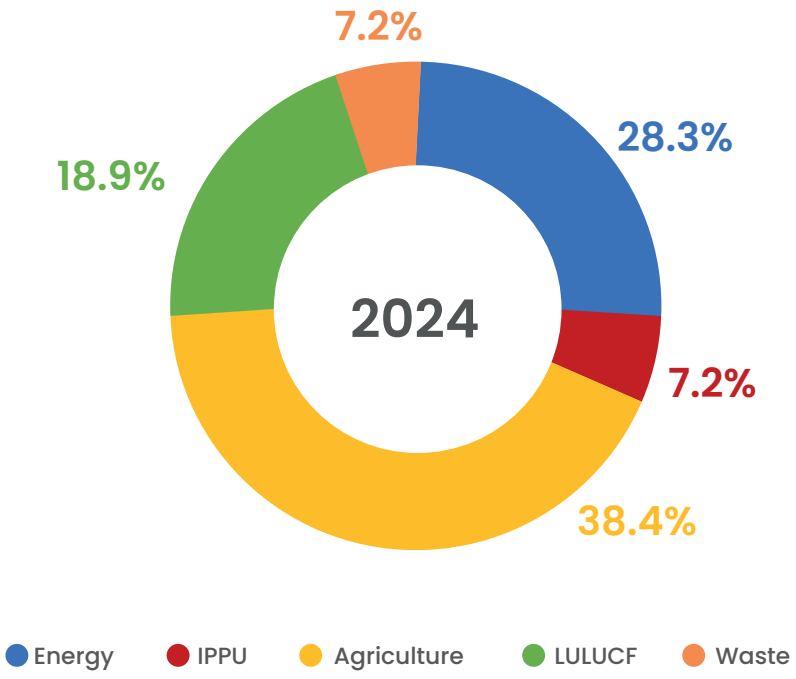
Figure 2.1 Net emissions by sector, in kt CO_2 eq, 1990–2024



Source: Prepared by the authors.

The composition of national emissions differs from that observed globally, primarily due to the higher relative share of the LULUCF and Agriculture sectors. In 2024, these sectors accounted for 57.3% of estimated emissions, while the Energy and IPPU sectors accounted for 35.5% and the Waste sector accounted for 7.2% (Figure 2.2).

Figure 2.2 Sectoral share of net GHG emissions in 2024



Source: Prepared by the authors.

Emissions in the Energy sector amounted to 426,906 kt CO_2 eq in 2024. The Fuel Combustion subsector (1.A) accounted for 95.4% of these emissions, while the Fugitive Emissions subsector (1.B) accounted for the remaining 4.6%. The Transport category was the most representative, accounting for 52% of the Energy sector's total emissions, followed by Manufacturing Industries and Construction and Energy Industries, with 16% and 15%, respectively.

Estimates of emissions from the IPPU sector totaled 108,602 kt CO_2 eq in 2024. The Metal Industry accounted for the largest share of emissions, accounting for 43% of the sector's emissions in kt CO_2 eq in 2024. The Mineral Industry Subsector was the second most representative, with 31%.

Emissions from the Agriculture sector totaled 579,322 kt CO_2 eq in 2024. Analyzing the contribution by subsector, it is possible to identify that the Enteric Fermentation subsector was the most representative of the Agriculture sector, with 62% of the total emissions in 2024, followed by the Agricultural Soils subsector, with 26%. On the other hand, the Manure Management and Liming subsectors together accounted for approximately 10% of the emissions, while the Rice Cultivation, Urea Application and Field Burning of Agricultural Residues subsectors together accounted for less than 3% of the sector's total emissions for that year.

Between 1990 and 2024, there was a 28% and 58% reduction in the emission of enteric methane per head of cattle and per kg of carcass produced, respectively. To achieve this result, the progress made in terms of sustainability of livestock production systems is noteworthy, as reflected in gains in production efficiency, such as improved pasture and reproductive management, reducing herd size and increasing production.

Net emissions from the LULUCF sector totaled 285,636 kt CO_2 eq in 2024. The sector's most representative net emissions came from the Grassland subsector (570,097 kt CO_2 eq), mainly reflecting conversions from Forest Land to Grassland (570,586 kt CO_2 eq). The largest net removals came from the Forest Land subsector, which accounted for -365,693 kt CO_2 eq, mainly as a result of protected vegetation within Conservation Units and Indigenous Lands.

Thanks to the effective implementation of the Action Plans for the Prevention and Control of Deforestation, emissions from this sector in 2024 were 89% lower than the peak recorded in 2004. Compared with 2022, there was a 67% reduction in emissions, primarily due to the decrease in deforestation in the Amazon, which fell by 50%, from 13,200 km² to 6,625 km². Decreases were also recorded in the Cerrado (24%, from 10,689 km² to 8,174 km²), in the Atlantic Forest (54%, from 1,033 km² to 475 km²), and in the Pampa (31%, from 755 km² to 524 km²).

Emissions from the Waste sector totaled 109,325 kt CO_2 eq in 2024. The Solid Waste Disposal subsector accounted for the largest share of emissions, with 73,509 kt CO_2 eq, or approximately 67% of the total. Wastewater Treatment and Discharge emitted 33,635 kt CO_2 eq in that year and accounted for approximately 31% of the sector's total. The other subsectors accounted for a smaller share of emissions.

Generally speaking, population growth and the increase in waste collection and proper disposal have led to a rise in emissions from the sector. While emissions from Managed Waste Disposal Sites increased by 11% compared to 2022, emissions from Unmanaged Waste Disposal Sites (controlled landfills and open dumps) increased by only 3% during this period, which is due to an increase in disposal in sanitary landfills, which, in turn, reduced the proportion of waste sent to Unmanaged Waste Disposal Sites or open dumps.

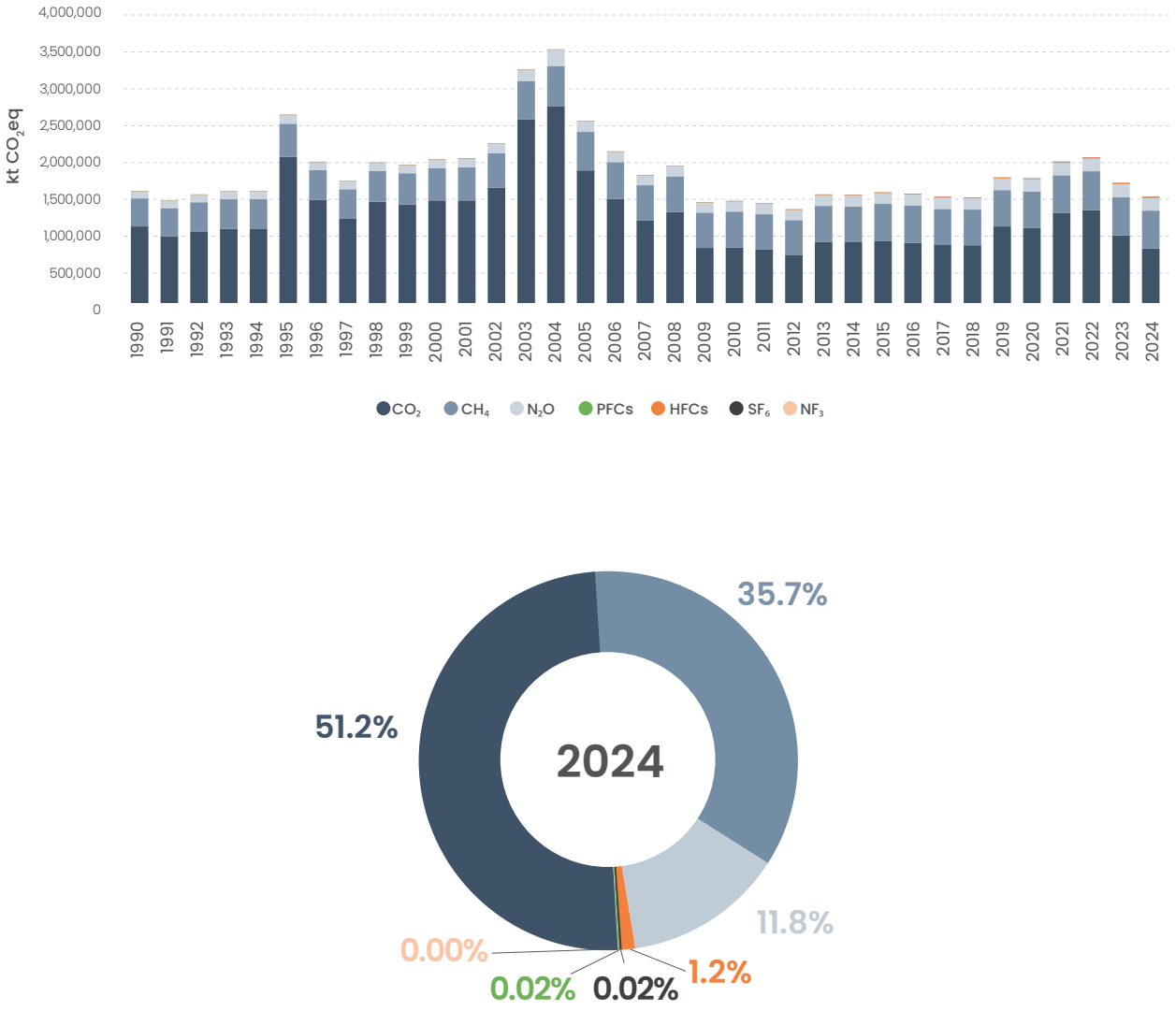
Table 2.1 Net emissions by sector, in kt CO_2 eq, selected years

SECTOR/CATEGORIES	1990	2005	2016	2022	2024
	NET EMISSIONS (kt CO_2 eq)				
TOTAL	**1,587,811**	**2,583,953**	**1,550,070**	**2,067,308**	**1,509,791**
1. ENERGY	**199,129**	**323,068**	**429,403**	**417,949**	**426,906**
1.A. Fuel combustion activities	190,697	304,467	408,153	399,301	407,267
1.A.1. Energy industries	28,638	52,671	81,803	57,637	63,253
1.A.2. Manufacturing industries and construction	37,632	65,562	72,579	70,153	67,363
1.A.3. Transport	84,544	139,744	205,098	218,668	221,573
1.A.4. and 1.A.5. Other sectors and Other (Not specified elsewhere)	39,883	46,490	48,673	52,843	55,079
1.B. Fugitive emissions from fuels	8,432	18,601	21,250	18,647	19,638
2. IPPU	**55,030**	**81,744**	**97,470**	**106,167**	**108,602**
2.A. Mineral industry	15,246	20,592	29,057	33,519	33,499
2.B. Chemical industry	8,591	13,498	9,387	7,690	7,099
2.C. Metal industry	29,975	44,665	46,679	46,430	46,811
2.D. Non-energy products from fuels and solvent use	1,091	1,249	2,764	2,031	2,429
2.E. Electronics industry	0	0	0	1	2
2.F. Product Uses as Substitutes for ODS*	0	1,554	9,293	16,153	18,402
2.G. Other product manufacture and use	128	187	290	343	360
3. AGRICULTURE	**379,893**	**502,837**	**545,467**	**573,075**	**579,322**
3.A. Enteric fermentation	269,942	348,725	353,117	356,168	356,287
3.B. Manure management	17,322	21,257	28,534	27,657	30,667
3.C. Rice cultivation	9,271	10,796	11,378	10,848	10,347
3.D. Agricultural soils	75,831	110,471	133,492	148,245	150,747
3.F. Field burning of agricultural residues	1,833	2,296	550	318	367
3.G. Liming	5,063	7,415	14,508	24,804	26,013
3.H. Urea application	631	1,878	3,888	5,035	4,894
4. LULUCF	**910,177**	**1,601,668**	**380,453**	**867,993**	**285,636**
4.A. Forest Land	-42,921	-277,386	-357,420	-347,524	-365,693
4.B. Cropland	79,352	199,463	129,084	193,603	122,091
4.C. Grassland	879,308	1,707,558	627,246	1,045,254	570,097
4.D. Wetlands	6,413	12,520	8,141	13,045	7,089
4.E. Settlements	6,898	7,450	4,258	5,636	3,348
4.F. Other land	1,275	5,071	8,727	14,751	7,689
4.G. Harvested wood products	-20,147	-53,008	-39,583	-56,771	-58,986
5. WASTE	**43,582**	**74,636**	**97,276**	**102,124**	**109,325**
5.A. Solid waste disposal	23,426	46,489	63,618	66,973	73,509
5.B. Biological treatment of solid waste	22	49	56	61	78
5.C. Incineration and open burning of waste	1,196	1,961	1,972	1,831	2,103
5.D. Wastewater treatment and discharge	18,939	26,137	31,631	33,259	33,635

* ODS: Ozone Depleting Substances

CO_2 was the predominant gas in Brazil's emissions, with a 51% share in 2024. Also in 2024, CH_4 and N_2O gases accounted for 36% and 12% respectively, while SF_6, HFCs, PFCs and NF_3 combined accounted for 1.27% of the total (Figure 2.3).

Figure 2.3 Brazil's net GHG emissions, in kt CO_2 eq, from 1990 to 2024



Source: Prepared by the authors.

CO_2 emissions resulted from activities mainly related to the use of fossil fuels for energy and to the changes in land use and land cover. Other sources that make up CO_2 emissions are the industrial processes for the production of pig iron and steel, cement, lime, soda ash, ammonia and aluminum, as well as the use of fertilizers in agriculture and the incineration or burning of solid waste.

National emissions of CH_4 come from agricultural activities, changes in land use and land cover, waste treatment, some industrial processes and from the extraction and refining of oil and natural gas.

National emissions of N_2O resulted from the application of inorganic N fertilizers and organic N fertilizers to the soil, as well as from the treatment of domestic wastewater, the burning of fossil fuels and biomass, industrial processes, and changes in land use and land cover.

With regard to fluorinated gases, the main emissions in Brazil are of HFCs. The main contribution of this family of gases came from the use of HFC-134a in the refrigeration and air conditioning category.

Highlights of emissions trends by sector[2]

- Brazil: Net emissions totaled 1,509,791 kt CO_2 eq in 2024, down 27% from 2022 and 41.6% from 2005. The decrease between 2022 and 2024 was primarily driven by the significant drop in LULUCF emissions, which was linked to a reduction in deforestation.
- Energy: Emissions reached 426,906 kt CO_2 eq in 2024. The increase reflected higher coal-fired thermal power generation, following the reversal of the favorable hydrological conditions observed in 2022; the growth of the motorcycle and light-duty truck fleet and increased consumption of Gasoline C (gasoline blended with anhydrous ethanol) and diesel; and the recovery of domestic and international aviation, with higher consumption of aviation kerosene.
- IPPU: Emissions reached 108,602 kt CO_2 eq in 2024, driven primarily by increased consumption of HFCs in refrigeration and air-conditioning equipment and non-energy products from fuels and solvent use. Emissions from the mineral and metal industry remained relatively stable, while those from the chemical industry decreased by about 8%.
- Agriculture: Emissions reached 579,322 kt CO_2 eq in 2024. Recent trends reflect the growth in cattle population and agricultural production, with effects on enteric fermentation, manure management, agricultural soils, inorganic N fertilizers, and liming; between 2023 and 2024, however, a one-off reduction in the cattle herd contributed to a drop of approximately 1% in emissions compared with the previous year.
- LULUCF: Net emissions fell from 867,993 kt CO_2 eq in 2022 to 285,636 kt CO_2 eq in 2024 (a 67% reduction), being the main factor driving the reduction in national emissions. During this period, deforestation decreased by 50% in the Amazon, 24% in the Cerrado, 54% in the Atlantic Forest, and 31% in the Pampa.
- Waste: Emissions reached 109,325 kt CO_2 eq in 2024, compared with 102,124 kt CO_2 eq in 2022. The increase is linked to the expansion of the population served by waste collection and the disposal of solid waste in sanitary landfills, alongside the closure of controlled landfills and open dumps.

Highlights of emissions trends by GHG

- CO_2: Net CO_2 emissions fell by 41.4% compared with 2022. The decrease was primarily driven by a 68.8% reduction in net LULUCF emissions, associated with a decrease in deforestation beginning in 2023, despite the increase in emissions from the Energy (+2.1%), Agriculture (+3.6%), and Waste (+14.7%) sectors. In 2024, the Energy sector accounted for 51.8% of net CO_2 emissions.

2 The trend analysis describes the main determinants or drivers that explain variations throughout the GHG emissions time series. Intensity indicators or implied emission factors are presented in the Common Reporting Tables (CRT) of the Inventory.

- CH_4: Emissions fell by 2.0%, primarily due to a 43.9% decrease in LULUCF emissions, associated with reduced deforestation, which offset the increase in emissions from the Agriculture (+0.7%) and Waste (+7.1%) sectors.
- N_2O: Emissions decreased by 1.4% in 2024. The decrease compared with 2022 was driven by a 43.1% drop in LULUCF emissions, while emissions increased in the Agriculture sector (+1.7%) and, more markedly, in the Energy sector (+7.3%), particularly in road transportation.
- HFCs: Emissions increased by 13.9% in 2024 compared with 2022. The increase is mainly associated with the expanded use of HFCs in refrigeration and air conditioning, including both the growth of the vehicle fleet equipped with air conditioning systems and the demand for air-conditioning in residential, commercial, and industrial buildings.
- PFCs, SF_6, and NF_3 showed different trends. Between 2022 and 2024, PFC emissions increased by 22.0%, driven by the rise in primary aluminum production, while SF_6 emissions increased by 5.1%, primarily due to leaks in high-voltage electrical equipment. NF_3, included in the NIR 2026, decreased by 18.9% due to a decline in the consumption of the gas used in semiconductor and TFT flat panel display production.

2.2 Other relevant information

The MCTI coordinates the preparation of Brazil's National Communications, Biennial Transparency Reports, and the National Inventory, which includes coordinating the preparation of the Inventory, and plays an important role in coordinating the different working groups that contribute to the collection of sectoral data.

While the First Biennial Transparency Report (BTR1) marked Brazil's first experience in reporting its Inventory under the Enhanced Transparency Framework (ETF) of the Paris Agreement, the NIR 2026 represents a further step in improving this process. In addition to updating the time series through 2024, this edition incorporates the results of lessons learned from accumulated institutional experience, national quality assurance and quality control processes, and the international technical expert review conducted after the submission of the BTR1.

The collaborative nature of the Inventory preparation remains a central element. The experience gained through the Fourth National Communication and the NIR 2024 involved a broad network of institutions and experts and established methodological bases, cooperation arrangements, and work procedures that continue to be refined. In the NIR 2026, this continuity is accompanied by greater integration among the Inventory's technical team, the agencies responsible for official databases, scientific institutions, and sector-specific organizations. The result is not limited to adding additional years to the time series: new activity data, emission factors, and parameters have made it possible to revise previous estimates[3], improve the traceability of the data, and, in some cases, begin estimating sources that had been classified as "not estimated" in the previous cycle.

Another improvement relates to the coverage of the reported gases. In the NIR 2026, the Inventory now includes the seven GHGs specified in the MPGs — CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3. The

3 Section 2.3.2 and the sections on uncertainty assessment, time-series consistency and recalculations in Chapters 4 to 8 of the NIR 2026 present the justifications for, and impacts of, the reviews by sector, subsector, and inventory category.

list of fluorinated substances covered by the IPPU sector has also been expanded, reflecting updated information on the gases used in the country. Among the precursor gases, this NIR also includes SO_2. This expansion enhances the completeness of the Inventory and reduces the need to use flexibility provisions provided for developing countries.

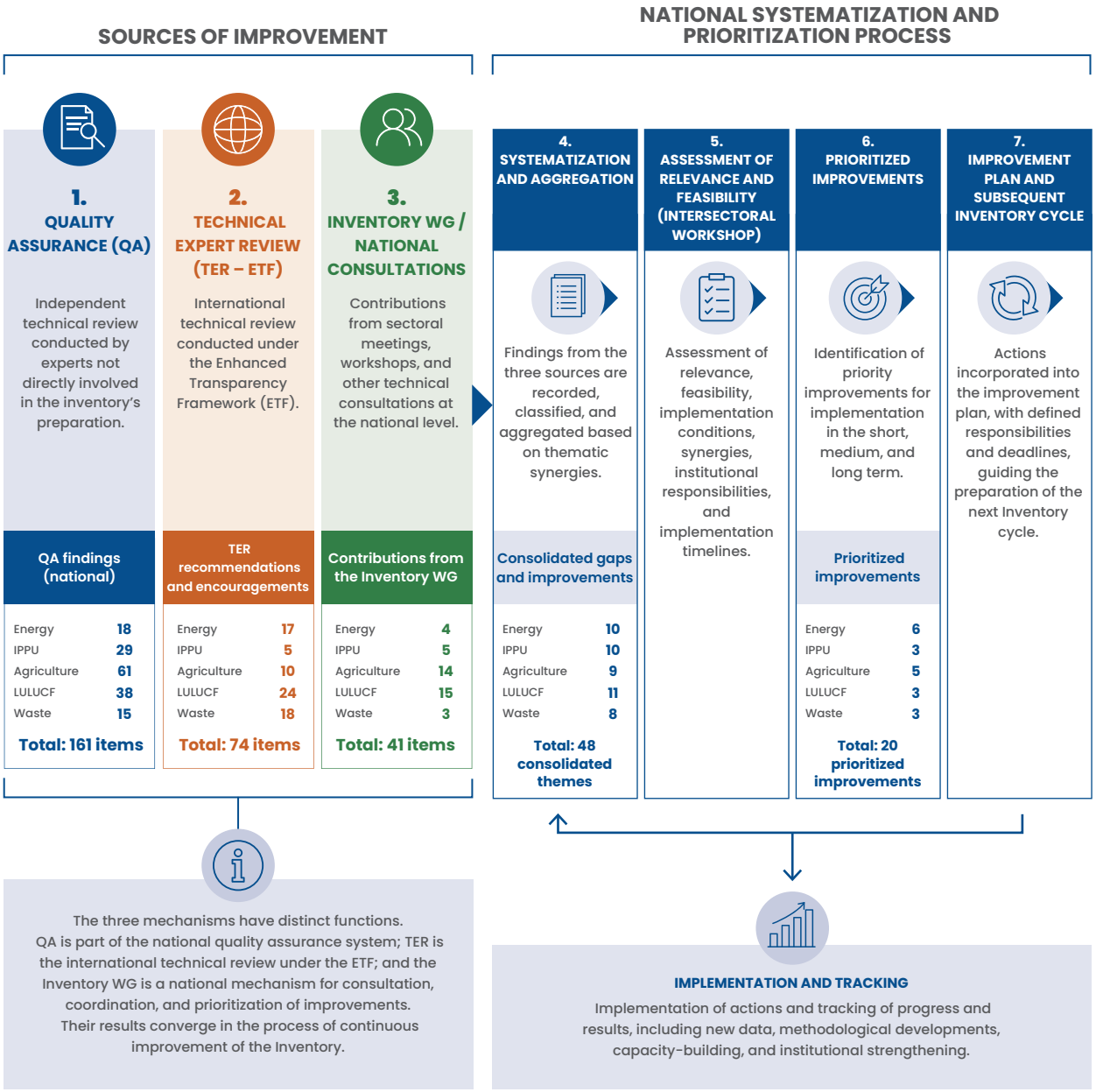
Greater completeness is directly linked to expanded access to data sources and strengthened institutional partnerships. A comparison of the "not estimated" categories (Dataframe 2.8, Section 2.7, "Overall Assessment of Completeness") between the NIR 2024 and the NIR 2026 shows that some of the gaps have been closed. Examples include the inclusion of emissions from natural gas processing, as well as emissions from its transmission and storage, based on the availability of more specific data. In the Waste sector, emissions associated with municipal solid waste buried by the public are now included in the calculations, and relevant time series have been revised and extended. In the IPPU sector, new data sources on foreign trade made it possible to estimate NF_3, and technical studies expanded the characterization of HFCs used in refrigeration and air conditioning. There are still categories for which sufficient data or a methodological basis for estimation are not yet available, but these constraints are more clearly identified, documented, and linked to improvement plans.

Another important improvement has been made in the way opportunities for improvement are identified, evaluated, and incorporated into the next cycle. The quality assurance (QA) process continues to be based on an independent technical review of the Inventory, while quality control (QC) consists of checks performed during its preparation. Starting with this BTR2, this system began to engage in a more structured dialogue with two additional sources of improvement: the recommendations and encouragements from the Technical Expert Review (TER), conducted within the framework of the ETF, and the contributions of the Technical Working Group on the National Inventory of Greenhouse Gas Emissions and Removals (Inventory WG), established under the Interministerial Committee on Climate Change (Brasil, 2024c)[4]. The work of the Inventory WG contributed, in particular, to systematizing technical issues identified by various sources, assessing their relevance and feasibility, and establishing priorities for improvement based on different implementation timelines.

Although they differ in nature, the results of these processes and initiatives were, in this cycle, systematized and evaluated jointly in terms of their relevance and feasibility, allowing for the prioritization of actions and the definition of different implementation timelines (Figure 2.4).

4 A temporary Technical Working Group established under the CIM, which brought together government representatives, experts, and partner institutions to systematize and prioritize improvements to the National GHG Inventory across different implementation timelines.

Figure 2.4 Systematization, prioritization, and implementation of opportunities for improving the National Inventory in the NIR 2026 cycle



Source: Prepared by the authors.

At the national level, the work carried out by the Inventory Technical Working Group made it possible to compile and discuss QA findings, TER recommendations, and sector-specific contributions, as well as to organize the identified issues into priorities and actions associated with different implementation timelines. This exercise helped distinguish between improvements that could be incorporated into the NIR 2026 and those that require methodological development, the collection of new data, or institutional coordination in subsequent cycles.

The incorporation of the TER recommendations into the NIR 2026 has had tangible effects on methods, data, and transparency. In the Energy sector, for example, the level of detail and the traceability of data on oil and natural gas were expanded, and new subcategories that had not

been previously estimated were incorporated. In the IPPU sector, methodological approaches and emission factors were reviewed, including those for cement production, and data on fluorinated gases were updated. In the Waste sector, time series, parameters, classification criteria, and *proxies* used to fill in missing data were reviewed. As a result, the international review is no longer merely a step that follows submission; rather, it explicitly provides feedback that informs the preparation of subsequent inventories.

This progress is also reflected in the use of the flexibility provisions set out in the MPGs. Given the completeness of the greenhouse gas estimates in this Inventory, Brazil no longer uses these provisions.

Together, these advances indicate a qualitative shift between the first two biennial reporting cycles. The NIR 2026 preserves the methodological continuity necessary to ensure the consistency of the time series, but expands its coverage, incorporates new evidence, strengthens the documentation of data and of methodological decisions, and makes the link between review, correction, and planning for improvements more explicit. Greater participation by data providers and partner institutions, a structured response to the TER's recommendations, the systematization and prioritization exercise carried out under the Inventory Technical Working Group, and the further development of the QA/QC plan all contribute to a more complete, transparent, and traceable Inventory. More than just recording emissions and removals, this process strengthens a national climate information infrastructure capable of learning with each cycle and providing an increasingly robust foundation for tracking Brazil's public policies and climate commitments.

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CHAPTER 3

Information necessary to track progress made in implementing and achieving nationally determined contributions under Article 4 of the Paris Agreement

3.1 National circumstances and institutional arrangements

Reducing greenhouse gas (GHG) emissions is the main pathway identified by science to curb global warming and prevent even more severe impacts. Mitigation includes the adoption of technological changes and replacements aimed at reducing the use of resources and emissions per unit of production, as well as the implementation of measures and policies aimed at reducing emissions and increasing carbon removals.

Brazil has specific national circumstances associated with its territorial extent, diversity of biomes, economic profile, and energy matrix, which influence both emissions dynamics and the strategies adopted for the implementation and tracking of its Nationally Determined Contribution (NDC). Population and urban growth brought the challenge of striking a balance between economic development, environmental conservation, and social inclusion. To this end, Brazil has stepped up its efforts towards sustainable development and, due to investments in research and innovation, has succeeded in increasing its industrial and agricultural production in line with environmental responsibility and with the fight against hunger and poverty. Investment in agricultural production has enabled Brazil to transform itself from a food-importing country with severe food insecurity in the 1970s to the world's second largest food exporter, a strategic stakeholder in the planet's food security.

The country has developed internationally recognized policies and technologies for sustainable agriculture, guided by an integrated landscape approach, the adoption of sustainable practices in areas suitable for agriculture, and incentives to promote environmental compliance by rural properties. The Brazilian Forest Code[1] is one of the most advanced environmental laws in the world. As a Federal Law, it establishes fundamental guidelines for the preservation of native vegetation on private rural properties in Brazil, and is essential for maintaining environmental balance, guaranteeing soil fertility, air quality, water availability and climate stability, which are essential factors for sustainable agricultural production. The legislation not only regulates the protection of vegetation, but also defines rules for Permanent Preservation Areas (APPs, Áreas de Preservação Permanente) and Legal Reserves (RLs, Reservas Legais), as well as providing for forest exploitation, the supply of raw materials, control of the origin of forest products, and fire prevention.

Additionally, the Forest Code creates the Rural Environmental Registry (CAR, Cadastro Ambiental Rural), a nationwide electronic public registry, which is mandatory for all rural properties, with the purpose of integrating environmental information on rural properties and landholdings, creating a database for control, monitoring, environmental and economic planning, and combating deforestation.

Thus, Brazil stands out both due to its natural characteristics and its political and economic actions. Extensive forest cover, high renewable energy generation potential, the development of low-carbon agricultural practices, advances in technology and innovation, legislation and the implementation of public policies, as well as active participation in negotiations and commitment to international agreements, are factors that, combined, give the country a

1 *Law No. 12,651, of May 25, 2012*. The first version of the Forest Code dates back to 1934. In 1965, it underwent a revision, and in the decades that followed, other laws and provisional measures further updated it.

strategic role in addressing climate change, enabling it to contribute significantly to mitigating its impacts and promoting sustainable development.

Unlike the pattern observed in many developed countries, where emissions associated with fossil fuel combustion predominate, Brazil's GHG emissions profile has a higher relative share from the LULUCF and Agriculture sectors. For more details on Brazil's emissions profile, see **Chapter 2** of this Report, as well as the detailed information presented in Brazil's National Inventory Report (NIR 2026).

To understand how national circumstances affect GHG emissions and removals over time, it is important to consider Brazil's territorial extent, climatic diversity, and economic complexity. The country encompasses equatorial, tropical, and temperate climate zones, with a predominantly tropical climate (IBGE, 2002). Further details are provided in **Chapter 1** (Information in response to TER recommendation 8.1 – Appendix 3). Climate variability, including events such as *El Niño* and *La Niña*, can alter precipitation regimes and intensify extreme events, such as droughts and wildfires, with potential impacts on emissions associated with deforestation, fires, and agricultural production. Thus, analyzing Brazil's emissions profile requires considering both the structural characteristics of its territory and economy and the climatic factors that affect the dynamics of the LULUCF and Agriculture sectors.

Historically, land-use conversions in the Amazon and Cerrado biomes have played an important role in the trends in GHG emissions observed in the country. In this context, the Action Plans for the Prevention and Control of Deforestation and Fires (PPCDs, Planos de Ação para Prevenção e Controle do Desmatamento e das Queimadas) are key instruments of Brazilian public policy aimed at reducing deforestation and fires and, consequently, mitigating GHG emissions associated with the LULUCF sector. The plans are structured into multi-year phases to update strategies, targets, and areas of action in accordance with the political and environmental context. Currently, the federal government has action plans for the prevention and control of deforestation for all biomes (Dataframe 3.1). The PPAmazônia and the PPCerrado – Action Plans for the Prevention and Control of Deforestation and Fires in the Amazon and in the Cerrado (Plano de Ação para Prevenção e Controle do Desmatamento e das Queimadas) – are the plans with the longest history in the country.

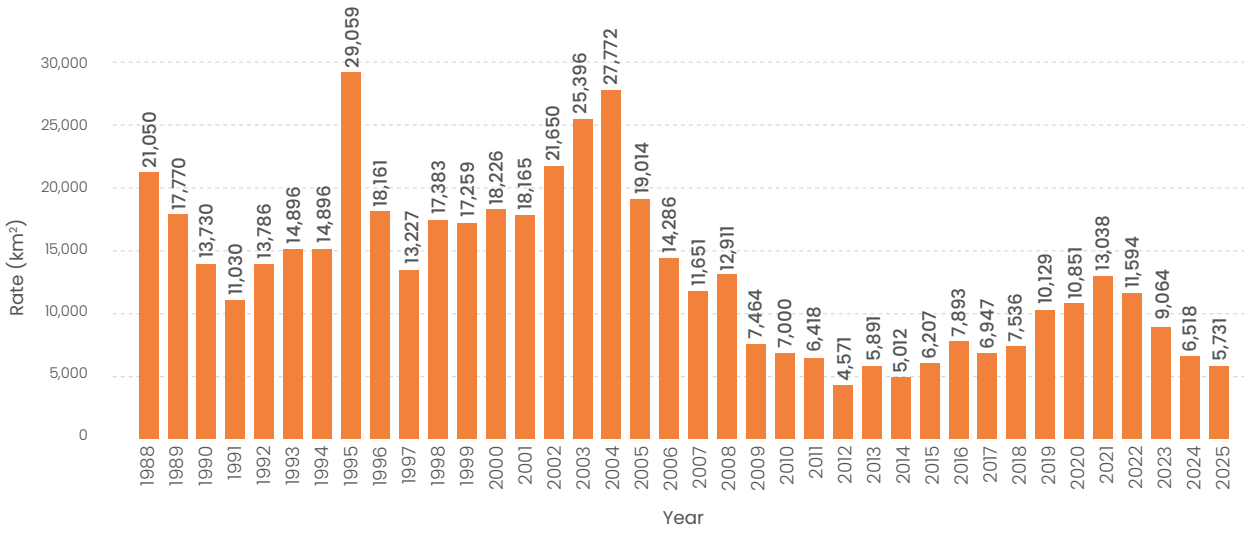
Dataframe 3.1 Action Plans for the Prevention and Control of Deforestation by biome

Biome	Plan	Current phase	Term
Amazon	PPAmazônia	5th phase	2023-2027
Cerrado	PPCerrado	4th phase	2023-2027
Atlantic Forest	PPMata Atlântica	1st phase	2025-2027
Caatinga	PPCaatinga	1st phase	2024-2027
Pantanal	PPPantanal	1st phase	2024-2027
Pampa	PPPampa	1st phase	2025-2027

Source: Compiled based on the Action Plans for the Prevention and Control of Deforestation and Fires of the Ministry of the Environment and Climate Change (MMA, Ministério do Meio Ambiente e Mudança do Clima).

The PPAmazônia is in its 5th phase (2023–2027), having achieved its greatest success in reducing deforestation between 2004 and 2012, when a reduction of approximately 83% was recorded. At the current stage, there has been a consistent and significant reduction in deforestation rates since 2023, reflecting the strengthening of control actions, as shown in Figure 3.1.

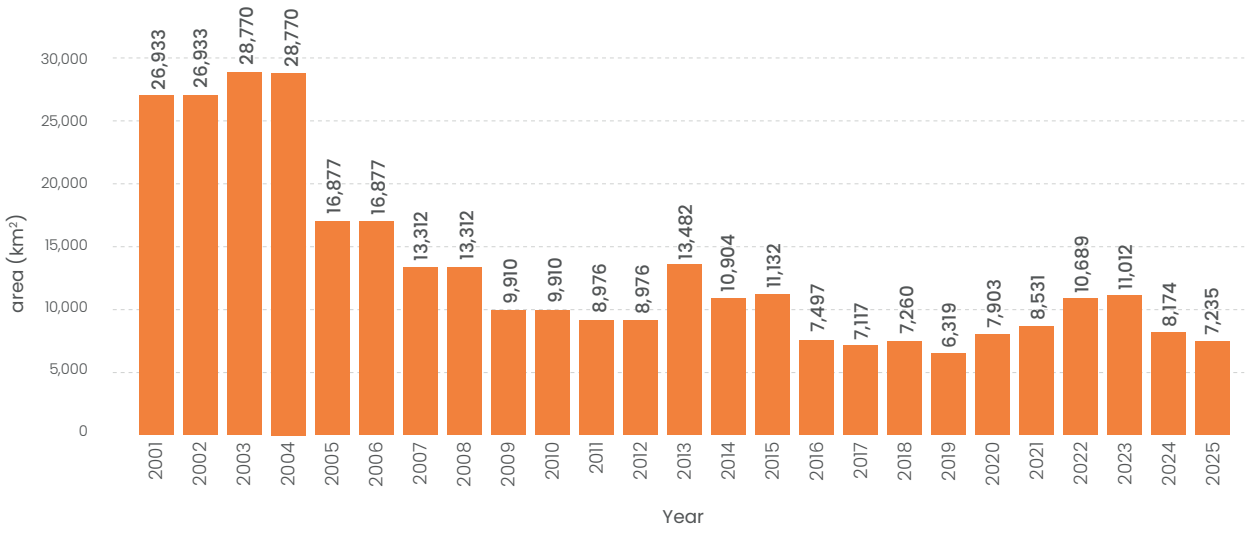
Figure 3.1 Deforestation rate in the Legal Amazon over the years



Source: INPE 2026a.

The PPCerrado was implemented in a context of high anthropogenic pressure on the biome. However, Figure 3.2 shows a trend toward decreasing deforestation rates in the biome, associated with the strengthening of monitoring systems, as well as the intensification of environmental enforcement actions.

Figure 3.2 Deforestation rate in the Cerrado in recent years



Source: INPE, 2026b.

Within the framework of policies aimed at the protection of biomes and biodiversity, key initiatives include the reactivation of the Amazon Fund (Fundo Amazônia) and the launch, between 2024 and 2025, of the action plans for the prevention and control of deforestation for the other biomes (Caatinga, Atlantic Forest, Pampa, and Pantanal).

In addition to these plans, the following are the key measures aimed at reducing deforestation in Brazil:

- The strengthening of interinstitutional governance through the Permanent Interministerial Working Group (GPTI, Grupo Permanente de Trabalho Interministerial), coordinated by the Office of the Chief of Staff, with the participation of various ministries, in addition to expanding the involvement of nongovernmental organizations and the scientific community (Brasil, 2023);
- The development and implementation of the Real-Time Deforestation Detection System (DETER, Sistema de Detecção do Desmatamento em Tempo Real), which enabled continuous monitoring and supported the integrated environmental enforcement action conducted by the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA, Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis), in coordination with the Federal Police, the Federal Highway Police, the National Public Security Force, and the Brazilian Army (Brasil, 2023);
- The creation of approximately 50 million hectares of Conservation Units and the official designation of around 10 million hectares of Indigenous Lands throughout the various phases of the PPAmazônia (Reis and Corazza, 2025; Brasil, 2023);
- The implementation of the Soy Moratorium, an agreement between civil society organizations and entities representing the productive sector that prohibits soybean cultivation in areas converted from native forests after July 2008 (Gibbs *et al.*, 2015); and
- The designation of priority municipalities for deforestation control actions and the adoption of restrictions on access to rural credit for properties with embargoed areas in the region starting in 2008 (Brasil, 2023).

Additionally, the National Biodiversity Strategy and Action Plan (EPANB, Estratégia e o Plano de Ação Nacionais para a Biodiversidade, 2025–2030)[2] was established as a planning instrument encompassing strategic goals for 2050, national biodiversity targets for 2030, and an action plan for the period from 2025 to 2030.

In 2023, within the framework of the National Commission for the Restoration of Native Vegetation (Conaveg, Comissão Nacional para Recuperação da Vegetação Nativa), the process of revising the National Plan for the Restoration of Native Vegetation (Planaveg, Plano Nacional de Recuperação da Vegetação Nativa) began, with a view to incorporating the current challenges and opportunities of the agenda and strengthening the political commitment to achieving the target of 12 million hectares of native vegetation under restoration by 2030. As a result of this process, the Plan's new strategic framework for the period 2025–2028 was established[3]. Planaveg's goal is to expand and strengthen public policies, financial incentives, markets, restoration technologies, good agricultural practices, and other actions necessary for the restoration of native vegetation.

2 Decree No. 12,485 of June 3, 2025, and GM - Minister's Office (Gabinete do Ministro)/MMA Ordinance No. 1,519 of November 25, 2025.

3 CONAVEG Resolution No. 4, dated November 25, 2024.

Also in 2023, the Amazon Restoration Arc (Arco da Restauração na Amazônia) initiative was launched, with the goal of restoring 6 million hectares of forest by 2030 and 24 million hectares by 2050. The initiative is linked to the mobilization of public and private investments, estimated at around BRL 200 billion, and to the generation of socioeconomic benefits, including significant potential for the creation of up to 10 million jobs in the region (BNDES, 2023).

Agriculture plays a significant role in the Brazilian economy and in the dynamics of national greenhouse gas emissions. Brazil has the second-largest cattle production in the world, behind only India, and is the largest producer of beef, accounting for 20.2% of global production, and the largest exporter, accounting for 25.1% of the total volume exported worldwide in 2025 (USDA, 2026; ABIEC, 2026). In addition to its economic importance, the sector plays a central role in mitigation strategies and in the transition to a low-carbon economy. For decades, the country has been investing in research and technological development in tropical agriculture which, together with public policies and technical assistance for the optimization of areas already in use and the recovery of pasture areas, enabled significant productivity gains without a proportional expansion of agricultural area (FGV, 2025). The supply of feedstocks for biofuel production and biomass for energy generation contributes to increasing the share of renewable energy in Brazil's energy matrix and reducing emissions in sectors such as Energy and IPPU. This intersectoral contribution may, however, be associated with increased production activity and, consequently, with pressures on emissions accounted for in the Agriculture sector.

In the Agriculture sector, key initiatives include the ABC+ Plan (2020–2030)[4], which continues the sectoral policy to address climate change in the agriculture sector, and the National Program for the Conversion of Degraded Pastures[5] (also known as *Caminho Verde Brasil* (Brazil's Green Pathway)), which aims to restore and convert up to 40 million hectares of pastures into productive areas over a ten-year period, contributing to increased productivity, improved land use, and the efforts to address climate change.

Family farming is a fundamental component of the Brazilian rural sector, with significant productive, social, and territorial relevance. More details are provided in **Chapter 1**. The diversity of production systems found in Brazilian family farming also points to its potential to contribute to climate change mitigation strategies. In different territorial contexts, some of these systems are characterized by greater production diversification, integration of crop, livestock, and forestry components, the presence of permanent vegetation cover, and the adoption of conservation-oriented, agroecological, or ecologically-based management practices, often associated, in certain contexts, with lower intensity of external input use.

Given its productive, territorial, and socio-environmental diversity, family farming is included in a cross-cutting manner in the mitigation agenda under the Climate Plan, particularly in the sectoral plans for Agriculture and Livestock; Land-Use Change in Private Rural Areas; and Land-Use Change in Public Areas and Collective Territories, contributing to the achievement of Brazil's NDC both in terms of agricultural production and land use and land-use change dynamics.

Currently, in the National Inventory, activity data associated with family farming production units are incorporated in aggregate form into official agriculture sector statistics, without specific disaggregation by production segment. The level of detail currently available

4 Sectoral Plan for Climate Change Adaptation and Low-Carbon Emission in Agriculture, aimed at Sustainable Development.

5 Decree No. 11,815, dated December 5, 2023.

limits the characterization of distinct mitigation, removal, and vulnerability profiles across different production systems.

The development of activity data and emission and removal factors calibrated for diversified, integrated, and smaller-scale systems, including agroforestry systems, crop-livestock-forestry integration, conservation-oriented management, and practices associated with traditional knowledge, together with improvements in monitoring, reporting, and verification (MRV) frameworks, could enable a more detailed characterization of intrasectoral variability[6].

The Brazilian energy sector has unique characteristics, notably the high share of renewable sources in electricity generation, with hydropower being the predominant source, as presented in **Chapter 1**. This profile contributes to Brazil's electricity generation having a low emissions intensity compared to international benchmarks, with significant effects on the country's greenhouse gas emissions pathway. However, in the context of climate change, the high dependence on hydropower generation makes the Brazilian electricity system more vulnerable to increasing variability in the rainfall regime, an issue that will be analyzed in **Chapter 4** of this Report.

With regard to renewable fuels, Brazil has the National Biofuels Policy (*RenovaBio)*[7], which establishes certification mechanisms for the efficient production of biofuels based on technical and environmental criteria and on carbon intensity. This policy plays an important role in the sector's expansion by strengthening regulatory predictability, promoting efficiency gains, and enhancing the socio-environmental traceability of production.

In 2024, the Fuel of the Future Law[8] consolidated new instruments to promote low-carbon sustainable mobility, including initiatives aimed at decarbonizing air transport and the natural gas sector, as well as fostering innovation, diversifying technological pathways, and expanding the supply of less carbon-intensive fuels. Brazil ranks among the world's leading biofuel producers, with a prominent position in ethanol and biodiesel production. In addition to their large-scale use as vehicle fuels, the sugarcane energy supply chain also contributes to electricity generation through the energy recovery of bagasse and other sugarcane residues, with this bioelectricity being fed into the Brazilian Interconnected System (SIN, Sistema Interligado Nacional).

In addition, the National Energy Transition Policy (PNTE, Política Nacional de Transição Energética)[9], approved in 2024, guides national efforts to transform the energy matrix toward a less carbon-intensive structure. The Energy Transition Acceleration Program (PATEN, Programa de Aceleração da Transição Energética)[10], in turn, strengthens instruments that support the transition, focusing on mobilizing financing, on infrastructure, and on innovation. The Legal Framework for Low-Carbon Hydrogen[11] is also part of this framework, expanding the institutional basis for the development of new energy pathways compatible with the decarbonization of the economy.

6 The Cooperation Project led by the Food and Agriculture Organization of the United Nations (FAO), in partnership with the Ministry of Agrarian Development and Family Farming (MDA, Ministério do Desenvolvimento Agrário e Agricultura Familiar), is endeavoring to obtain exploratory estimates of emission intensity in systems characteristic of Brazilian family farming.

7 Law No. 13,576 of 2017.

8 Law No. 14,993/2024.

9 CNPE – National Energy Policy Council (Conselho Nacional de Política Energética) Resolution No. 5/2024.

10 Law No. 15,103/2025.

11 Law No. 14,948/2024.

At the regional level, the Amazon Energy Program[12] (Programa Energias da Amazônia) was established with the aim of expanding the replacement of diesel fuel with renewable sources and more sustainable energy solutions in the region's isolated power systems, contributing to emissions reductions and improved energy supply conditions.

At the intersection of the Energy, Industry, and Transport sectors, key initiatives include the Green Mobility Program (Mover, Programa Mobilidade Verde)[13], which strengthens sustainability and decarbonization requirements for the vehicle fleet and encourages the development of new technologies and investments in mobility and logistics; and the Better Air Program (Programa MelhorAr)[14], an initiative aimed at reducing air pollutant emissions from road freight and passenger transport vehicles. These instruments focus primarily on fuels, vehicles, industrial production, and emissions, without replacing mobility policies aimed at reducing motorized travel, prioritizing public transport, and promoting active modes of transportation.

It is also important to mention the New Industry Brazil Program (Programa Nova Indústria Brasil)[15], which addresses reindustrialization with a focus on low-carbon development, technology chains, and competitiveness.

In the context of urban mobility, a key development is the recent approval of the Legal Framework for Public Transport (Law No. 15,432/2026), which seeks to establish new forms of financing and promote the energy transition and fleet electrification. In addition, the National Urban Mobility Study (ENMU, Estudo Nacional de Mobilidade Urbana), conducted by the Brazilian Development Bank (BNDES, Banco Nacional de Desenvolvimento Econômico e Social) and the Ministry of Cities, supports a portfolio of long-term metropolitan investments focused on efficiency and on reducing climate impacts.

In this context, the Fleet Renewal subcategory, part of the Sustainable Urban Mobility subcomponent of the New Growth Acceleration Program (Novo PAC, Novo Programa de Aceleração do Crescimento), supports the acquisition of vehicles and equipment with lower environmental impacts for public transport, contributing to fleet modernization and the adoption of lower-emission technologies. In 2024, approximately BRL 10.6 billion was allocated to urban fleet renewal, including 2,296 electric buses, 3,015 Euro 6-compliant buses, and 39 rail vehicles, distributed across 61 municipalities and seven Brazilian states.

These instruments reflect an integrated approach to promoting less carbon-intensive technologies and practices in the productive and transport sectors, contributing to the transition to a low-emission economy.

In addition, the Ecological Transformation Plan was launched in 2023, coordinated by the Ministry of Finance, outlining a vision of economic growth, social inclusion, and environmental preservation, and seeking to mobilize investments based on decarbonization.

Also aligned with the Plan is the Pact for Ecological Transformation initiative, signed in 2024, which represents a commitment among the Executive, Legislative, and Judicial Branches to work harmoniously and in an integrated manner to promote ecological transformation

12 Decree No. 11,648/2023.

13 Law No. 14,902/2024.

14 MT - Ministry of Transport (Ministério dos Transportes) Ordinance No. 192/2025.

15 CNDI/MDIC (Conselho Nacional de Desenvolvimento Industrial (National Council for Industrial Development)/Ministério do Desenvolvimento, Indústria, Comércio e Serviços (Ministry of Development, Industry, Trade and Services)) Resolution No. 1/2023.

through legislative, administrative, and judicial measures. Another noteworthy initiative is the establishment of the Commitment to Climate Federalism[16], which places climate change at the center of the political and governmental agenda at different levels of government.

In addition, a noteworthy initiative is the development of national long-term planning, led by the National Planning Secretariat of the Ministry of Planning and Budget (SEPLAN/MPO - Secretaria Nacional de Planejamento/Ministério do Planejamento e Orçamento), within the scope of the Brazil 2050 Strategy project[17], with the aim of incorporating climate change, among other aspects, into the country's long-term planning (see Box 1.2).

It is also worth noting the importance of science and its role in informing public policy. Under the Climate Plan, the MCTI – Ministry of Science, Technology and Innovation (Ministério da Ciência, Tecnologia e Inovação) is responsible for technical and scientific coordination. Within the CIM – Interministerial Committee on Climate Change (Comitê Interministerial sobre Mudança do Clima), the Scientific Advisory Chamber (CAC, Câmara de Assessoramento Científico) was established, comprising experts from the scientific community, with the aim of ensuring that the formulation and implementation of climate policies in Brazil are guided by the best available scientific evidence and knowledge.

In addition to the institutional examples mentioned above, other institutional arrangements are related to the climate agenda, including the National Commission for Reducing Greenhouse Gas Emissions from Deforestation and Forest Degradation, Conservation of Forest Carbon Stocks, Sustainable Management of Forests, and Enhancement of Forest Carbon Stocks – REDD+ (CONAREDD+, Comissão Nacional para Redução das Emissões de Gases de Efeito Estufa Provenientes do Desmatamento e da Degradação Florestal, Conservação dos Estoques de Carbono Florestal, Manejo Sustentável de Florestas e Aumento de Estoques de Carbono Florestal), and the National Commission for the Restoration of Native Vegetation (Conaveg). CONAREDD+ aims to coordinate, enforce, and monitor the implementation of the National REDD+ Strategy and coordinate the development of eligibility criteria for payments and REDD+ results-based actions in Brazil. Conaveg is responsible for coordinating the implementation, monitoring, and evaluation of the National Policy for the Restoration of Native Vegetation (Proveg, Política Nacional de Recuperação da Vegetação Nativa) and the National Plan for the Restoration of Native Vegetation (Planaveg, Plano Nacional de Recuperação da Vegetação Nativa).

Also worth noting is the Brazilian Greenhouse Gas Emissions Trading System (SBCE, Sistema Brasileiro de Comércio de Emissões de Gases de Efeito Estufa), established in 2024[18]. This policy aims to promote sustainable development and reindustrialization based on new technologies and contribute to the implementation of the PNMC – National Policy on Climate Change (Política Nacional sobre Mudança do Clima) and the fulfillment of commitments made under the UNFCCC. The Law provides for gradual implementation in five phases: regulation; operationalization of reporting instruments by operators; a period during which operators are required only to submit a plan for monitoring and reporting emissions and removals; entry into force of the first National Allocation Plan; and full implementation (Article 50). Operators of facilities and sources with emissions exceeding 10,000 tCO_2e/year are subject to monitoring and

16 Resolution No. 3 of the Federation Council, dated July 3, 2024.

17 Established by MPO Ordinance No. 244 of August 7, 2024, and SEPLAN/MPO Ordinance No. 345 of October 11, 2024. Available at: https://www.gov.br/planejamento/pt-br/assuntos/planejamento/estrategia-2050-conteudo/normativos. Accessed on: Sep. 11, 2026.

18 Law No. 15,042, dated December 11, 2024.

reporting obligations, while those with emissions exceeding 25,000 tCO_2e/year are additionally subject to periodic reconciliation of obligations (Article 30).

Since 2025, the Extraordinary Secretariat for the Carbon Market of the Ministry of Finance (SEMC/MF, Secretaria Extraordinária do Mercado de Carbono/Ministério da Fazenda) has temporarily exercised the responsibilities of the managing body (Decree No. 12,677/2025). In 2026, regulations were developed to define the sectors and the timetable for monitoring, reporting, and verification (MRV) obligations.

The SBCE is currently in the regulatory and operational development phase, with the gradual implementation of its monitoring, reporting, and verification (MRV) instruments, the establishment of emissions limits, allowance allocation rules, and mechanisms for trading carbon assets. In this context, its contribution to the achievement of Brazil's climate targets is expected to take place progressively as the system becomes operational and its regulatory instruments provide effective incentives for reducing greenhouse gas emissions. The effectiveness of the SBCE will also depend on the ability of regulated operators to make the investments necessary to implement mitigation measures and adopt low-carbon technologies. To this end, it will be essential to expand access to national and international climate financing instruments capable of enabling the decarbonization of regulated sectors and enhancing the system's contribution to the achievement of Brazil's NDC.

3.1.1 Institutional arrangements currently in force to track the progress made in implementing and achieving the NDC

As detailed in **Chapter 1,** the National Policy on Climate Change (PNMC), established in 2009, plays a central role in the national climate planning system. One of its key instruments is the 2024-2035 Climate Plan, which guides adaptation and mitigation actions aimed at reducing the adverse effects of climate change and the vulnerability of environmental, social, and economic systems. In accordance with the Constitution, the PNMC, and the commitments Brazil has made under international agreements, the country has sought to strengthen its climate governance and integrate environmental policy into the national development strategy by improving institutional and regulatory frameworks and economic instruments, as well as by expanding intersectoral coordination. These efforts have contributed to strengthening governance, advancing financing mechanisms, and supporting the reduction of greenhouse gas emissions.

In this context, there has been a growing integration of the climate change agenda into the federal government's institutional framework, with the creation and strengthening of specific units within various ministries. Examples include units dedicated to climate change within the Ministry of Health; Ministry of Indigenous Peoples; Ministry of Cities; Ministry of Tourism; Ministry of the Environment and Climate Change; Ministry of Science, Technology and Innovation; Ministry of Integration and Regional Development; among others.

Currently, the Interministerial Committee on Climate Change (CIM) is the main collegiate body of Brazil's climate change governance framework, responsible for coordinating the implementation and monitoring of the Climate Plan. It also plays a role in interministerial coordination and in aligning national strategies with international commitments, such as Brazil's Nationally Determined Contribution (NDC) under the Paris Agreement (Brasil, 2025).

The CIM has determined that the Climate Plan is the instrument for achieving the NDC[19] targets. The Climate Plan seeks to combine technical rigor, based on the best available science and evidence from a wide range of sectors, with active and informed engagement with the Brazilian population (Brasil, 2026a).

As detailed in **Chapter 1,** the development of the Climate Plan involved a broad participatory process that brought together different sectors of society and involved approximately 24,000 people. Dozens of workshops and technical meetings were held, in addition to nine territorial plenary sessions that brought together participants from all regions of the country, as well as digitally, through public consultations conducted as part of the Participatory Climate Plan (Plano Clima Participativo) initiative (Information provided in response to TER recommendation 8.2 - Appendix 3). These contributions resulted in 1,292 proposals aimed at formulating the National Adaptation and Mitigation Strategies and structuring their respective sectoral and thematic plans (Brasil, 2026a).

The Climate Mitigation Plan consists of the National Mitigation Strategy (ENM, Estratégia Nacional de Mitigação) and its eight Sectoral Mitigation Plans (PSM, Planos Setoriais de Mitigação), which organize the Plan's implementation instruments. Further details will be provided in section **3.4** of this chapter.

The Cross-Cutting Strategy for Monitoring, Management, Evaluation, and Transparency (ET-MGAT, Estratégia Transversal de Monitoramento, Gestão, Avaliação e Transparência)[20] serves as a necessary instrument for structuring the operationalization and institutionalization of the monitoring and evaluation of climate commitments. The ET-MGAT stipulates that the evaluation of progress toward the achievement of the NDC shall be integrated into the biennial evaluation cycle of the Climate Plan (Brasil, 2026b).

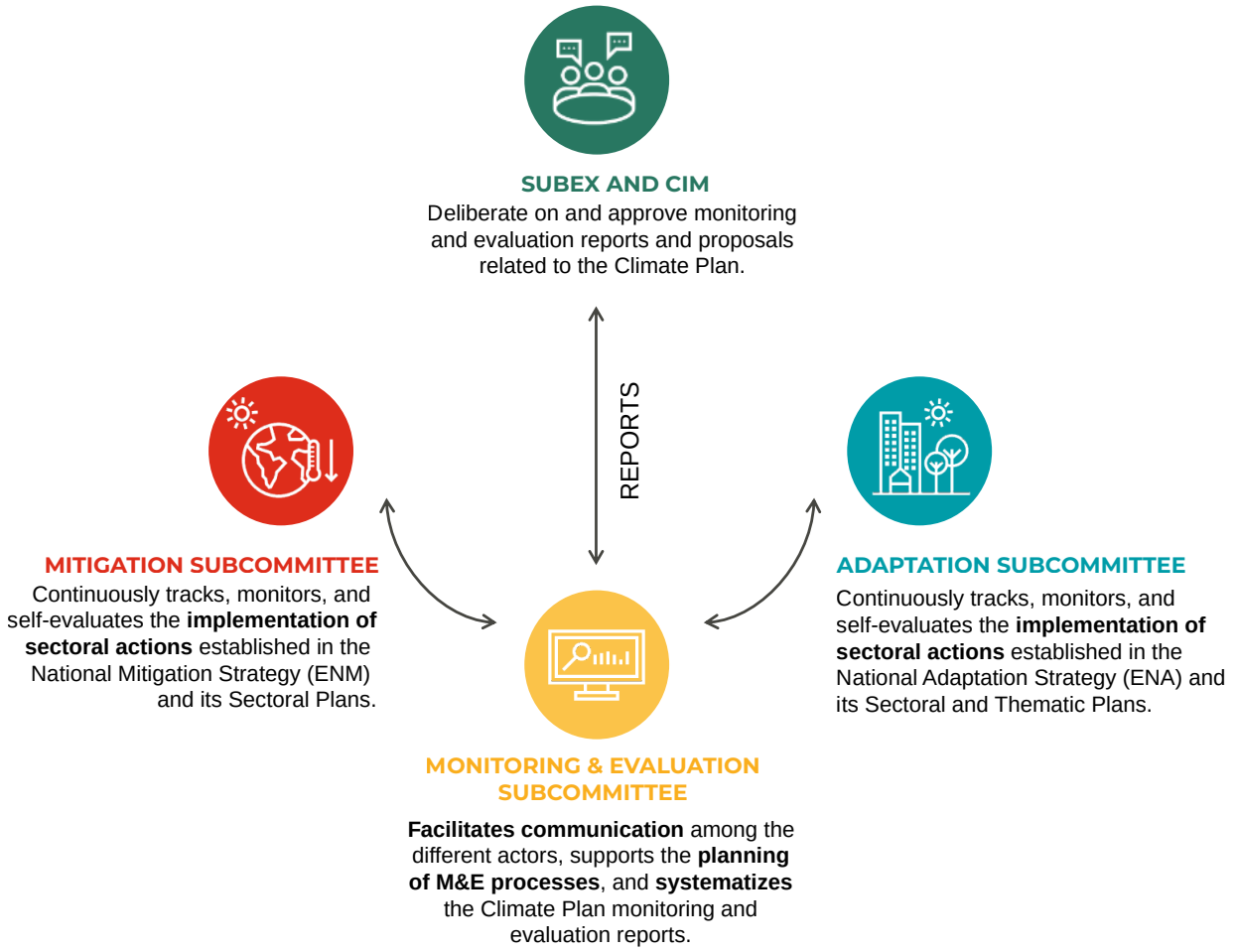
Through the ET-MGAT, efforts are made to align the Climate Plan's evaluation methodologies with existing national parameters and the guidelines of the United Nations Framework Convention on Climate Change (UNFCCC), with a view to promoting consistency between national and international monitoring and transparency processes. This alignment is intended to support the preparation of the Biennial Transparency Reports (BTRs) and to integrate the monitoring, evaluation, and updating cycles of the Climate Plan (Brasil, 2021).

Governance for the monitoring, evaluation, and updating of the Climate Plan takes place within the framework of the CIM and is based on the synergistic action of the Plenary of Ministers, the Executive Subcommittee (SUBEX, Subcomitê-Executivo), the Adaptation, Mitigation, and Monitoring and Evaluation Subcommittees, and the CIM's Advisory Chambers (Scientific Advisory Chamber, Interfederative Coordination Chamber, and Social Participation Chamber), with a view to institutionalizing data collection and information production, technical analysis, approval, validation, and public disclosure of the information generated through the cycles established in the ET-MGAT.

19 CIM Resolution No. 3/2023, Available at: https://www.gov.br/mma/pt-br/composicao/smc/dgov/cim/resolucoes/resoluon3de14desetembrode2023-resoluon3de14desetembrode2023-dou-imprensanacional.pdf. Accessed on: May 11, 2026.

20 Available at https://www.gov.br/mma/pt-br/centrais-de-conteudo/publicacoes/mudanca-do-clima/estrategia-transversal-monitoramento-gestao-avaliacao-transparencia-1.pdf. Accessed on: May 11, 2026.

Figure 3.3 Workflow for preparing Monitoring and Evaluation reports among the Adaptation, Mitigation, and Monitoring and Evaluation Subcommittees under the CIM



Source: Brasil, 2026b.

Specifically, for climate transparency, the MCTI is responsible for managing data and climate data systems and producing reports for submission to the UNFCCC, through the General Coordination of Climate Science (CGCL, Coordenação-Geral de Ciência do Clima). The CGCL also serves as the National Designated Entity (NDE) for the Convention's Technology Mechanism in Brazil, responsible for assessing technological needs for the implementation of climate action plans in the country and developing Technology Action Plans (TAPs), taking into account priority sectors and key technologies, with a view to achieving the mitigation targets set out in the NDC.

The MCTI coordinated the preparation of BTR1, which was submitted in December 2024 and underwent a technical expert review (TER) in 2025, in accordance with Chapter VII of the annex to Decision 18/CMA.1, resulting in the TERR - Technical Expert Review Report[21] - which included recommendations for improving the report.

21 Available at: https://unfccc.int/documents/655374. Accessed on: Sep. 11, 2026.

The actions undertaken for BTR2 in response to the recommendations and encouragements concerning the tracking of progress made in implementing and achieving the NDC are presented in the **Appendix** at the end of this Chapter.

3.1.2 Arrangements and data systems for monitoring, reporting and archiving of information related to implementing and achieving the NDC

3.1.2.1 Measurement and reporting of greenhouse gas emissions

The National Emissions Registry System (SIRENE, Sistema de Registro Nacional de Emissões)[22], established by Decree No. 9,172/2017, is a computerized system developed by the MCTI, whose main objective is to make available the results of the National Inventory of anthropogenic greenhouse gas emissions by sources and removals by sinks. SIRENE aims to ensure reliability and transparency in the process of preparing greenhouse gas emissions inventories.

SIRENE provides charts and tables of national emissions, which can be exported in an editable format based on filters selected by the user. In addition, all official publications and transparency reports are made available to the public on the platform. SIRENE also provides emissions and energy scenarios for 2012-2050, generated based on information from the "Mitigation Options of Greenhouse Gas Emissions in Key Sectors in Brazil" project, a GEF project previously implemented by the MCTI with support from the United Nations Environment Programme (UNEP). SIRENE also provides a breakdown of GHG emissions and removals by federative unit.

The system includes the SIRENE Organizacionais (Organizational SIRENE) module, which is publicly accessible and free of charge, developed to provide visibility and transparency for the voluntary submission of results from organizations' GHG emissions and removals inventories. The module was developed in a collaborative process with various public and private institutions. The initiative establishes standardized requirements for GHG accounting nationwide, ensuring data reliability and robustness; encourages organizations to manage data collection and raise awareness of its importance, preparing them for carbon markets and trading scenarios; and supports Brazil's productive sector, decision-makers, and public managers in developing and prioritizing policies and actions to achieve the NDC targets.

3.1.2.2 Reporting of sectoral greenhouse gas emission reduction in agriculture

The ABC+ Integrated Information System (SINABC, Sistema Integrado de Informações do ABC+)[23], coordinated by the Ministry of Agriculture and Livestock (MAPA, Ministério da Agricultura e Pecuária), aims to consolidate and systematize the results of the ABC Plan's implementation.

The SINABC Platform has three pillars:

- The Governance System of the ABC Plan (SIGABC, Sistema de Governança do Plano ABC), with public access to be maintained by the State Management Groups (GGEs, Grupos Gestores Estaduais) of the ABC+ Plan. These groups are responsible for coordinating and guiding the Plan's actions within the scope of each Brazilian federative unit. Currently, GGEs have been formally established in all federative units, and are structured in 20 of them, through the

22 Available at: https://www.gov.br/mcti/pt-br/sirene. Accessed on: Sep. 11, 2026.

23 Established by Decree No. 10,606, dated January 22, 2021, as amended by Decree No. 12,757, dated November 24, 2025.

approval and implementation of State Action Plans and the establishment of partnerships with federal, state, and municipal government institutions, as well as nongovernmental institutions and the private sector;

- The Rural Credit and Proagro - Agricultural Activity Guarantee Program (Programa de Garantia da Atividade Agropecuária) Operations System (SICOR, Sistema de Operações do Crédito Rural e do Proagro), including the development of a business intelligence dashboard based on cross-referencing the rural credit operations databases of the Central Bank of Brazil (Banco Central do Brasil) (SICOR), the MMA, rural properties (SICAR – National Rural Environmental Registry System (Sistema Nacional de Cadastro Ambiental Rural)) and the Brazilian Institute of Geography and Statistics (IBGE, Instituto Brasileiro de Geografia e Estatística); and
- The Multi-institutional Platform for Monitoring Greenhouse Gas Emission Reductions in Agriculture - the ABC[24] Platform (Plataforma ABC), which consists of the development of a technological solution to consolidate the key metrics of ABC+'s sustainable practices. The platform was set up via a technical cooperation agreement between the Secretariat for Innovation, Sustainable Development, Irrigation and Cooperativism of the Ministry of Agriculture and Livestock (MAPA) and the Federal Data Processing Service (SERPRO, Serviço Federal de Processamento de Dados).

3.1.2.3 Long-term, low-emission and climate-resilient development

The National Simulator of Sectoral Policies and Emissions (SINAPSE, Simulador Nacional de Políticas Setoriais e Emissões) is a federal government tool that projects scenarios to evaluate the impacts of implementing sectoral public policies with the potential to reduce GHG emissions. The system was developed through a partnership between the Ministry of Science, Technology and Innovation (MCTI) and the National Education and Research Network (RNP, Rede Nacional de Ensino e Pesquisa). SINAPSE supports Brazilian decision-makers and public managers in developing and prioritizing the introduction of policies to achieve the NDC targets, including the actions envisaged in the Sectoral Mitigation Plans of the Climate Plan.

SINAPSE allows users to simulate future climate mitigation scenarios through 33 policy measures across seven sectors, ranging from avoided deforestation, industrial energy efficiency, energy recovery from biogas, incentives for renewable energy generation, incentives for the sale of hybrid and electric vehicles, and electrification of cooking appliances, to measures that reduce emissions in two or more sectors. Users can export data from the generated scenarios, including all selected parameters. These include policy implementation levels, energy impacts, and impacts on emissions, comparing the levels of implementation and combination of policies against the baseline values of the indicators. It is also possible to evaluate different pathways for achieving the NDC targets through combinations of emissions mitigation policies.

24 Available at: https://www.gov.br/agricultura/pt-br/assuntos/sustentabilidade/planoabc-abcmais/abc/sinabc/plataforma-abc. Accessed on: Sep. 14, 2026.

3.1.2.4 National Climate Transparency System (DataClima+)

The DataClima+ project, under the responsibility of the MCTI, aims to strengthen Brazil's national transparency system through climate data governance, to support the formulation of national policies and meet the requirements of the ETF under the Paris Agreement, as presented in **Box 1.3**.

In the context of the arrangements described in this section, the initiative focuses on establishing the processes, institutional responsibilities, and structures necessary for monitoring, reporting, and archiving information related to the implementation and achievement of the NDC.

DataClima+ is being designed as a modular and integrated system intended to organize information produced by various national institutions and systems. Modules on Mitigation, Adaptation, Public Policies, NDC Tracking, and Means of Implementation are planned. In addition, DataClima+ will have the institutional arrangements necessary to ensure the timely receipt of data and the capacity-building needed to ensure that key stakeholders benefit from the information system. The DataClima+ project is organized into three components:

- Component 1: Design and development of an integrated climate data system for Brazil, connecting existing and new databases. It will also formalize the institutional arrangements necessary to support data collection, governance, and management through an integrated climate transparency framework to ensure that national efforts are coordinated and efficient. In the case of tracking and progress in the implementation of the NDC and information on means of implementation (support needed and received by the country), new integrated IT modules will be created. Component 1 also includes stakeholder engagement actions and capacity-building needed to ensure the adoption of the system;
- Component 2: Enhancement of the individual modules of the integrated climate data platform in accordance with the ETF and its Modalities, Procedures and Guidelines (MPGs): GHG emissions, adaptation, NDC tracking, and means of implementation. This will be achieved mainly by standardizing processes following a Business Process Management approach and through project actions that enhance databases, tools, models and system capacity for each module;
- Component 3: Support for national policymakers and decision-makers in effectively incorporating climate data and projections into their regulatory and planning processes. This will be achieved by enhancing databases, tools and models to evaluate the effectiveness of different sectoral policy scenarios in achieving national climate targets (SINAPSE module). It will also establish institutional arrangements to integrate SINAPSE not only into sectoral and subnational planning and budget bodies, but also into efforts to develop a long-term national strategy in accordance with Article 4, paragraph 19, of the Paris Agreement.

Thus, the system will implement policies, rules, processes, organizational structures, and technologies aligned with best practices in governance and business process management. It will also adopt standardized and well-documented procedures, which will serve as the basis for organizational knowledge management, increasing the system's efficiency and strengthening the institutional capacity to prepare transparency reports.

3.1.2.5 Climate Plan Monitoring and Evaluation System (IndicaClima)

The National Climate Plan Monitoring and Evaluation System (IndicaClima), under the responsibility of the Ministry of the Environment and Climate Change (MMA), is in the final stages of development and aims to integrate and organize information on the implementation of the Climate Plan's policies, actions, targets, and indicators, enhancing transparency and the capacity to monitor national climate policy.

The Climate Plan is the main instrument for planning and implementing national climate policy, bringing together goals, targets, and actions aimed at guiding national efforts to address climate change and fulfill Brazil's commitments under the Paris Agreement. In this context, the information compiled by IndicaClima reflects the implementation stage of climate policies and measures at the national level and provides important input for the monitoring, evaluation, and reporting processes of Brazil's climate action, including within the scope of the transparency instruments established under the Paris Agreement.

IndicaClima will feature two complementary interfaces. The first one will be aimed at managers responsible for implementing and tracking climate policies, enabling the systematic tracking of information and supporting evidence-based decision-making. The second one will be a public interface designed to provide information on the progress of the Climate Plan's implementation, based on data consolidated and validated by the Interministerial Committee on Climate Change (CIM).

Thus, IndicaClima will contribute to strengthening national arrangements for climate monitoring, evaluation, and transparency by systematically organizing information on the implementation of the policies and measures envisaged in the Climate Plan and increasing the availability of information to public managers and society.

3.2 Description of Brazil's nationally determined contribution under Article 4 of the Paris Agreement, including updates

Since the original submission in 2016, Brazil has submitted updates of its first NDC in 2020, 2022 and 2023[25]. The updated version of this NDC establishes emissions limits of 1.32 Gt $CO_{2\,eq}$ in 2025 and 1.20 Gt CO_2 eq in 2030 (GWP AR5), representing reductions of 48% and 53%, respectively, compared with national GHG emissions in 2005, according to the results of the National Inventory published in the Fourth National Communication (4NC). The targets are expected to contribute to the long-term goal of achieving climate neutrality by 2050.

In 2024, Brazil submitted its second NDC to the UNFCCC, establishing an emissions limit of between 1.05 and 0.85 Gt CO_2 eq (GWP AR5) for 2035, corresponding to a reduction of 59% to 67% compared with 2005 emissions, according to data from Brazil's National GHG Inventory published in the Fourth National Communication (4NC).

Regardless of any recalculations of the National Inventory's time series that may alter the result of the emissions of the base year (2005), the absolute net emissions limits remain unchanged:

25 See NDC Registry - UNFCCC, available at: https://unfccc.int/NDCREG. Accessed on: Sep. 14, 2026.

1.32, 1.20, and 0.85–1.05 Gt CO_2 eq in 2025, 2030, and 2035, respectively. However, considering the result of the emissions of the base year (2.58 Gt CO_2 eq) presented in BTR2 (NIR 2026), the percentage reductions relative to 2005 emissions increase from 48% to 49% in 2025 and from 53% to 54% in 2030, while the percentage reductions in 2035 (59%–67%) remain unchanged.

In light of Brazil's submission of its second NDC to the UNFCCC in 2024, this BTR2 provides the information necessary to describe this contribution. However, the tracking of progress presented refers to the implementation of the country's first NDC, which establishes targets for 2025 and 2030.

Brazil's second NDC was developed within the framework of the Interministerial Committee on Climate Change (CIM), the main collegiate body for national climate governance. Its formulation took into account the processes and outcomes of the update of the Climate Plan, designated by the CIM as the main instrument for achieving the NDC targets, as well as the goals established by the National Policy on Climate Change.

Thus, the NDC states that the Climate Plan plays a central role at the national level in coordinating mitigation and adaptation policies and measures by systematizing the pathways for fulfilling Brazil's commitment under the UNFCCC and its Paris Agreement, in line with national sustainable development goals, including social, environmental, and climate justice (Brasil, 2024).

The NDC includes national adaptation and mitigation guidelines and goals, incorporating and/or reinforcing, for example, climate justice, ecosystem conservation and restoration, a just and inclusive transition, broad social participation, coordination among federative entities, low-greenhouse-gas-emission agriculture, sustainable biofuel production, expansion of renewable sources in the electricity matrix, and incentives for the gradual replacement of fossil fuels, among others.

Also noteworthy is the significant progress made in addressing the climate change adaptation agenda, reflecting a maturing process driven by greater availability of information (for example, through the AdaptaBrasil MCTI platform), recognition that climate change is already a reality, as evidenced by recent disasters, such as the floods in the state of Rio Grande do Sul and the extreme droughts in the Amazon, and the development of the Climate Plan itself - which includes the national strategy and 16 sectoral adaptation plans. Together, these factors reinforced the urgency of accelerating the planning and implementation of adaptation and resilience measures. The country has evolved from an initial framework, established with the development of the first version of the National Adaptation Plan in 2016, toward a more central, robust, multisectoral, federative, and institutionalized system. Further details on the progress of adaptation in the country are presented in **Chapter 4**.

To enhance the clarity, transparency, and understanding of Brazil's NDC, Table 3.1 provides a description of the information, following the tabular format suggested in the Appendix to Annex II of Decision 5/CMA.3.

Table 3.1 Description of Brazil's first nationally determined contribution under Article 4 of the Paris Agreement

Description	
Target(s) and description, including target type(s), as applicable (b, c).	Net emissions limits of 1.32 Gt CO_2 eq in 2025 and 1.2 Gt CO_2 eq in 2030 (fixed targets that do not depend on the emission level of the 2005 base year).
Target year(s) or period(s), and whether they are single-year or multi-year target(s), as applicable.	Single-year targets for 2025 and 2030.
Reference point(s), level(s), baseline(s), base year(s) or starting point(s), and their respective value(s), as applicable.	2.58 Gt CO_2 eq (GWP AR5) in 2005.
Time frame(s) and/or periods for implementation, as applicable.	2020–2025 for the 2025 target. 2020–2030 for the 2030 target.
Scope and coverage, including, as relevant, sectors, categories, activities, sources and sinks, pools and gases, as applicable.	Economy-wide absolute net emissions targets consistent with all the sectors of Brazil's National Greenhouse Gas Emissions Inventory and all the gases reported: CO_2, CH_4, N_2O, SF_6, NF_3, perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs).
Intention to use cooperative approaches that involve the use of ITMOs under Article 6 towards achieving the NDC under Article 4 of the Paris Agreement, as applicable.	Brazil strives to achieve the targets of the NDCs through domestic measures coordinated and implemented by the federal government. The Brazilian government does not rule out the use of internationally transferred mitigation outcomes (ITMOs), as defined in Article 6 of the Paris Agreement, to complement the national efforts to achieve Brazil's NDC. Brazil may also consider the possibility of transferring international mitigation outcomes generated within its national territory. Any international transfers of mitigation outcomes obtained within Brazilian territory will be subject to the prior and formal consent of the federal government, in accordance with the terms and conditions, including the legislation, to be developed nationally for this purpose. The international transfer of mitigation outcomes represents an opportunity to mobilize financial resources to support investments in decarbonization in the country; such transfers must comply with the authorization and accounting procedures provided for under Article 6, including the application of corresponding adjustments.
Any updates or clarifications of previously reported information, as applicable.	Information on emissions in 2005 and reference values may be updated and recalculated due to methodological improvements applicable to Brazil's National Inventory of Greenhouse Gas Emissions.

Source: Compiled by the authors, based on the Appendix to Decision 5/CMA.3.

3.3 Information necessary to track progress made in implementing and achieving Brazil's nationally determined contribution

In accordance with the targets mentioned in the previous item, the country will use the indicators described in Table 3.2 to track progress and achievement of the Brazilian NDC targets.

Table 3.2 Indicators to track progress and achievement of Brazil's NDC targets

Indicators	Details
Total net GHG emissions	Indicator that measures the achievement of the NDC, given that Brazil's NDC establishes GHG emissions limits for 2025 and 2030.
GHG emissions reduction	Indicator that measures progress toward achieving the NDC, representing the percentage change in total net GHG emissions between the base year (2005) and the target years (2025 and 2030).

Source: Compiled by the authors.

Information on Brazil's emissions in 2005 and reference values may be updated and recalculated as a result of improvements in the methodologies applicable to inventories.

Assessment of achievement of the NDC targets is carried out through the preparation of the National Inventory of Emissions and Removals of Greenhouse Gases. The emissions of the gases covered are aggregated in terms of global warming potential over a 100-year time horizon (GWP 100), based on the values stipulated in the IPCC's Fifth Assessment Report (AR5), as agreed by the CMA. Brazil updates its national inventories for the time series based on the 2006 IPCC Guidelines.

In accordance with Decision 18/CMA.1, Brazil also presents the emissions of gases aggregated in terms of global temperature potential over a 100-year time horizon (GTP 100) in the National Inventory of Emissions and Removals of Greenhouse Gases (see NIR, section **2.8 Information on the metrics used**).

Table 3.3 provides a summary of methodologies and accounting approaches relevant to the assessment of the progress and achievement of the NDC targets. The details are presented in the structured summaries through the common tabular format (CTFs).

Table 3.3 Methodologies and accounting approaches consistent with Article 4, paragraphs 13 and 14, of the Paris Agreement and with Decision 4/CMA.1

Reporting requirement	Description or reference to the relevant section of the BTR
Accounting of anthropogenic emissions and removals in accordance with methodologies and common metrics assessed by the IPCC and adopted by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement	
Methodology and/or accounting approach used to assess the implementation and achievement of the targets.	Emissions of the gases covered are calculated based on the 2006 IPCC Guidelines. The methodological level (Tier) used depends on the availability of data in the various sectors. An effort is made to use at least Tier 2 for the key categories identified. The emissions of the gases covered are aggregated in terms of global warming potential over a 100-year time horizon (GWP 100), based on the values provided in the IPCC Fifth Assessment Report, or 100-year time-horizon GWP values from a subsequent IPCC assessment report, as agreed by the CMA. The Brazilian government has adopted the latest National GHG Inventory to track progress made on its NDC. Achievement of the 2025 target will be measured in BTR3, which is scheduled for submission in 2028, with 2026 being the last year of the NIR time series. Similarly, achievement of the 2030 target will be measured in BTR5, which is scheduled for submission in 2032, with 2030 being the last year of the NIR time series (Information in response to TER recommendation 10.2 – Appendix 3).
IPCC approach used to estimate emissions and removals from harvested wood products.	Brazil used the atmospheric flow approach, in accordance with the 2006 IPCC Guidelines, to estimate emissions and removals from harvested wood products (HWP), as it is more representative of the national context. Nevertheless, in order to meet the transparency criteria of the Paris Agreement (paragraph 56 of Decision 18/CMA.1), Brazil also presents the results from the production approach as supplementary information in the NIR 2026.
Methodological consistency between the communication and implementation of NDCs	
Consistency in scope and coverage, definitions, data sources, metrics, assumptions and methodological approaches between the communication and implementation of the NDC.	To ensure methodological consistency between the communication and implementation of the NDC, the gases and sectors covered by the iNDC submitted in 2015 and the first NDC (ratified in 2016), as well as their respective updates in 2020, 2022, and 2023, were retained. All categories of anthropogenic emissions and removals corresponding to the NDC were accounted for and no emission or removal categories were excluded.

Reporting requirement	Description or reference to the relevant section of the BTR
Technical changes to update reference points and reference levels	
Updates to reference points or levels, improvements in accuracy, and technical and methodological changes during the implementation of the NDC.	NIR 2026, **section 2.3.2 Consistency and recalculations of the time series.**
Striving to include all categories of anthropogenic emissions or removals in the NDC	
Accounting, inclusion and maintenance of the categories of anthropogenic emissions and removals corresponding to the NDC.	NIR 2026, **section 2.7 General assessment of completeness**.

Source: Compiled by the authors, based on Table 3 of Annex II to Decision 5/CMA.3.

Table 3.4 presents progress toward achieving Brazil's NDC targets, based on the results of the most recent National Inventory, published in this BTR2. In the last year of the time series (2024), Brazil emitted 1.51 Gt CO_2 eq, corresponding to a reduction of 1.07 Gt CO_2 eq, or 42%, compared with 2005 (2.58 Gt CO_2 eq).

Table 3.4 Tracking progress in implementing and achieving the NDC

Indicators	Unit	Reference year	Reference level	Target year	Target level	Level in 2020	Level in 2021	Level in 2022	Level in 2023	Level in 2024
Total net GHG emissions	Gt CO_2 eq	N.A	N.A	2025	1.32	1.77	2.01	2.07	1.71	1.51
				2030	1.20					
GHG emissions reduction	%	2005	2.58 Gt CO_2 eq	2025	49%	31%	22%	20%	34%	42%
				2030	54%					

N.A: Not applicable.
Source: Compiled by the authors.

3.4 Mitigation policies and measures, actions and plans, including those with mitigation co-benefits resulting from adaptation actions and economic diversification plans, related to implementing and achieving a nationally determined contribution under Article 4 of the Paris Agreement

In the First Biennial Transparency Report (BTR1)[26], submitted in December 2024 to the UNFCCC, Brazil reported seven mitigation measures considered to have a significant impact on the key categories of greenhouse gas (GHG) emissions and removals of the National Inventory. The approach adopted at that time was based on the presentation of specific mitigation measures, reflecting the stage of development of national instruments at the time. Starting with BTR2, the country adopts a structured approach in which information on GHG emission reductions and increased removals is organized based on the Climate Plan, particularly on its mitigation component. This transition results from the consolidation of the Climate Plan as an instrument for planning and coordinating national climate action, overcoming the limitation faced in BTR1, when the Plan was still under development.

The designation of the Climate Plan as the instrument for achieving the targets set in Brazil's NDC was established through Resolution No. 03/2023 of the Interministerial Committee on Climate Change (CIM). Accordingly, starting with this BTR2, the country's mitigation measures are organized according to the scope of action of the Climate Mitigation Plan, comprised of the National Mitigation Strategy (ENM) and its Sectoral Mitigation Plans (PSM), which organize the instruments for implementing the Climate Mitigation Plan.

The Plan also consolidates the framework for planning and coordinating the country's climate action, as Brazil's NDC targets are defined based on an integrated approach that considers the effects of sectoral policies across the economy.

Thus, the measures reported in BTR1 (PPCDs, Planaveg, ABC+ Plan, Increased Electricity Supply from Renewable Sources, RenovaBio, Procel - National Electricity Conservation Program (Programa Nacional de Conservação de Energia Elétrica) Seal, and Conpet - National Program for the Rationalization of the Use of Oil Derivatives and Natural Gas (Programa Nacional de Racionalização do Uso dos Derivados do Petróleo e do Gás Natural) Seal) are now treated, within the framework of BTR2, as implementation instruments associated with the impactful actions set out in the Sectoral Mitigation Plans (PSM) (Tables 3.5 to 3.12).

In this context, the PPCDs and Planaveg are included in the implementation instruments of the Sectoral Mitigation Plans (PSM) for Land-Use Change in Public Areas and Collective Territories and Land-Use Change in Private Rural Areas, while the ABC+ Plan is included in the PSM for Agriculture and Livestock and Land-Use Change in Private Rural Areas. The action "Increased Electricity Supply from Renewable Sources" is included in the PSM for Energy; RenovaBio in the PSM for Cities, Transport, and Energy; the PROCEL Seal in the PSM for Industry and Energy; and the

26 Available at: https://unfccc.int/documents/644852. Accessed on: Sep. 14, 2026.

CONPET Seal in the PSM for Industry, within the framework of the Brazilian Labeling Program (PBE, Programa Brasileiro de Etiquetagem).

The Sectoral Mitigation Plans (PSM) organize sectoral actions and targets, while the specific implementation instruments comprise policies, programs, laws, regulations, and incentives. It should be emphasized that this organization does not imply the establishment of independent sectoral commitments, but rather reflects the approach adopted for implementation and reporting, in line with the integrated nature of the NDC.

The following sections present the relevant information on the Climate Mitigation Plan, as set out in paragraphs 80 to 90 of the Annex to Decision 18/CMA.1.

Climate Mitigation Plan

Objective: To guide, promote, and monitor coordinated sectoral and cross-cutting policies and actions that ensure the achievement of the country's mitigation targets and accelerate the transition to a net-zero emissions economy, covering all GHGs, by 2050, while fostering innovation, competitiveness, job and income generation, social and environmental equity, and the integrity of natural ecosystems.

Type of instrument: Regulatory, economic, and technical-scientific.

Status: Under implementation.

Start year of implementation: 2023.

Estimates of GHG emission reductions (CO_2 eq) resulting from the implementation of the Climate Mitigation Plan

Expected:

747 Mt CO_2 eq in 2025, relative to total emissions reported in the National GHG Inventory in 2022.

867 Mt CO_2 eq in 2030, relative to total emissions reported in the National GHG Inventory in 2022.

Achieved:

558 Mt CO_2 eq in 2024, relative to total emissions reported in the National GHG Inventory in 2022.

The estimates of expected emission reductions were calculated based on the difference between the emissions reported for 2022 in the National GHG Inventory and the NDC emissions targets for 2025 and 2030. The emission reduction achieved was calculated based on the difference between the emissions reported for 2022 and 2024 in the National GHG Inventory. The year 2022 was selected as the base year for the calculations because it immediately precedes the start of implementation of the Climate Mitigation Plan (2023). Emissions levels in 2022 may be updated and recalculated due to methodological improvements applicable to Brazil's National Greenhouse Gas Emissions Inventory.

Long-term trend in GHG emissions and removals: despite the emission reductions observed during the initial period of implementation of the Climate Mitigation Plan (2023-2024), it is not yet possible to determine how its implementation affects Brazil's emissions trend in the medium and long term (Information in response to TER recommendation 11.5 - Appendix 3).

Description: the Climate Mitigation Plan consists of the National Mitigation Strategy (ENM) and eight Sectoral Mitigation Plans (PSM), namely:

1. Land-Use Change in Public Areas and Collective Territories;
2. Land-Use Change in Private Rural Areas;
3. Agriculture and Livestock;
4. Energy;
5. Transport;
6. Cities;
7. Industry; and
8. Solid Waste and Domestic Wastewater.

The ENM establishes national economy-wide net GHG emissions targets and their respective sets of guidelines, defined based on contributions from the various bodies comprising the CIM and consultation and participation processes involving civil society organizations, social movements, the private sector, the scientific community, and subnational entities.

The ENM guidelines are:

1. **Alignment of national climate commitments**: Ensures that the ENM's targets and actions are consistent with Brazil's NDC and other international agreements, aiming to achieve net-zero emissions by 2050, in line with the 1.5ºC temperature limit, while respecting the principles of equity and sustainable development;
2. **Climate action based on scientific evidence**: Planning based on scientific data, using the best available science and advanced assessment tools to develop cost-effective medium- and long-term pathways, based on the systemic analysis and scientific knowledge of complex systems;
3. **Integrated intersectoral approach:** Support and promotion of decarbonization activities and increased social and environmental sustainability across all sectors of the Brazilian economy, from an integrated perspective. Alignment of the ENM with national sectoral and intersectoral policies related to climate change mitigation;
4. **Just and inclusive transition**: A systemic, inclusive, and long-term perspective on mitigation actions, ensuring that no one is left behind. Valuing traditional knowledge and local cultures, with a focus on reducing social, income, gender, racial, and religious inequalities;
5. **Coordination of incremental and transformational actions**: Expansion and strengthening of existing solutions with positive impacts on GHG emissions mitigation, coordinated with investment in all stages of the development cycle of new technologies aimed at mitigation;
6. **Development, expansion, improvement, and coordination of means of implementation**: Decarbonization and the development of the Brazilian economy require new economic, financial, regulatory, technological, and capacity-building means of implementation, as well as the improvement and expansion of existing instruments with proven mitigation results;
7. **Broad social participation in the formulation, implementation, monitoring, and evaluation of the ENM**: Partnerships among governments, the productive sector, academia, and civil society to implement and monitor mitigation actions, with social participation forums and mechanisms for transparency and independent evaluation of the ENM's effectiveness;
8. **Integration of climate and digital transitions for a vision of the futur**e: Integration of climate, digital, and artificial intelligence transitions to position Brazil at the forefront of the Fourth Industrial Revolution, fostering sustainable and digital technologies, increasing productivity

and competitiveness, creating quality jobs, and making the low-carbon transition a global example of sustainable development;

9. **Integration with the National Adaptation Strategy**: Promote coordination between measures to reduce greenhouse gas emissions and initiatives to adapt to climate impacts through the development of decarbonization policies and programs that also aim to increase the resilience of communities and ecosystems, generating co-benefits for climate change adaptation capacity;
10. **Coordination of the Sectoral Mitigation Plans with other public policies**: Mitigation policies can generate multiple co-benefits, such as biodiversity conservation, food, water, and energy security, reduced inequalities and pollution, promotion of health and social justice, and valuing traditional peoples and communities.

The ENM and PSM may be periodically updated, in line with international monitoring and Global Stocktake processes, ensuring the incorporation of scientific, technological, and governance advances and that Brazil is prepared to respond to national and global demands in an integrated manner (Brasil, 2026a).

Each Sectoral Plan has at least one responsible ministry, whose role encompasses developing the action plan, identifying and mobilizing those responsible for its implementation, coordinating actions, directing efforts, and monitoring results. However, given the integrated and cross-cutting nature of various public policies, multiple actions within a Sectoral Plan entail shared responsibility with other ministries and bodies (Brasil, 2026b).

The ENM sets out twelve national goals, as follows (Brasil, 2026b):

1. Ensure the integrity of national biomes through the conservation, restoration, and sustainable use of their ecosystems;
2. Promote the widespread adoption of sustainable, low-GHG-emission agriculture and livestock production models, ensuring food security for all;
3. Expand the sustainable production of biofuels, promote technological innovation, and develop value chains related to bioenergy;
4. Expand the share of clean and renewable technologies and energy sources in the national energy matrix, ensuring energy security and accessibility for all;
5. Encourage the replacement of fossil fuels by promoting the development and efficient use of sustainable biofuels, electrification solutions, and low-carbon hydrogen;
6. Promote circularity through the sustainable and efficient use of natural resources and energy efficiency throughout supply chains;
7. Leverage innovative and low-carbon solutions in domestic industrial production and develop carbon capture, utilization, and storage technologies in industrial production, bioenergy production, and the fossil fuel production sectors;
8. Build the capacity of and encourage subnational entities to adopt integrated and sustainable urban development, as well as strategies to address climate change aligned with national guidelines;
9. Generate jobs, income, and productive inclusion in economic activities related to the decarbonization of the economy and sustainable development, promoting a just, inclusive, and sustainable socioeconomic transition;
10. Transform Brazil's comparative advantages into competitive advantages, making the country a provider of climate-related goods, services, and solutions to a world transitioning to low-carbon development models;

11. Take specific actions to mitigate non-CO_2 pollutants that have a high impact on global warming;
12. Prioritize mitigation measures that have the potential to generate co-benefits for climate change adaptation and resilience, as well as for sustainable development.

To guide the implementation of mitigation actions at the federal level, the ENM 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. The ENM is also expected to inform other fiscal and budgetary instruments to ensure the implementation and monitoring of initiatives that promote climate resilience and greenhouse gas emissions mitigation (Brasil, 2026b).

Given the complexity of achieving national and sectoral mitigation targets, it is recognized 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 climate 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 plans (Brasil, 2026b).

The ENM's sectoral targets are linked to impactful actions outlined in the Sectoral Mitigation Plans, as detailed in Tables 3.5 to 3.12. Considering the broad scope of Brazil's economy-wide NDC, as well as the interdependence among sectors, certain instruments may be associated with more than one PSM. In such cases, monitoring and evaluation are conducted in a coordinated manner to avoid double-counting of impacts.

Table 3.5 Sectoral Mitigation Plan for Land-Use Change in Public Areas and Collective Territories

Impactful Actions	Targets
Eliminate illegal deforestation in all Brazilian biomes.	Bring the deforestation rate in public areas across all Brazilian biomes to zero by 2030.
Prevent, reduce, and offset deforestation resulting from large-scale developments and infrastructure projects through native vegetation restoration.	Offset deforestation through the restoration of native vegetation in all large-scale developments in public areas by 2030.
Reduce illegal logging in public areas of the Amazon.	Reduce the area of illegal logging in public areas in the Amazon by 80% by 2030.
Prevent and reduce fires in native vegetation on public lands, agrarian reform settlements, and collective territories, incorporating and valuing traditional fire management practices.	Reduce the area of native vegetation burned in public areas by 60% by 2030. Reduce the area of native vegetation burned in agrarian reform settlements and Quilombola territories by 30% by 2030.
Establish and implement terrestrial and marine conservation units in accordance with the National System of Nature Conservation Units (SNUC, Sistema Nacional de Unidades de Conservação da Natureza) and recognize and implement other conservation strategies.	4.3 million hectares of conservation units established between 2023 and 2027. At least 80% of the Amazon biome and 30% of each biome and of the coastal-marine system conserved and effectively managed by 2030.
Identify, demarcate, and regularize Indigenous Lands.	4.5 million hectares of Indigenous territories delimited by 2027.
Allocate public lands for protection and sustainable use, particularly for Indigenous Peoples and Traditional Peoples and Communities (PIPCTs, Povos Indígenas e Povos e Comunidades Tradicionais).	21 million hectares of public lands allocated by 2027.
Restore native vegetation in public areas, agrarian reform settlements, and collective territories.	2.5 million hectares of native vegetation undergoing restoration in public areas, agrarian reform settlements, and collective territories by 2030.
Reduce the legally authorized removal of native vegetation in agrarian reform settlements and collective territories.	Reduce the rate of legally authorized removal of native vegetation by 50% by 2030. Specific targets for Quilombola territories: 60% reduction in the rate of legally authorized removal of native vegetation by 2030.
Partial results on progress toward achieving the targets related to impactful actions will be reported starting with BTR3 and in subsequent reports. **Main implementation instruments** PPCDs (PPAmazônia (PPAmazon), PPCerrado, PPCaatinga, PPPantanal, PPMata Atlântica (PPAtlantic Forest), and PPPampa) National Policy for the Restoration of Native Vegetation (Proveg) – Decree No. 8,972, dated January 23, 2017	

Impactful Actions	Targets
National Plan for the Restoration of Native Vegetation (Planaveg) – Interministerial Ordinance No. 230, dated November 14, 2017 Atlantic Forest Law – Law No. 11,428/2006 Public Forest Management Law – Law No. 11,284/2006 Native Vegetation Protection Law – Law No. 12,651/2012 Agrarian Reform - Law No. 8,629/1993 National System of Nature Conservation Units – Law No. 9,985/2000 Ecological-Economic Zoning of Brazil (ZEE, Zoneamento Ecológico-Econômico do Brasil) – Decree No. 4,297/2002 National Policy on Territorial and Environmental Management of Indigenous Lands (PNGATI, Política Nacional de Gestão Territorial e Ambiental de Terras Indígenas) – Decree No. 7,747/2012	
Sectors affected: LULUCF	
Gases affected: CO_2, CH_4, N_2O	
National Inventory Categories and Subcategories Affected by the Actions 4.A. Forest Land 4.B. Cropland 4.C. Grassland 4.D. Wetlands 4.F. Other Land	
Estimated cost: approximately BRL 9 billion	
Implementing entities: MMA, MT - Ministry of Transport (Ministério dos Transportes), MME – Ministry of Mines and Energy (Ministério de Minas e Energia), Office of the Chief of Staff of the Presidency of the Republic, MPI - Ministry of Indigenous Peoples (Ministério dos Povos Indígenas), MDA, INCRA - National Institute for Rural Settlement and Agrarian Reform (Instituto Nacional de Colonização e Reforma Agrária), IBAMA - Brazilian Institute of the Environment and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis), and ICMBio – Chico Mendes Biodiversity Conservation Institute (Instituto Chico Mendes de Conservação da Biodiversidade)	
Assessment of social, economic, and environmental impacts and co-benefits of the PSM for Land-Use Change in Public Areas and Collective Territories The impact assessment of the Sectoral Plans of the Climate Mitigation Plan was conducted as part of the ICAT Brazil Phase 3 Project, implemented by the Brazil Climate Center (CBC, Centro Brasil no Clima) with support from the Initiative for Climate Action Transparency (ICAT) and technical support from the World Resources Institute (WRI). This assessment adopted a qualitative approach, based primarily on ICAT's Sustainable Development Methodology[1] and Stakeholder Participation Guide[2]. The following are the impacts of the impactful actions under the Sectoral Mitigation Plan for Land-Use Change in Public Areas and Collective Territories: Environmental: Reduction of GHG emissions and short-lived climate pollutants, as well as prevention of habitat loss and improvement of air, water, and soil quality; ecosystem restoration, increased landscape connectivity, and strengthened ecosystem resilience; preservation of large expanses of natural areas and promotion of sustainable management; strengthening the role of traditional peoples and communities as guardians of biodiversity, ensuring the continuity of ecosystem services and the protection of threatened species.	

Impactful Actions	Targets
Economic: Conservation can drive sustainable economic growth, with positive effects on productive efficiency, the value of environmental assets, and the diversification of markets and opportunities; it can also combat illegal practices that generate tax revenue losses and disrupt sustainable supply chains. These actions contribute to increasing the value of sustainable forest and agroextractive supply chains, boosting sustainable markets, reducing costs associated with losses of forest assets, damage to infrastructure, and public expenditure on firefighting, as well as preserving the productivity of these areas. Creation of demand for environmental restoration services, which also boost markets for forest offsets, reforestation, and carbon credits. These actions strengthen the bioeconomy and sustainable finance sectors of the economy, promoting innovation and income generation through ecosystem restoration. Expanded opportunities for tourism, sustainable management of forest resources, and sociobiodiversity products strengthen community-based production models, with the potential to generate income, local employment, and economic diversification in historically vulnerable territories. Potential negative impacts would include the costs of implementing the actions and conflicts related to land tenure and employment. Social: Land tenure security, territorial autonomy, and protection of traditional ways of life, as well as contributing to conflict reduction and strengthening community-based territorial management. These actions are essential for guaranteeing collective rights and strengthening socio-environmental equity; improving public health conditions and increasing stability in local communities; promoting environmental education, cultural appreciation, and social inclusion, potentially strengthening community participation in decision-making processes and natural resource management; and creating employment and capacity-building opportunities, particularly during the implementation of restoration projects.	

1 Available at: https://climateactiontransparency.org/wp-content/uploads/2020/04/Sustainable-Development-Assessment-Guide.pdf. Accessed on: Sep. 14, 2026.
2 Available at: https://climateactiontransparency.org/wp-content/uploads/2020/04/Stakeholder-Participation-Assessment-Guide.pdf. Accessed on: Sep. 14, 2026.

Source: Compiled by the authors.

Table 3.6 Sectoral Mitigation Plan for Land-Use Change in Private Rural Areas

Impactful Actions	Targets
Ensure that all removal of native vegetation in private rural areas takes place only with valid environmental authorization.	Reduce the rate of unauthorized removal of native vegetation in private rural areas to zero by 2030.
Prevent and reduce fires in native vegetation in private rural areas.	By 2030, reduce the burned area by 50% compared to the historical average.
Reduce the authorized removal of native vegetation in private rural areas.	Reduce the rate of authorized removal of native vegetation by 50% by 2030 compared to 2022.
Restore native vegetation in private rural areas.	9.5 million hectares of native vegetation undergoing restoration by 2030.
Expand the production of Planted Forests for sustainable use – ABC+ Plan.	Increase the area of planted forests by 4 million hectares by 2030.
Restore Degraded Pastures in private rural areas – ABC+ Plan.	Increase the area of restored pastures by 30 million hectares by 2030.
Expand the adoption of No-Till Farming (NTCS-V - No-Till Cropping System for Vegetables and NTCS-G - No-Till Cropping System for Grains) in agricultural areas – ABC+ Plan.	2030: Expand the area by 12.5 million hectares, comprising 4.5 million hectares under the no-till cropping system and 8 million hectares under no-till farming, and increase the area under the no-till cropping system for vegetables by 0.08 million hectares.
Expand the implementation of Integrated Systems (CLI - Crop-Livestock Integration, CLFI - Crop-Livestock-Forestry Integration, and AFS - Agroforestry Systems) – ABC+ Plan.	2030: Expand the area under integrated systems (CLI, CFI - Crop-Forestry Integration, CLFI, and LFI - Livestock-Forestry Integration) by 10.1 million hectares.
Expand agroecological and low-carbon traditional production systems in family farming.	Implement 180 projects for native vegetation recovery and restoration by 2030. Support 1,680 family farming units with agroecological systems for restoring productivity by 2030. Establish 200 soil management and conservation demonstration units by 2027.
Partial results on progress toward achieving the targets related to impactful actions will be reported starting with BTR3 and in subsequent reports. **Main implementation instruments** Plan for Adaptation and Low-Carbon Emission in Agriculture (ABC+ Plan) National Program for the Conversion of Degraded Pastures (*Caminho Verde Brasil* (Brazil's Green Pathway)) – Decree No. 11,815 of December 5, 2023 New Harvest Plan (*Novo Plano Safra*) Agricultural Policy for Planted Forests (Decree No. 8,375/2014) – National Plan for the Development of Planted Forests Law No. 12,805 of April 29, 2013 – National Policy for Crop-Livestock-Forestry Integration National Plan for Agroecology and Organic Production (2024-2027) Native Vegetation Protection Law – Law No. 12,651/2012	

Impactful Actions	Targets
National Policy for the Restoration of Native Vegetation (Proveg) – Decree No. 8,972, dated January 23, 2017 National Plan for the Restoration of Native Vegetation (Planaveg) – Interministerial Ordinance No. 230, dated November 14, 2017 National Policy on Integrated Fire Management – Law No. 14,944, of July 31, 2024 PPCDs (PPAmazônia, PPCerrado, PPCaatinga, PPPantanal, PPMata Atlântica and PPPampa) Atlantic Forest Law – Law No. 11,428/2006	
Sectors affected: LULUCF	
Gases affected: CO_2, CH_4, N_2O	
National Inventory Categories and Subcategories Affected by the Actions 4.A. Forest Land 4.B. Cropland 4.C. Grassland 4.D. Wetlands 4.F. Other Land	
Estimated cost: over BRL 7 billion	
Implementing entities: MAPA, MMA, MDA, MF, SFB – Brazilian Forest Service (Serviço Florestal Brasileiro), INCRA, Embrapa - Brazilian Agricultural Research Corporation (Empresa Brasileira de Pesquisa Agropecuária)	
Assessment of social, economic, and environmental impacts and co-benefits of the PSM for Land-Use Change in Private Rural Areas The impact assessment of the Sectoral Plans of the Climate Mitigation Plan was conducted as part of the ICAT Brazil Phase 3 Project, implemented by the Brazil Climate Center (CBC) with support from the Initiative for Climate Action Transparency (ICAT) and technical support from the World Resources Institute (WRI). This assessment adopted a qualitative approach, based primarily on ICAT's Sustainable Development Methodology[1] and Stakeholder Participation Guide[2]. The following are the impacts of the impactful actions under the Sectoral Mitigation Plan for Land-Use Change in Private Rural Areas: Environmental: Reduction of GHG emissions and short-lived climate pollutants, as well as prevention of habitat loss and improvement of air, water, and soil quality; ecosystem restoration, increased landscape connectivity, and strengthened ecosystem resilience to climate change. Economic: Reduction of costs associated with losses of agroforestry assets, damage to infrastructure, and firefighting expenditures, as well as preservation of the productivity of these areas. Creation of demand for environmental restoration services, which also boost markets for forest offsets, reforestation, and carbon credits. These actions strengthen the bioeconomy and sustainable finance sectors of the economy, promoting innovation and income generation through ecosystem restoration. Social: Employment and capacity-building opportunities, particularly in restoration projects and ABC+ technologies.	

1 Available at: https://climateactiontransparency.org/wp-content/uploads/2020/04/Sustainable-Development-Assessment-Guide.pdf. Accessed on: Sep. 14, 2026.

2 Available at: https://climateactiontransparency.org/wp-content/uploads/2020/04/Stakeholder-Participation-Assessment-Guide.pdf. Accessed on: Sep. 14, 2026.

Source: Compiled by the authors.

Table 3.7 Sectoral Mitigation Plan for Agriculture and Livestock

Impactful Actions	Targets
Expand the adoption of No-Till Farming (NTCS-V and NTCS-G) in agricultural areas.	2030: Expand the area by 12.5 million hectares, comprising 4.5 million hectares under the no-till cropping system and 8 million hectares under no-till farming (base year: 2019). 2030: Expand the area under the no-till cropping system for vegetables by 0.08 million hectares (base year: 2019).
Restore Degraded Pastures on rural properties.	2030: Increase the area of restored pastures by 30 million hectares (base year: 2019).
Expand the implementation of Integrated Systems (Crop-Livestock Integration – CLI, Crop-Livestock-Forestry Integration – CLFI, and Agroforestry Systems – AFS).	2030: Expand the area under integrated systems by 10.1 million hectares (base year: 2019).
Expand the adoption of Intensive Finishing.	2030: Increase intensive finishing by 5 million animals slaughtered at up to 36 months of age (in units) (base year: 2019).
Expand the use of bioinputs.	2030: Increase the use of bioinputs by 13 million hectares (base year: 2019).
Optimize and expand the sustainable use of irrigated systems.	2030: Increase irrigated areas by 3 million hectares (base year: 2019).
Manage animal production waste for biogas production.	2030: Increase the volume of treated animal manure by 208.4 million m^3 (5,000 properties) (base year: 2019).
Increase livestock productivity (genetic improvement, animal health, nutrition, and management).	2030: Increase milk production from 2,141 liters (2019) to 2,650 liters per milked cow per year (base year: 2019); 2030: Increase production from 38.3 kg (2019) to 46 kg of carcass weight per head of cattle per year (base year: 2019).
Expand the adoption of GHG emission mitigation practices in irrigated rice cultivation.	2030: Increase the area under mitigation practices by 20% (base year: 2019).
Expand agroecological and traditional low-carbon production systems in family farming.	2030: Implement 180 projects for forest recovery and restoration, including under the National Productive Forests Program. Support 1,680 family farming units with agroecological systems for restoring productivity.
Expand the production and use of bioinputs in family farming.	2030: Establish 270 bioinput production units operated by family farmers and their organizations.
Establish agroecological corridors in metropolitan regions based on family farming.	2030: Establish 50 hectares of productive agroecological corridors in priority metropolitan regions.

Impactful Actions	Targets
Promote agroecological and low-carbon rice production in family farming.	2030: Expand the area under certified agroecological rice cultivation by 300 hectares in agrarian reform settlements and family farming territories.
Expand the adoption of low-GHG-emission models: Integrated Multi-Trophic Aquaculture (IMTA) and Aquaponics.	Increase the area under established integrated multi-trophic aquaculture production systems to 23,000 hectares and transition existing production models to IMTA by 2030.
Expand the use of bioinputs derived from aquaculture to promote sustainable production.	Achieve a macroalgae cultivation area of 125,000 hectares by 2030.
Expand the adoption of Recirculating Aquaculture Systems (RAS) and Biofloc systems, and encourage the expansion of shrimp farming into inland areas.	Expand the production area under RAS and Biofloc systems by 15,000 hectares and establish 40% of new shrimp farming projects in inland areas by 2030.

Partial results on progress toward achieving the targets related to impactful actions will be reported starting with BTR3 and in subsequent reports.

Main implementation instruments

Plan for Adaptation and Low-Carbon Emission in Agriculture (ABC+ Plan)
National Program for the Conversion of Degraded Pastures (*Caminho Verde Brasil* (Brazil's Green Pathway)) - Decree No. 11,815 of December 5, 2023
New Harvest Plan (*Novo Plano Safra*)
National Bioinputs Program – Decree No. 10,375/2020, as amended by Decree No. 11,940/2024
More Healthy Milk Program (PMLS, Programa Mais Leite Saudável) – Decree No. 8,533/2015
National Plan for Agroecology and Organic Production (Planapo, Plano Nacional de Agroecologia e Produção Orgânica)
National Program for Strengthening Family Farming (Pronaf, Programa Nacional de Fortalecimento da Agricultura Familiar)
National Policy on Technical Assistance and Rural Extension for Family Farming and Agrarian Reform – Law No. 12,188/2010
National Policy for the Sustainable Development of Aquaculture and Fisheries – Law No. 11,959 of June 29, 2009
National Program for the Sustainable Development of Aquaculture (ProAqui, Programa Nacional de Desenvolvimento Sustentável da Aquicultura) – Decree No. 11,852 of December 26, 2023
National Irrigation Policy – Law No. 12,787, of January 11, 2013
National Policy for Crop-Livestock-Forestry Integration – Law No. 12,805 of April 29, 2013
National Policy on Urban and Peri-Urban Agriculture – Law No. 14,935/2024

Sectors affected: Energy and Agriculture

Gases affected: CO_2, CH_4, N_2O

Impactful Actions	Targets

National Inventory Categories and Subcategories Affected by the Actions
1.A.4.c Fuel Combustion Activities / Other Sectors - Agriculture / Forestry / Fishing
3.A. Enteric fermentation
3.B. Manure management
3.C. Rice cultivation
3.D. Agricultural soils
3.E. Prescribed burning of savannahs
3.F. Field burning of agricultural residues
3.G. Liming
3.H. Urea application
3.I. Other carbon-containing fertilizers
3.J. Other

Estimated cost: over BRL 14 billion

Implementing entities: MAPA, MDA, Embrapa, ATER - Technical Assistance and Rural Extension (Assistência Técnica e Extensão Rural), INCRA, MMA, MDS - Ministry of Development and Social Assistance, Family and Fight Against Hunger (Ministério do Desenvolvimento e Assistência Social, Família e Combate à Fome), MCidades - Ministry of Cities, MPA - Ministry of Fisheries and Aquaculture (Ministério da Pesca e Aquicultura), Universities, and Federal Institutes

Assessment of social, economic, and environmental impacts and co-benefits of the PSM for Agriculture and Livestock
The impact assessment of the Sectoral Plans of the Climate Mitigation Plan was conducted as part of the ICAT Brazil Phase 3 Project, implemented by the Brazil Climate Center (CBC) with support from the Initiative for Climate Action Transparency (ICAT) and technical support from the World Resources Institute (WRI). This assessment adopted a qualitative approach, based primarily on ICAT's Sustainable Development Methodology[1] and Stakeholder Participation Guide[2].
The following are the impacts of the impactful actions of the Sectoral Mitigation Plan for Agriculture and Livestock:
Environmental: Resilience to climate change, reduced dependence on synthetic fertilizers and pesticides, improved soil quality, restoration of productive areas, reduced need for new areas, and reduced GHG emissions.
Economic: The use of bioinputs reduces dependence on synthetic fertilizers and improves the efficiency of agricultural systems; the restoration of degraded pastures increases the profitability of rural properties and the stability of production in areas already in use, although these measures may entail high costs. More productive animals generate higher production per hectare or animal unit, which tends to improve the profitability of the activity. Agroecological systems in metropolitan corridors can contribute significantly to boosting the local economy and supplementing the income of farming families. Integrated Systems (CLI, CLFI, and AFS) have the potential to provide greater production security and income generation, and contribute to the diversification of production and agricultural landscapes.
Social: Agroecological, traditional, and family farming production systems value local and traditional knowledge, strengthen cultivation practices aligned with the way of life of these communities, and protect their cultural identity. The establishment of productive belts contributes to food self-sufficiency and strengthens local production of fresh, healthy food. Employment and training opportunities, such as through the expansion of ABC+ technologies and new improvements in agriculture.

1 Available at: https://climateactiontransparency.org/wp-content/uploads/2020/04/Sustainable-Development-Assessment-Guide.pdf. Accessed on: Sep. 14, 2026.
2 Available at: https://climateactiontransparency.org/wp-content/uploads/2020/04/Stakeholder-Participation-Assessment-Guide.pdf. Accessed on: Sep. 14, 2026.

Source: Compiled by the authors.

Table 3.8 Sectoral Mitigation Plan for Industry

Impactful Actions	Targets
Expand cogeneration and the use of renewable electricity at industrial facilities.	Increase the consumption of renewable electricity in industry, helping to ensure that the share of renewables in Brazil's electricity matrix remains above 82.7% by 2030.
Electrify industrial processes.	Increase the share of electricity in industrial energy consumption to at least 21.8% by 2030 (PDE 2034).
Expand the use of renewable fuels as a substitute for fossil fuels.	2030: Increase the consumption of renewable fuels and ensure that the share of renewable energy sources in industrial energy consumption remains above 65% (PDE 2034 and BEN 2024).
Implement measures to improve energy efficiency in industry.	Achieve a 2% improvement in energy efficiency by 2030 compared to 2023 levels.
Gradually reduce the consumption of HFCs in Brazil.	Reduce HFC consumption by 10% in 2029 relative to the baseline (Kigali Amendment).

Partial results on progress toward achieving the targets related to impactful actions will be reported starting with BTR3 and in subsequent reports.

Main implementation instruments

National Electricity Conservation Program (PROCEL) – Interministerial Ordinance No. 1,877/1985; Decree No. 9,863/2019
Energy Efficiency Program (PEE, Programa de Eficiência Energética) – Law No. 9,991, dated July 24, 2000
National Energy Plan
Ten-Year Energy Expansion Plan
Legal Framework for Distributed Generation – Law No. 14,300/2022
Energy Transition Acceleration Program (Paten) – Law No. 15,103/2025
New Industry Brazil (NIB, Nova Indústria Brasil) – CNDI/MDIC Resolution No. 1/2023
Inmetro - National Institute of Metrology, Quality and Technology (Instituto Nacional de Metrologia, Qualidade e Tecnologia)/PBE + Brazilian Labeling Program (PBE)
National Program for the Decarbonization of Natural Gas Producers and Importers and Incentives for Biomethane – Decree No. 12,614/2025,
Legal Framework for Low-Carbon Hydrogen; establishes provisions on the National Low-Carbon Hydrogen Policy – Law No. 14,948/2024
Brazilian Greenhouse Gas Emissions Trading System (SBCE) – Law No. 15,042 of December 11, 2024
Fuel of the Future Law – Law No. 14,993 of October 8, 2024
National Strategy for Industrial Decarbonization (ENDI, Estratégia Nacional de Descarbonização Industrial)
National Strategy for Circular Economy (ENEC, Estratégia Nacional de Economia Circular) - Decree No. 12,082, dated June 27, 2024
Climate Fund/BNDES

Sectors affected: Energy, Industrial Processes and Product Use (IPPU), and Waste

Gases affected: CO_2, CH_4, N_2O, fluorinated gases (HFC, PFC, NF_3 and SF_6)

Impactful Actions	Targets
National Inventory Categories and Subcategories Affected by the Actions 1.A.1.c. Energy Industries - Coke production (coking plants) 1.A.2. Manufacturing industries and construction 2.A. Mineral industry 2.B. Chemical industry 2.C. Metal industry 2.D. Non-energy products from fuels and solvent use 2.E. Electronics industry 2.F. Product uses as substitutes for ozone depleting substances 2.G. Other product manufacture and use 5.D.2. Industrial wastewater treatment and discharge	
Estimated cost: over BRL 4 billion	
Implementing entities: MDIC (DCARB – Department of Decarbonization and Green Finance (Departamento de Descarbonização e Finanças Verdes) / SEV – Secretariat for Green Economy, Decarbonization and Bioindustry (Secretaria de Economia Verde, Descarbonização e Bioindústria)), MME, ANP – National Agency of Petroleum, Natural Gas and Biofuels (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis), EPE – Energy Research Office (Empresa de Pesquisa Energética), ONS – National Electric System Operator (Operador Nacional do Sistema Elétrico), INMETRO, BNDES, ANEEL – National Electric Energy Agency (Agência Nacional de Energia Elétrica), MAPA, MF (SEMC), MCTI, MMA, IBAMA	
Assessment of social, economic, and environmental impacts and co-benefits of the PSM for Industry The impact assessment of the Sectoral Plans of the Climate Mitigation Plan was conducted as part of the ICAT Brazil Phase 3 Project, implemented by the Brazil Climate Center (CBC) with support from the Initiative for Climate Action Transparency (ICAT) and technical support from the World Resources Institute (WRI). This assessment adopted a qualitative approach, based primarily on ICAT's Sustainable Development Methodology[1] and Stakeholder Participation Guide[2]. The following are the impacts of the impactful actions of the Sectoral Mitigation Plan for Industry: Environmental: Greater efficiency in the use of natural resources; reduced emissions; reduced pressure on water resources; reduced waste generation; less raw material extraction; and greater efficiency in the use of production inputs. In the case of expanding the use of renewable fuels, land-use planning is necessary to minimize losses of native vegetation and avoid impacts on ecosystems. Economic: Job creation; competitiveness; income generation. Social: In the case of expanding the use of renewable fuels, there may be greater demand for land used for biomass cultivation, potentially increasing land conflicts, hence the importance of sound planning. Overall, these initiatives contribute to the modernization of industry and the promotion of technological innovation.	

1 Available at: https://climateactiontransparency.org/wp-content/uploads/2020/04/Sustainable-Development-Assessment-Guide.pdf. Accessed on: Sep. 14, 2026.

2 Available at: https://climateactiontransparency.org/wp-content/uploads/2020/04/Stakeholder-Participation-Assessment-Guide.pdf. Accessed on: Sep. 14, 2026.

Source: Compiled by the authors.

Table 3.9 Sectoral Mitigation Plan for Cities

Impactful Actions	Targets
Adopt urban planning principles that help optimize necessary urban travel and reduce dependence on individual motorized modes of transport.	2030: Reduce the average time spent commuting in major Brazilian cities by at least 5%.
Increase the share of active modes of transportation in the modal split of major Brazilian cities.	2030: Achieve a share of at least 34.5% for active modes of transportation in the national modal split.
Increase the share of public transport in the modal split of major Brazilian cities.	2030: Achieve a public transport share of at least 33.5% in the modal split.
Decarbonize the urban, semi-urban, and metropolitan public transport system.	2030: Achieve a share of at least 5.8% of vehicles powered by renewable energy in the fleet allocated to public transport.
Decarbonize urban freight transport, the public vehicle fleet, and essential service vehicles.	2030: 19% of the fleet across three vehicle categories - urban freight vehicles (UFVs), public fleet vehicles, and essential service vehicles - powered by low- or zero-emission alternatives.
Encourage the decarbonization of individual motorized transportation.	2030: Reduce the share of gasoline in the fuel supply for light-duty vehicles by 25%.
Expand, conserve, and restore urban vegetation cover.	Equitable expansion of urban vegetation cover by 90,000 hectares by 2030.
Promote energy efficiency and expand the use of low-carbon technologies in the housing sector.	Support the construction of 470,000 housing units under the MCMV - My House, My Life (Minha Casa, Minha Vida) program using industrialized construction systems that reduce CO_2 emissions and waste generation.
Reduce urban expansion and the resulting removal of vegetation, and increase the reuse of underutilized spaces in cities.	2030: Reduce the area of land converted to settlements by 40%. Reduce the number of vacant housing units in the country by 30%.

Partial results on progress toward achieving the targets related to impactful actions will be reported starting with BTR3 and in subsequent reports.

Main implementation instruments

National Program for the Production and Use of Biodiesel (PNPB, Programa Nacional de Produção e Uso do Biodiesel) – Law No. 11,097 of 2005, as amended by Law No. 13,033 of 2014, as further amended by Law No. 13,263 of 2016

National Urban Mobility Policy (PNMU, Política Nacional de Mobilidade Urbana) – Law No. 12,587/2012

National Biofuels Policy (RenovaBio) – Law No. 13,576/2017, Decree No. 9,888/2019

Resilient Green Cities Program (PCVR, Programa Cidades Verdes Resilientes) – Decree No. 12,041 of June 5, 2024

City Statute / Master Plans – Law No. 10,257/2001

Metropolis Statute – Law No. 13,089/2015

Brazilian Habitat Quality and Productivity Program (PBQP-H, Programa Brasileiro de Qualidade e Produtividade do Habitat) – Ministry of Cities Ordinance No. 134/1998

Brazil Bicycle Program (PBB, Programa Bicicleta Brasil) – Law No. 13,724 of October 4, 2018

My House, My Life (MCMV) Program – Law No. 14,620/2023

National Urban Development Policy – currently under development

Impactful Actions	Targets
Urban Development Program (*Pró-Cidades* (Pro-Cities)) – Resolution No. 897/2018 of the FGTS - Severance Indemnity Fund (Fundo de Garantia do Tempo de Serviço) Board of Trustees Federal Government Property Democratization Program – *Imóvel da Gente* (Property for the People) – Decree No. 11,929/2024 Native Vegetation Protection Law – Law No. 12,651/2012 National System of Nature Conservation Units – Law No. 9,985/2000 New Growth Acceleration Program (*Novo PAC*) - Decree No. 11,632/2023 National Solid Waste Policy (PNRS, Política Nacional de Resíduos Sólidos) - Law No. 12,305/2010 Legal Framework for Basic Sanitation – Law No. 11,445/2007, as amended by Law No. 14,026/2020 Legal Framework for Urban Public Transport – Law No. 15,432/2026 National Urban Mobility Study (ENMU), developed by the Ministry of Cities in partnership with the Brazilian Development Bank (BNDES) Municipal land use planning and regulation instruments (regulated by the City Statute) Fuel of the Future Program; ProBioQav – National Sustainable Aviation Fuel Program (Programa Nacional de Combustível Sustentável de Aviação); PNDV – National Green Diesel Program (Programa Nacional de Diesel Verde); Biomethane; CCS - Law No. 14,993 of October 8, 2024	
Sectors affected: Energy and LULUCF	
Gases affected: CO_2, CH_4, N_2O	
National Inventory Categories and Subcategories Affected by the Actions 1.A.3.b.i. Fuel Combustion Activities - Transport - Cars 1.A.3.b.ii.1. Fuel Combustion Activities - Transport - Light-duty trucks (Light Commercial Vehicles) 1.A.3.b.ii.6. Fuel Combustion Activities - Transport - Light-duty trucks (Minibuses) 1.A.3.b.ii.7. Fuel Combustion Activities - Transport - Light-duty trucks (Urban buses) 1.A.4.a. Fuel Combustion Activities - Transport - Other Sectors (Commercial/Institutional) 1.A.4.b. Fuel Combustion Activities - Transport - Other Sectors (Residential) 4.E. Settlements	
Estimated cost: over BRL 7 billion	
Implementing entities: MCidades, MMA, MS - Ministry of Health (Ministério da Saúde), MT, MME, EPE, State and Municipal Governments, ANFAVEA – National Association of Automotive Vehicle Manufacturers (Associação Nacional dos Fabricantes de Veículos Automotores), MDIC, ABVE - Brazilian Electric Vehicle Association (Associação Brasileira do Veículo Elétrico)	
Assessment of social, economic, and environmental impacts and co-benefits of the PSM for Cities The impact assessment of the Sectoral Plans of the Climate Mitigation Plan was conducted as part of the ICAT Brazil Phase 3 Project, implemented by the Brazil Climate Center (CBC) with support from the Initiative for Climate Action Transparency (ICAT) and technical support from the World Resources Institute (WRI). This assessment adopted a qualitative approach, based primarily on ICAT's Sustainable Development Methodology[1] and Stakeholder Participation Guide[2]. The following are the impacts of the impactful actions of the Sectoral Mitigation Plan for Cities: Environmental: Mitigation of GHG emissions; potential to reduce local air pollution; reduction of noise pollution. Economic: Increased demand for electricity and greater need for investment in charging infrastructure and modernization of the urban electricity system; electrification of transport in cities creates new economic opportunities (such as job creation). Social: The transformation of cities toward a low-carbon future is linked to the promotion of social justice and, thus, presents an opportunity to expand access to mobility, reduce territorial inequalities, and improve the population's living conditions, health, and well-being.	

1 Available at: https://climateactiontransparency.org/wp-content/uploads/2020/04/Sustainable-Development-Assessment-Guide.pdf. Accessed on: Sep. 14, 2026.

2 Available at: https://climateactiontransparency.org/wp-content/uploads/2020/04/Stakeholder-Participation-Assessment-Guide.pdf. Accessed on: Sep. 14, 2026.

Source: Compiled by the authors.

Table 3.10 Sectoral Mitigation Plan for Transport

Impactful Actions*	Targets
Increase the use of biofuels in the transport sector.	A 20% blend of biodiesel in diesel fuel sold to end consumers by 2030.
Increase the use of *Sustainable Aviation Fuel* (SAF) in domestic flight operations.	Minimum emission reduction of 3% for domestic flights in 2030.
Increase the use of low-carbon fuels in domestic navigation.	Reduce gCO_2e/MJ emissions by 6% by 2030.
Improve pavement quality on federal highways.	Increase by 5% the percentage of federally managed highways in good condition by 2030, based on the 2024 ICS - Surface Condition Index (Índice de Condição da Superfície) indicator. Increase the IDPAV - Pavement Performance Index (Índice de Desempenho do Pavimento) indicator by 5% on federally concessioned highways by 2030, based on the 2024 indicator value.
Reduce fossil fuel consumption in airport operations, particularly during aircraft taxiing.	Reduce fossil fuel consumption during aircraft taxiing by 25% by 2030.
Increase the share of rail and waterway transport in the freight transport modal split.	Shift 31.5 billion TKU (useful ton-kilometers) of freight transport from road to rail by 2030. Increase the share of freight transported by domestic navigation to 15% of the total freight transported by the sector by 2030.
Increase the use of green diesel in the transport sector.	2% blending of green diesel into diesel fuel sold to end consumers by 2030.
Increase the use of medium- and heavy-duty electric vehicles in the transport sector.	Electric vehicles accounting for 6% of medium- and heavy-duty vehicle sales in 2030.
Partial results on progress toward achieving the targets related to impactful actions will be reported starting with BTR3 and in subsequent reports. **Main implementation instruments** National Program for the Production and Use of Biodiesel (PNPB) – Law No. 11,097 of 2005, as amended by Law No. 13,033 of 2014, as further amended by Law No. 13,263 of 2016 National Biofuels Policy (RenovaBio) – Law No. 13,576/2017, Decree No. 9,888/2019 National Logistics Plan (PNL, Plano Nacional de Logística) 2035 – Ministry of Infrastructure Ordinance No. 123/2020 Fuel of the Future Program; ProBioQav; PNDV; Biomethane; CCS - Law No. 14,993 of October 8, 2024 Green Mobility Program (Mover) – Law No. 14,902/2024 Energy Transition Acceleration Program (Paten) - Law No. 15,103/2025 Action Plan for Reducing GHG Emissions from Brazilian Civil Aviation – Resolution A37-19 New Growth Acceleration Program (Novo PAC) - Decree No. 11,632 of August 11, 2023 The importance of logistics and regulatory planning instruments is also noteworthy, as they guide the organization of the transport modal split and the incorporation of sustainability criteria into infrastructure, contributing to structural reductions in emissions from the sector.	
Sectors affected: Energy	

Impactful Actions*	Targets
Gases affected: CO_2, CH_4, N_2O	
National Inventory Categories and Subcategories Affected by the Actions 1.A.3. a.ii. Fuel Combustion Activities - Transport - Domestic aviation 1.A.3.b.ii. Fuel Combustion Activities - Transport - Light-duty trucks (Semi-Light-duty trucks) 1.A.3.b.iii. Fuel Combustion Activities - Transport - Medium-duty, Semi-heavy-duty, and Heavy-duty trucks) 1.A.3.c Fuel Combustion Activities - Railways 1.A.3.d.ii Fuel Combustion Activities — Transport - Domestic navigation 1.A.5. Other (Not specified elsewhere)	
Estimated cost: over BRL 3 billion	
Implementing entities: MT, MME, CNPE, ANP, MDIC, SAC – Civil Aviation Secretariat (Secretaria de Aviação Civil), ANAC – National Civil Aviation Agency (Agência Nacional de Aviação Civil), SNHN - National Secretariat for Waterways and Navigation (Secretaria Nacional de Hidrovias e Navegação)/ MPOR - Ministry of Ports and Airports (Ministério de Portos e Aeroportos), ANTAQ – National Agency for Waterway Transportation (Agência Nacional de Transportes Aquaviários), DNIT – National Department of Transport Infrastructure (Departamento Nacional de Infraestrutura de Transportes), ANTT – National Land Transport Agency (Agência Nacional de Transportes Terrestres), Highway concessionaires, State Regulatory Agencies and DER – State Highway Departments (Departamentos de Estradas de Rodagem), Aircraft operators, SNTF – National Secretariat for Rail Transport (Secretaria Nacional de Transporte Ferroviário), Railway and Waterway Concessionaires, Ministry of Defense (Brazilian Navy), Green Diesel Production Companies and Associations, SENATRAN – National Traffic Secretariat (Secretaria Nacional de Trânsito), ANFAVEA	
Assessment of social, economic, and environmental impacts and co-benefits of the PSM for Transport The impact assessment of the Sectoral Plans of the Climate Mitigation Plan was conducted as part of the ICAT Brazil Phase 3 Project, implemented by the Brazil Climate Center (CBC) with support from the Initiative for Climate Action Transparency (ICAT) and technical support from the World Resources Institute (WRI). This assessment adopted a qualitative approach, based primarily on ICAT's Sustainable Development Methodology[1] and Stakeholder Participation Guide[2]. The following are the impacts of the relevant impactful actions of the Sectoral Mitigation Plan for Transport: Environmental: Reduction of GHG emissions and local pollutants; improved air quality along highway corridors, in port cities, and in areas with heavy freight traffic, as well as reduced risk of major oil spills and emissions associated with the use of heavy fuel oil; benefits for the circular economy and more efficient use of resources, such as the reuse of waste and used oils to produce SAF, marine fuels, and green diesel. Road pavement improvements and increased average speeds may intensify habitat fragmentation and wildlife-vehicle collisions. Need for land use planning and environmental safeguards in infrastructure projects to reduce the risks of deforestation, degradation, and impacts on aquatic and coastal ecosystems. Need for integration between transport, land use, and ecosystem conservation policies. Economic: Stimulation and diversification of supply chains linked to bioenergy, SAF, alternative marine fuels, and green diesel; creation of direct and indirect jobs in agroindustry, refining, logistics, and technology services; strengthening of energy security by reducing dependence on imported fossil fuel products and diversifying supply sources. Road pavement improvements, reduced use of fossil fuels in infrastructure, and increased shares of rail and waterway transport can reduce average logistics costs, fleet maintenance costs, operational disruptions, and exposure to oil price shocks, with positive effects on competitiveness, production efficiency, and the value of logistics assets in	

Impactful Actions*	Targets
strategic corridors. The absence of climate criteria in road pavement engineering increases the vulnerability of highways to extreme events. There may be an increase in operating and compliance costs, particularly where low-emission fuels are still significantly more expensive than fossil fuels (as in the case of SAF and green diesel), and these costs may be passed on to freight rates, fares, and ticket prices, affecting supply chains and end users. There are also risks of disruption to traditional segments (such as long-distance road transportation) due to the modal shift to rail and waterway transport, and of the concentration of economic benefits among large agribusiness groups, shipowners, airlines, and major construction contractors, to the detriment of small producers, independent transport operators, and local businesses. There is a risk of technological lock-in to liquid fuels if policies excessively prioritize biofuels and green diesel over complementary strategies, such as electrification, energy efficiency, and structural changes in the transport modal split, which could limit long-term decarbonization potential. Social: Improvements in public health, road safety, quality of life, and institutional strengthening. Reduction of local pollutants in urban areas, ports, waterways, and high-traffic highway corridors, generating significant co-benefits in terms of reduced morbidity and mortality from respiratory and cardiovascular diseases and fewer serious road accidents. Certification, traceability, and governance mechanisms (RenovaBio, CORSIA, green diesel schemes, performance contracts, and MRV systems) can raise standards of decent work, corporate transparency, and social inclusion in decision-making, strengthening climate and territorial governance in the transport sector. Risks to food security, health, and well-being of vulnerable populations, whether due to competition between land for food and energy production (biofuels, green diesel, SAF) or the potentially regressive increase in transport fares and prices of essential goods resulting from the pass-through of fuel and investment costs; risks of involuntary displacement of rural, traditional, and riverside communities, increased vulnerability of communities in areas undergoing logistics infrastructure upgrading, and intensification of territorial conflicts and land disputes associated with the expansion of energy crops, railways, waterways, ports, and highways; risks to working conditions and equity: increased precarious seasonal employment, exclusion of workers with lower levels of education due to automation processes and requirements for new skills, persistence of gender and racial disparities in access to the opportunities generated, and the possibility of violations of rights in poorly regulated feedstock supply chains. To reduce these risks, planning for a socially just transition is necessary, with specific instruments to protect populations that are most exposed to risks and to distribute the social benefits of decarbonization more equitably. In this context, it is essential to develop instruments that promote a just transition in the transport sector, taking into account the impacts on workers, independent transport operators, and vulnerable populations, in order to ensure an equitable distribution of benefits and mitigate the risks associated with the transition.	

*The actions proposed in this plan have no direct influence on GHG emissions from international transport (Information provided in response to TER recommendation 11.4 – Appendix 3).

1 Available at: https://climateactiontransparency.org/wp-content/uploads/2020/04/Sustainable-Development-Assessment-Guide.pdf. Accessed on: Sep. 14, 2026.

2 Available at: https://climateactiontransparency.org/wp-content/uploads/2020/04/Stakeholder-Participation-Assessment-Guide.pdf. Accessed on: Sep. 14, 2026.

Source: Compiled by the authors.

Table 3.11 Sectoral Mitigation Plan for Energy

Impactful Actions	Targets
Meet the increase in demand while maintaining or increasing the share of renewable energy in the electricity matrix.	82.7% renewable energy in the electricity matrix by 2030.
Strengthen the production and sustainable use of biofuels.	Biodiesel: Mandatory 20% blend by 2030; Ethanol: Mandatory 30% blend by 2030.
Increase the production of synthetic fuels from low-carbon sources.	SAF: Production of 1.6 billion liters by 2030. Green Diesel: Production of 1.6 billion liters by 2030.
Expand the production and use of biomethane.	Reduction of up to 5% by 2030 in GHG emissions from gaseous fuel consumption, relative to the ten-year average supply of natural gas from domestic production and imports.
Reduce the emissions intensity of the oil and natural gas Exploration and Production (E&P) segment.	By 2030, maintain the emissions intensity of the oil and natural gas Exploration and Production (E&P) segment at its 2022 level (15 kgCO_2/boe).
Reduce the emissions intensity of the petroleum refining segment.	By 2030, 30 kg CO_2 per CWT.
Reduce emissions from the transport of oil, natural gas, and petroleum products.	Avoid the consumption of up to 125,000 m³ of diesel fuel in the transport of oil, natural gas, and petroleum products by 2030.
Promote energy efficiency and decarbonization in buildings.	2% improvement in efficiency by 2030, relative to 2024.
Promote energy efficiency and the decarbonization of industry.	3% improvement in efficiency by 2030, relative to 2024.

Partial results on progress toward achieving the targets related to impactful actions will be reported starting with BTR3 and in subsequent reports.

Main implementation instruments

National Program for the Production and Use of Biodiesel (PNPB) – Law No. 11,097/2005, as amended by Law No. 13,033/2014, as further amended by Law No. 13,263/2016
National Biofuels Policy (RenovaBio) – Law No. 13,576/2017, Decree No. 9,888/2019
National Energy Plan
Ten-Year Energy Expansion Plan
National Energy Transition Policy (PNTE) and National Energy Transition Plan (PLANTE, Plano Nacional de Transição Energética) – CNPE Resolution No. 5/2024
Guidelines for promoting the decarbonization of oil and natural gas exploration and production activities – CNPE Resolution No. 8/2024
New Industry Brazil (NIB) – CNDI/MDIC Resolution No. 1/2023
Brazilian Greenhouse Gas Emissions Trading System – Law No. 15,042/2024
Fuel of the Future Program; ProBioQav; PNDV; Biomethane; CCS - Law No. 14,993/2024
Energy Efficiency Program (PEE/ANEEL)
PROCEL

Sectors affected: Energy

Gases affected: CO_2, CH_4, N_2O

Impactful Actions	Targets

National Inventory Categories and Subcategories Affected by the Actions

1.A.1.a Fuel Combustion Activities - Energy industries (Main activity electricity and heat production)
1.A.1.b Petroleum refining
1.A.1.c Fuel Combustion Activities - Energy industries (Manufacture of solid fuels and other energy industries, excluding coking plants)
1.A.3.e.i Transport - Pipeline transport
1.A.3.e.ii Transport - Off-road
1.B. Fugitive Emissions from Fuels.
1.C. CO_2 Transport and Storage

Estimated cost: over BRL 9 billion

Implementing entities: MME, ANEEL, EPE, ONS, MAPA, MF (SEMC), Embrapa, MT, ANAC, MCidades, States and Municipalities, ANP, IBP - Brazilian Institute of Oil, Gas and Biofuels (Instituto Brasileiro de Petróleo, Gás e Biocombustíveis), ABPIP - Brazilian Association of Independent Oil and Gas Producers (Associação Brasileira dos Produtores Independentes de Petróleo e Gás), MDIC, MCTI

Assessment of social, economic, and environmental impacts and co-benefits of the PSM for Energy

The impact assessment of the Sectoral Plans of the Climate Mitigation Plan was conducted as part of the ICAT Brazil Phase 3 Project, implemented by the Brazil Climate Center (CBC) with support from the Initiative for Climate Action Transparency (ICAT) and technical support from the World Resources Institute (WRI). This assessment adopted a qualitative approach, based primarily on ICAT's Sustainable Development Methodology[1] and Stakeholder Participation Guide[2].

The following are the impacts of the impactful actions of the Sectoral Mitigation Plan for Energy:

Environmental: Reduction of GHG emissions; replacement of inefficient equipment reduces the consumption of fuels and natural resources for energy generation, transport, and use.

Economic: Job creation; strengthening of supply chains, competitiveness, energy security, and income generation; stimulation of supply chains and technological innovation in the energy sector. Need for appropriate financing instruments and incentive mechanisms for small and medium-sized enterprises to ensure that economic benefits are not concentrated solely among large groups in the sector.

Social: Expanded access to energy; reduced energy vulnerability and increased autonomy in energy consumption, particularly in rural and remote regions where biofuels can be produced and distributed locally; need for technical training and workforce skills development. Need for planning to prevent disputes over land use and encroachment on productive areas, which can lead to pressure on local communities, changes in territorial land use, and a reduction in the availability of land for food production. The installation of centralized wind and solar power generation facilities may pose risks to the physical and mental health of nearby communities due to noise, vibrations, and changes in social and productive dynamics.

1 Available at: https://climateactiontransparency.org/wp-content/uploads/2020/04/Sustainable-Development-Assessment-Guide.pdf. Accessed on: Sep. 14, 2026.
2 Available at: https://climateactiontransparency.org/wp-content/uploads/2020/04/Stakeholder-Participation-Assessment-Guide.pdf. Accessed on: Sep. 14, 2026.

Source: Compiled by the authors.

Table 3.12 Sectoral Mitigation Plan for Solid Waste and Domestic Wastewater

Impactful Actions	Targets
Reduce the amount of solid waste and residual waste sent for final disposal, prioritizing treatment and recovery solutions for organic waste.	Reduce the amount of waste and residual waste sent to final disposal facilities by 25.3% by 2030 and achieve treatment and recovery of 14.3% of the total mass of organic waste by 2030.
Maximize energy recovery from biogas at sanitary landfills.	Recover energy from 25.15% of the biogas generated at sanitary landfills by 2030, relative to 2020.
Restore areas used for inadequate final disposal of residual waste and solid waste.	Restore at least one inadequate waste disposal site per state by 2030.
Achieve universal collection and treatment of domestic wastewater.	Collect and treat 90% of domestic wastewater by 2033.
Maximize energy recovery from biogas at domestic wastewater treatment plants.	Recover energy from 12.5% of the biogas generated at domestic wastewater treatment plants by 2030.

Partial results on progress toward achieving the targets related to impactful actions will be reported starting with BTR3 and in subsequent reports.

Main implementation instruments

National Solid Waste Policy (PNRS) - Law No. 12,305/2010
National Solid Waste Plan (Planares, Plano Nacional de Resíduos Sólidos) – Decree No. 11,043/2022
National Basic Sanitation Policy – Law No. 11,445/2007 and its Legal Framework – Law No. 14,026/2020
Energy Transition Acceleration Program (Paten) – Law No. 15,103/2025
National Program for the Decarbonization of Natural Gas Producers and Importers and Incentives for Biomethane – Law No. 14,993/2024, Decree No. 12,614/2025.

Sectors affected: Waste

Gases affected: CO_2, CH_4, N_2O

National Inventory Categories and Subcategories Affected by the Actions

5.A. Solid waste disposal
5.B. Biological treatment of solid waste
5.C. Incineration and open burning of waste
5.D. Wastewater treatment and discharge (excluding Industrial wastewater treatment)

Estimated cost: over BRL 4 billion

Implementing entities: MMA, MCidades, MME, ANP, SESAI - Special Secretariat for Indigenous Health (Secretaria Especial de Saúde Indígena), States, Municipalities, private sector

Assessment of social, economic, and environmental impacts and co-benefits of the PSM for Solid Waste and Domestic Wastewater

The impact assessment of the Sectoral Plans of the Climate Mitigation Plan was conducted as part of the ICAT Brazil Phase 3 Project, implemented by the Brazil Climate Center (CBC) with support from the Initiative for Climate Action Transparency (ICAT) and technical support from the World Resources Institute (WRI). This assessment adopted a qualitative approach, based primarily on ICAT's Sustainable Development Methodology[1] and Stakeholder Participation Guide[2].

These are the impacts of the impactful actions of the Sectoral Mitigation Plan for Solid Waste and Domestic Wastewater:

Impactful Actions	Targets
Environmental: Reduction of soil, groundwater, and water body pollution; mitigation of greenhouse gas emissions, particularly methane; extension of the useful life of sanitary landfills; production of organic compost through the recovery of organic waste, with energy recovery from biogas and biomethane, reducing dependence on fossil fuels and encouraging more sustainable waste disposal practices; environmental restoration and improvement of soil quality by restoring degraded sites and reversing the impacts caused by inadequate waste disposal. Economic: Economic viability of treatment facilities through increased revenue from organic waste recovery and the sale of biomethane and electricity generated from biogas; job creation at waste recovery facilities, landfills, and wastewater treatment facilities. Reduced dependence on imports of feedstocks and fertilizers through the production and use of organic compost in Brazilian agriculture. Social: Direct effects on public health and the reduction of risks to health and life, since inadequate disposal of waste and residual waste is associated with the spread of diseases and the occurrence of floods and landslides, particularly in areas of greater social vulnerability. Proper management of waste and domestic wastewater contributes to safer and cleaner urban environments, reducing the incidence of arboviral diseases, helminth infections, and other health conditions associated with pollution and the accumulation of residual waste and untreated sewage. Improvements in housing conditions, ensuring access to essential sanitation and hygiene services; reduction of inequalities in access to basic infrastructure. Reduction of food insecurity by preventing food waste as the first measure to reduce waste generation. Job and income generation at solid waste recovery, treatment, and final disposal facilities, prioritizing the participation of organizations of reusable and recyclable material collectors.	

1 Available at: https://climateactiontransparency.org/wp-content/uploads/2020/04/Sustainable-Development-Assessment-Guide.pdf. Accessed on: Sep. 14, 2026.
2 Available at: https://climateactiontransparency.org/wp-content/uploads/2020/04/Stakeholder-Participation-Assessment-Guide.pdf. Accessed on: Sep. 14, 2026.

Source: Compiled by the authors.

3.5 Summary of greenhouse gas emissions and removals

Information on Brazil's GHG emissions and removals is provided in **Chapter 2. National Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases,** as well as the details presented in Brazil's National Inventory Report (NIR 2026). Nevertheless, a summary of net emissions (in kt CO_2 eq) for the time series from 1990 to 2024 is presented below.

SECTOR	NET EMISSIONS (kt CO_2 eq)					
	1990	1991	1992	1993	1994	1995
TOTAL	1,587,811	1,452,767	1,540,824	1,585,037	1,590,410	2,671,788
1. ENERGY	199,129	202,820	207,643	212,136	220,571	236,869
2. IPPU	55,030	59,156	58,099	60,737	60,981	65,686
3. AGRICULTURE	379,893	390,942	400,402	405,214	413,521	417,761
4. LULUCF	910,177	754,540	827,678	858,232	844,733	1,898,823
5. WASTE	43,582	45,309	47,002	48,718	50,604	52,648
	2002	2003	2004	2005	2006	2007
TOTAL	2,263,704	3,310,325	3,529,494	2,583,953	2,150,338	1,815,522
1. ENERGY	301,966	296,226	312,340	323,068	327,974	341,534
2. IPPU	77,799	78,800	81,426	81,744	82,548	83,750
3. AGRICULTURE	454,202	483,763	503,024	502,837	496,190	485,445
4. LULUCF	1,363,166	2,382,399	2,561,266	1,601,668	1,166,155	825,976
5. WASTE	66,571	69,136	71,437	74,636	77,470	78,817
	2014	2015	2016	2017	2018	2019
TOTAL	1,535,248	1,570,579	1,550,070	1,508,598	1,498,221	1,780,847
1. ENERGY	487,393	462,366	429,403	436,206	414,064	414,486
2. IPPU	97,180	98,158	97,470	101,716	100,247	96,161
3. AGRICULTURE	529,873	535,649	545,467	527,109	526,607	527,115
4. LULUCF	326,353	377,836	380,453	345,795	357,450	643,360
5. WASTE	94,449	96,570	97,276	97,772	99,852	99,724

Notes: IPPU - Industrial Processes and Product Use; LULUCF - Land Use, Land-Use Change and Forestry
Source: Compiled by the authors.

NET EMISSIONS (kt CO_2 eq)						
	1996	1997	1998	1999	2000	2001
TOTAL	2,003,838	1,728,980	1,992,195	1,962,936	2,037,972	2,055,260
1. ENERGY	253,597	269,818	278,057	288,006	294,721	303,504
2. IPPU	65,210	67,895	72,596	72,128	76,742	72,891
3. AGRICULTURE	391,988	400,116	405,913	411,781	426,321	442,672
4. LULUCF	1,238,455	934,857	1,177,557	1,130,954	1,178,057	1,171,805
5. WASTE	54,589	56,294	58,072	60,066	62,130	64,388
	2008	2009	2010	2011	2012	2013
TOTAL	1,947,486	1,428,644	1,447,752	1,414,030	1,328,824	1,539,088
1. ENERGY	361,188	349,825	383,941	396,921	430,117	460,935
2. IPPU	84,804	76,045	88,084	95,660	95,448	96,371
3. AGRICULTURE	495,379	502,659	516,847	520,867	519,184	524,566
4. LULUCF	925,612	416,480	373,158	312,934	195,089	363,688
5. WASTE	80,503	83,635	85,722	87,648	88,985	93,527
	2020	2021	2022	2023	2024	
TOTAL	1,770,532	2,006,879	2,067,308	1,706,509	1,509,791	
1. ENERGY	391,641	439,950	417,949	422,671	426,906	
2. IPPU	97,551	106,454	106,167	106,409	108,602	
3. AGRICULTURE	540,594	555,438	573,075	584,832	579,322	
4. LULUCF	640,759	803,891	867,993	487,319	285,636	
5. WASTE	99,987	101,146	102,124	105,278	109,325	

3.6 Projections of greenhouse gas emissions and removals

3.6.1 Introduction

Brazil has made projections of GHG emissions and removals[27] to guide the prioritization and improvement of policy instruments that will help the country achieve its NDC targets, including its commitment to climate neutrality by 2050, with greater economy-wide cost-effectiveness.

Integrated Assessment Models (IAMs) are important tools for the long-term assessment of low-GHG-emission scenarios. They make it possible to investigate the interconnections between different sectors of the economy and identify more cost-effective options for achieving decarbonization targets and goals. Perfect foresight[28] models, therefore, assume optimal combinations of factors over the medium and long term.

GHG emissions mitigation pathways were developed based on technological and public policy assumptions, as well as estimates of economic activity variables at the national and international levels.

In addition to the limitations inherent in the integrated modeling process, which result in simplified mathematical representations of the different sectors that make up a complex system, there are a number of uncertainties to be considered when defining feasible mitigation goals, targets, and pathways with significant impacts on the country's development.

The first uncertainty to be highlighted regards the uncertainty that is inherent in perfect foresight models, which assume optimal combinations of factors over the medium and long term, without considering changes and effects arising from future social, economic, and technological dynamics.

A second source of uncertainty lies in the assumptions regarding the effective implementation of public policies and the achievement of their targets within the set timeframes, which may be subject to delays or partial achievement, as well as the possibility that the technologies considered may not become viable within the set timeframes, with their implementation costs potentially underestimated or outdated in the model.

Another uncertainty associated with this exercise concerns the failure of existing models to account for the impacts of climate change itself over time, such as potential adverse effects on mitigation pathways, including declining agricultural productivity and reduced water availability, as well as the costs of inaction in the face of climate change.

Furthermore, it should be noted that the socioeconomic scenario used in the modeling was SSP2 (Shared Socioeconomic Pathways – Riahi *et al.*, 2017), which entails moderate challenges for mitigation and adaptation. Given the volatility, uncertainty, complexity, and ambiguity involved

27 MCTI project supported by the European Union's Climate Dialogues initiative (EUCDs-GIZ), through which the Center for Energy and Environmental Economics (Cenergia, Centro de Economia Energética e Ambiental) of the Energy Planning Program of the Federal University of Rio de Janeiro (COPPE - Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering (Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa de Engenharia) /UFRJ - Federal University of Rio de Janeiro (Universidade Federal do Rio de Janeiro)) was hired to make the projections.

28 The perfect foresight assumption refers to optimization under conditions of complete and accurate knowledge about the future, considering the modeling horizon. This means that the optimization outcome for each time interval assumes perfect information about future events and market conditions, disregarding the uncertainty associated with decisions made by economic agents and sectors.

in the projection of future scenarios, national climate ambition depends on factors that are difficult to predict over the coming decade, through 2035, both nationally and internationally. These factors include levels of global cooperation, investment and international trade flows, and technological development and diffusion. Under a favorable international scenario, with exponential growth in cooperation and technological diffusion, Brazil may achieve the highest level of its climate ambitions. Under a scenario of fragmented international cooperation, on the other hand, this could limit Brazil's potential to contribute to the objectives of the UNFCCC and its Paris Agreement.

Thus, in setting its new climate target for 2035, Brazil's NDC recognizes that future projections involving complex systems are inherently uncertain, requiring the consideration of scenarios that reflect the country's climate ambition, in line with a net-zero emissions pathway by 2050 and the best available scientific knowledge on scenario planning appropriate for complex systems and a systemic perspective.

It should be emphasized that the scenarios presented are of an analytical nature, serving to assess pathways aligned with long-term mitigation targets. They should not be interpreted as instruments for assessing progress in implementing or achieving Brazil's first or second NDC, in accordance with paragraph 93 of the annex to Decision 18/CMA.1, as the country has not established a projection as a baseline for either of them.

Furthermore, it should be noted that the allocation of emission categories in the sectors presented in the scenarios (Energy, Transport, Industry, Agriculture, LULUCF, and Waste) does not correspond to the allocation of emission categories presented in the National Inventory of GHG Emissions by Sources and Removals by Sinks and the National Climate Change Plan (Climate Plan), due to the methodological specificities of each exercise.

3.6.2 The BLUES model, scenarios, and assumptions

The researchers worked together with the ministries that make up the CIM to define key assumptions and parameters needed to develop GHG emissions scenarios for Brazil through 2060. This BTR presents the results of emissions projections through 2040.

The projections were developed using an integrated assessment model (IAM) called BLUES (Brazilian Land Use and Energy System). It is a perfect-foresight optimization model developed on the MESSAGE (Model for Energy Supply Strategy Alternatives and their General Environmental Impacts) platform (Rochedo *et al.*, 2018). MESSAGE is a linear programming optimization software platform designed to facilitate model development, with the aim of evaluating energy supply alternatives subject to constraints related to investments, variable and fixed operating costs, fuel prices and availability, environmental regulations, technology market penetration rates, and any other constraints that can be incorporated using MESSAGE's mathematical capabilities.

The BLUES model is an intertemporal least-cost optimization model designed for Brazil that uses input parameters such as costs and performance characteristics of more than 24,000 technological alternatives, including efficiencies, capacity factors, and environmental indicators. This model can assess all sectors of the Brazilian economy, taking into account the energy and land-use sectors, making it possible to examine the interactions between the economy, society,

and the environment. Its objective function[29] seeks to minimize costs, subject to technological and environmental constraints.

The parameters considered in the model are based on the best scientific information available; each technology is associated with a total cost and greenhouse gas emissions, including a breakdown by type of gas.

Thus, the selection of technologies is based on minimizing the overall cost of the entire system, while adhering to a set of assumptions and boundary conditions that represent real-world constraints.

Brazil's economic and population growth pathways through 2050 were developed in alignment with both the data generated by the COFFEE (Computable Framework for Energy and the Environment)[30] and TEA (Total Economy Assessment)[31] models, based on the assumptions of an SSP2 scenario (Shared Socioeconomic Pathways – Riahi *et al.*, 2017), and other modeling exercises, estimates, and projections conducted within the Federal Public Administration and available at the time, with a view to outlining a feasible scenario consistent with Brazil's expected economic and social development through 2050.

The assumptions used in the modeling follow the SSP2 scenario, which is widely used in climate policy research and analysis. SSP2 is a pathway considered intermediate, or "Middle of the Road," meaning that it assumes moderate challenges for mitigation and adaptation, with social, economic, and technological trends not deviating significantly from historical patterns (Riahi *et al.*, 2017). Development and income growth continue unevenly, with some countries making relatively good progress, while others fall short of expectations. Global and national institutions work toward achieving sustainable development goals, but progress is slow. Environmental systems undergo degradation, although there are some improvements, and resource and energy use intensity generally declines. Global population growth is moderate and stabilizes in the second half of the century. Income inequality persists or improves slowly, with continuing challenges in reducing vulnerability to social and environmental changes.

Final demand for agricultural and industrial products, useful energy, and transport services is determined independently and exogenously, based on economic and population growth projections. Thus, it is in this context of economic growth, increased activity levels, and rising demand that more cost-effective production processes and technological solutions (in terms of GHG abatement costs) are needed for GHG mitigation to occur effectively.

In addition to the assumptions related to the socioeconomic context, the modeling work was guided by the commitments set out in the first NDC for 2025, 2030, and 2050, which was in effect during the preparation of the study, and by the public policies that are most relevant to the mitigation agenda in each sector. These assumptions were aligned with the relevant sectoral ministries, based on a review of the main public policies and their respective targets to be considered as boundary conditions or parameters in the modeling exercise. Dataframe 3.2

29 Concept in optimization, used to describe the mathematical function that one wishes to maximize or minimize in a specific problem.

30 The COFFEE model was the first global IAM developed in a developing country to assess climate, land-use, energy, and environmental policies, providing experts and decision-makers with relevant information on potential development strategies and the implications of long-term climate scenarios. It is a perfect-foresight linear programming optimization model (Rochedo, 2016).

31 The TEA model is a multiregional, multisectoral Computable General Equilibrium (CGE) model that tracks the production and distribution of goods in a dynamic and recursive scenario for the global economy (Cunha *et al.*, 2020).

summarizes the main input assumptions and boundary conditions adopted to reflect existing public policies and commitments, as well as the constraints applied.

Dataframe 3.2 Summary of the main assumptions related to public policies and boundary conditions adopted in the BLUES model

Targets established in the First NDC (economy-wide)

- Maximum emissions of 1.32 Gt CO_2 eq in 2025;
- Maximum emissions of 1.2 Gt CO_2 eq in 2030;
- Net-zero GHG emissions by 2050.

Land Use, Land-Use Change and Forestry

- Achievement of the target of restoring 12 million hectares (Mha) of native vegetation by 2030;
- Restoration of an additional 8.9 million hectares of native vegetation between 2031 and 2050;
- Elimination of illegal deforestation by 2030, reduction of authorized native vegetation removal (through economic incentives), and offsetting of authorized native vegetation removal through native vegetation restoration from 2030 onward.

Agriculture and Livestock: ABC+ Plan targets[32] achieved

- Restoration of degraded pastures (30 Mha by 2030; up to an additional 60 Mha by 2050);
- Intensive finishing of beef cattle (5 million head by 2030);
- Integrated systems (10 Mha by 2030; up to an additional 28 Mha by 2050);
- Commercial planted forest production (4 Mha by 2030);
- Use of bioinputs (13 Mha by 2030);
- Irrigated systems (3 Mha by 2030, with potential expansion of between 4.2 and 6 Mha by 2040);
- No-till cropping systems (12.5 Mha by 2030);
- Use of agricultural waste, primarily in biodigesters (208 million m^3 by 2030).

Energy

- B15 diesel (15% biodiesel and 85% conventional diesel) from 2025 onward;
- Gasoline containing 27.5% ethanol by volume;
- Generation provided for under Law No. 14,182 of 2021 and Decree No. 11,042 of 2022:
    - 8 GW from natural gas-fired thermal power plants from 2025 onward;
    - 2 GW from Small Hydropower Plants from 2025 onward;
- Consideration of the time required for disruptive technologies to mature before their introduction;
- Introduction of already contracted capacity;
- Abreu e Lima Refinery (RNEST, Refinaria Abreu e Lima), with a processing capacity of 230,000 barrels per day in 2030;
- Angra III Nuclear Power Plant (Usina Nuclear Angra III) in operation by 2030.

32 The ABC+ Plan is the short name for the "Sectoral Plan for Climate Change Adaptation and Low-Carbon Emission in Agriculture, aimed at Sustainable Development" and represents a strategic national agenda of the Brazilian government that continues the sectoral policy to address climate change in the agriculture sector.

Waste and Wastewater • Use of technologies by region through 2050 (recycling, anaerobic digestion, composting, energy recovery, production of waste-derived fuel, and construction of sanitary landfills), based on the National Solid Waste Plan[33] (Planares) and the National Basic Sanitation Plan (Plansab, Plano Nacional de Saneamento Básico).[34]
Transport • Implementation of a selected set of infrastructure projects under the New Growth Acceleration Program (Novo PAC)[35] (Highways, Railways, Waterways, Ports, and Airports), with completion expected by 2050.

Source: Compiled by the authors.

Based on the assumptions presented in Dataframe 3.2 and extensive discussions with the Brazilian government, two emissions scenarios were developed, differentiated by the intensity and persistence of legal deforestation, which was considered a key variable. In order to quantify the impact of different land-use pathways on net GHG emissions, the elimination of illegal deforestation by 2030 and two levels of legal deforestation after 2030 were considered, while keeping all other macroeconomic, demographic, technological, and sectoral assumptions constant:

- With Measures (WM): A reference scenario conditional on the continuation of public policies in effect and commitments undertaken by the country at the time of modeling, which considered policies and measures to achieve the NDC targets and the maintenance of current levels of legal deforestation;
- With Additional Measures (WAM): Considered the WM scenario and a 75% reduction in legal deforestation levels from 2030 onward.

The 2025 and 2030 NDC targets constitute boundary conditions of the model, and the macroeconomic, technological, and sectoral assumptions are kept constant across the WM and WAM scenarios, with the difference between them being the intensity of legal deforestation after 2030. As mentioned previously, the mitigation actions included in the scenarios presented (WM and WAM) do not directly correspond to the actions planned and implemented under the Sectoral Mitigation Plans (PSM) of the Climate Plan.

According to paragraph 95 of Decision 18/CMA.1, projections shall begin, where possible, from the most recent year in the Party's National Inventory report and extend at least 15 years beyond the next year ending in zero or five. In the present case, 2020 was used as the base year (Figure 3.4), as reported in a national document - the 6th edition of the Annual Estimates (Brasil, 2022) - reflecting the conditions, data, and assumptions available at the time when the study was conducted, between 2023 and 2024.

33 Available at: https://sinir.gov.br/informacoes/plano-nacional-de-residuos-solidos/. Accessed on: Sep. 14, 2026.

34 Available at: https://www.gov.br/cidades/pt-br/acesso-a-informacao/acoes-e-programas/saneamento/plano-nacional-de-saneamento-basico-plansab. Accessed on: Sep. 14, 2026.

35 The New Growth Acceleration Program (*Novo PAC*) is an investment program coordinated by the Federal Government in partnership with the private sector, states, municipalities, and social movements to accelerate economic growth and social inclusion, generate employment and income, and reduce social and regional inequalities.

3.6.3 Results of the projections

Based on economic and population growth projections and on the assumptions established, the BLUES model estimated possible pathways in which the increased demand for products and services resulting from this growth could be met through the reduction in net GHG emissions necessary to achieve the 2025, 2030, and 2050 targets in the most cost-effective manner for the Brazilian economy as a whole.

The results of the projections of greenhouse gas emissions and removals under WM and WAM scenarios are presented in Figure 3.4 and Tables 3.13 and 3.14.

The results obtained from the decarbonization scenarios analyzed suggest a significant structural transformation in the Brazilian economy and energy matrix. The modeling indicates the technical and economic conditions for achieving a low-carbon development model, while preserving energy security, industrial competitiveness, and the expansion of the supply of goods and services. However, this transition does not occur uniformly: each sector follows a distinct pathway, determined by its pace of technological development, energy demands, and mitigation potential. Overall, the results indicate potential for emissions reductions across all sectors, particularly Energy and LULUCF.

The LULUCF sector shows a clear downward trend in emissions over the period analyzed. In the scenario with lower rates of authorized native vegetation removal (WAM), CO_2 emissions decrease continuously, becoming negative earlier and to a greater extent, as a result of the incorporation of important measures, such as the elimination of illegal deforestation, the reduction of authorized native vegetation removal, large-scale restoration of native vegetation, and the implementation of land-use programs.

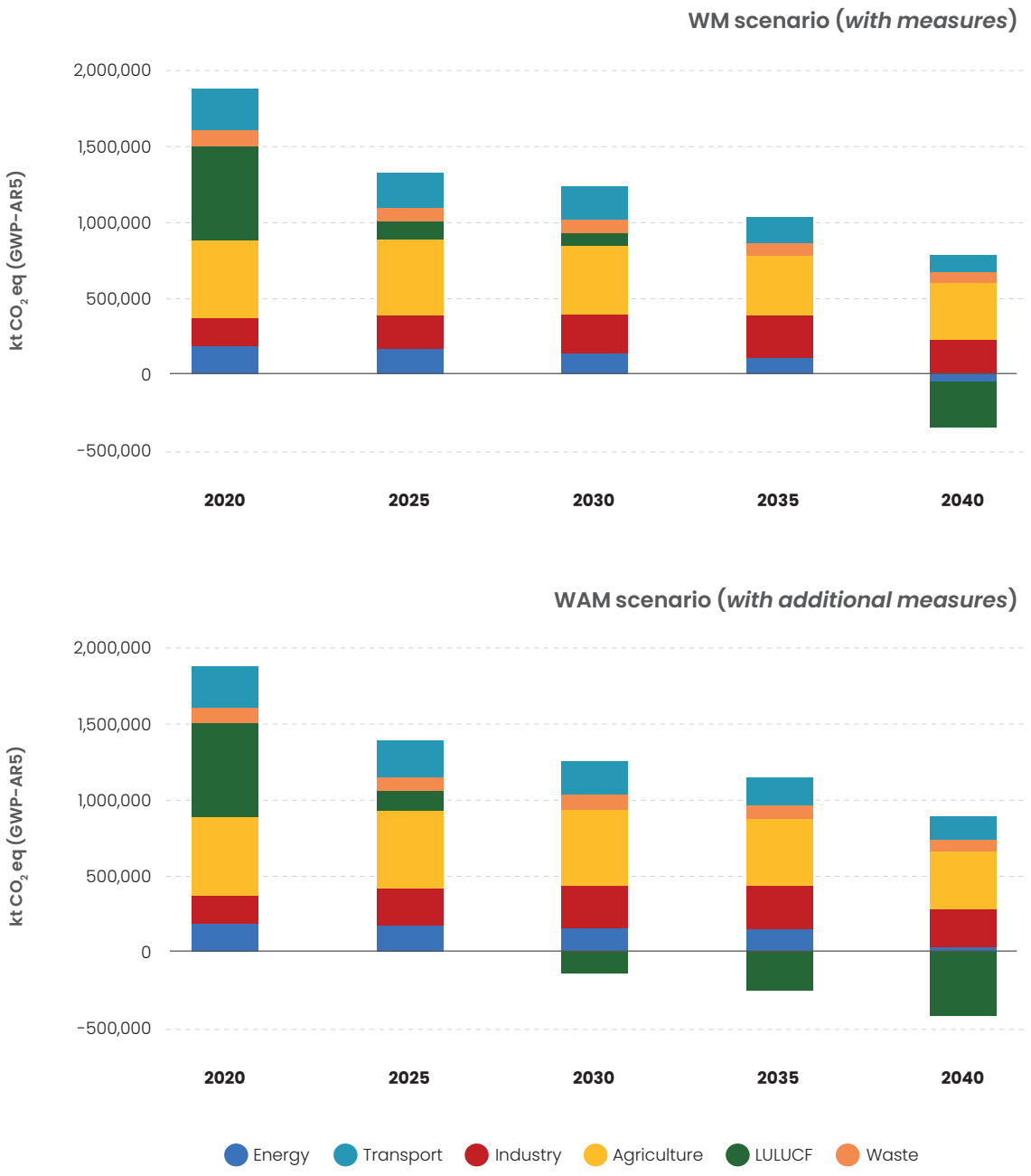
After 2030, both scenarios show significant emissions reductions in the energy and transport sectors, with greater reductions under the WM scenario. The actions considered in these sectors include significant growth in renewable energy sources (solar, wind, and biomass), the gradual reduction in the use of fossil fuels, and the deployment of carbon capture and storage (CCS) technologies, particularly Bioenergy with Carbon Capture and Storage (BECCS). Electrification and the use of biofuels are central elements for mitigation in the transport sector.

Emissions pathways in the other sectors (agriculture, waste, and industry) are similar in both scenarios. In the industry sector, emissions reductions result from the reduced use of fossil fuels and the increased share of renewable energy sources, particularly biomethane, as well as advances in the electrification of industrial energy consumption.

In the waste sector, emissions reductions result from structural measures, such as the closure of open dumps and controlled landfills, biogas recovery at sanitary landfills, and an increase in the amount of dry waste sent for recycling.

In the agriculture sector, emissions reductions result from the increasing adoption of low-emission practices, such as crop-livestock-forestry integration (CLFI), intensive finishing, manure management, efficient fertilizer use, and genetic improvements in cattle herds. Furthermore, the agriculture sector contributes to freeing up land and increasing productivity per hectare, which favors the expansion of areas of native vegetation and integrated systems.

Figure 3.4 Projections of greenhouse gas emissions and removals under WM and WAM scenarios (2020-2040)



Source: Compiled by the authors.

Table 3.13 Information on projections of greenhouse gas emissions and removals under a WM scenario

Sector	Base Year (kt CO_2 eq)	Projections of GHG emissions and removals (kt CO_2 eq)			
	2020	2025	2030	2035	2040
Energy*	142,216.00	152,421.00	125,034.00	91,559.00	-45,208.00
Transport	186,858.00	185,600.00	181,900.00	134,900.00	90,200.00
Industry**	165,666.00	204,421.00	201,054.00	218,622.00	201,695.00
Agriculture	554,989.00	560,320.10	517,647.70	494,560.00	447,853.00
LULUCF	644,456.00	139,137.90	100,024.30	-2,829.00	-292,339.20
Waste Management	91,439.00	78,100.00	74,340.00	63,188.00	63,283.00
Gas					
CO_2 with LULUCF	1,081,877.00	642,544.60	589,093.40	426,091.30	-48,666.80
CO_2 without LULUCF	485,591.00	551,883.70	533,307.40	470,724.70	280,898.80
CH_4 with LULUCF	542,243.00	509,800.60	446,490.20	407,733.10	361,304.70
CH_4 without LULUCF	505,089.00	474,700.60	414,792.30	378,435.70	335,367.00
N_2O with LULUCF	153,080.00	167,654.80	164,416.40	166,175.60	152,845.90
N_2O without LULUCF	142,064.00	154,277.80	151,876.00	153,698.60	141,557.20
HFCs	7,850.00	NE	NE	NE	NE
PFCs	249.00	NE	NE	NE	NE
SF_6	325.00	NE	NE	NE	NE
Total with LULUCF	**1,785,624.00**	**1,320,000.00**	**1,200,000**	**1,000,000.00**	**465,483.80**
Total without LULUCF	**1,141,168.00**	**1,180,862.10**	**1,099,975.70**	**1,002,829.00**	**757,823.00**

NE: not estimated
* Energy sector without emissions from Manufacturing Industries and Construction
** IPPU emissions, including emissions from energy consumption in Manufacturing Industries and Construction
Source: Compiled by the authors.

Table 3.14 Information on projections of greenhouse gas emissions and removals under a WAM scenario

Sector	Base Year (kt CO_2 eq)	Projections of GHG emissions and removals (kt CO_2 eq.)			
	2020	2025	2030	2035	2040
Energy*	142,216.00	152,421.00	148,112.00	122,791.00	16,562.00
Transport	186,858.00	185,600.00	184,200.00	160,400.00	140,400.00
Industry**	165,666.00	204,421.00	216,364.00	230,053.00	186,955.00
Agriculture	554,989.00	560,320.10	531,279.70	500,149.00	447,899.70
LULUCF	644,456.00	139,137.90	-95,677.30	-306,225.00	-397,287.20
Waste Management	91,439.00	78,100.00	76,619.00	67,037.00	66,056
Gas					
CO_2 with LULUCF	1,081,877.00	642,544.60	422,675.90	181,188.30	-65,806.10
CO_2 without LULUCF	485,591.00	551,883.70	563,584.20	529,671.30	369,128.10
CH_4 with LULUCF	542,243.00	509,800.60	464,170.90	420,971.30	370,120.40
CH_4 without LULUCF	505,089.00	474,700.60	431,770.90	391,271.30	343,120.40
N_2O with LULUCF	153,080.00	167,654.8	174,050.60	172,045.40	156,271.20
N_2O without LULUCF	142,064.00	154,277.80	161,219.60	159,487.40	145,624.20
HFCs	7,850.00	NE	NE	NE	NE
PFCs	249.00	NE	NE	NE	NE
SF_6	325.00	NE	NE	NE	NE
Total with LULUCF	**1,785,624.00**	**1,320,000.00**	**1,060,897.40**	**774,205.00**	**460,585.50**
Total without LULUCF	**1,141,168.00**	**1,180,862.10**	**1,156,574.70**	**1,080,430.00**	**857,872.70**

NE: not estimated
* Energy sector without emissions from Manufacturing Industries and Construction
** IPPU emissions, including emissions from energy consumption in Manufacturing Industries and Construction
Source: Compiled by the authors.

Regarding the analysis by gas, sectoral CO_2 emissions are similar to those observed for total GHG emissions, but with the difference that the agriculture sector plays a less significant role in total emissions, since most of its emissions consist of non-CO_2 gases (primarily CH_4 and N_2O).

Regarding carbon removals by category, the results are very similar under WM and WAM scenarios, reflecting the implementation of actions focused on soil management and integrated systems. By 2040, native vegetation restoration becomes the leading contributor to carbon removals.

3.6.4 Sectoral results

Energy sector

Regarding the projection of primary energy supply in Brazil under the WM and WAM scenarios between 2025 and 2040, the results indicate significant changes in the composition of the primary energy matrix, particularly the substantial growth of biomass, especially under the WM scenario, in which the need to offset deforestation-related emissions leads to a more pronounced expansion of this energy source.

Fossil fuels, particularly oil, remain relatively stable until 2030, but show divergent trends in 2040. The WM scenario shows the greatest decline in primary energy supply from this source over the period, with the largest relative decrease in the share of fossil fuels in the overall energy matrix, as they are replaced by renewable sources. At the same time, solar, wind, and biomass energy sources continue to expand.

Regarding the evolution of electricity generation by source between 2025 and 2040, rapid growth is observed in renewable energy sources, both variable (wind and solar photovoltaic) and baseload (biomass and hydropower), which progressively replace fossil fuel sources in the Brazilian electricity matrix.

Even with the introduction of new natural gas-fired thermal power plants by 2030, electricity generation from this source declines substantially in the following decades. By 2040, natural gas-fired electricity generation would be below 30 TWh/year, potentially reaching approximately 20 TWh/year under the WM scenario, with a need for carbon capture and storage associated with thermal power generation, specifically from biomass.

The evolution of installed capacity in the Brazilian electricity system between 2025 and 2040 follows the same trend observed in electricity generation, with significant growth in renewable energy sources and a gradual reduction in fossil fuel sources over the period.

Overall, the expansion of installed capacity is led by wind and solar photovoltaic power, reflecting the need to meet growing demand with low-carbon technologies. However, due to differences in the capacity factors of each source, the magnitude of installed capacity differs from that observed in generation. Despite the declining share of fossil fuel sources, they remain necessary to ensure the stability of the electricity system, particularly natural gas-fired thermal power plants, which play an important role in system dispatch in a context of high penetration of variable renewables.

Regarding biofuel production, the historical trend continues, with ethanol and biodiesel predominating. From 2035 onward, new technological pathways begin to gain importance, with the introduction of synthetic fuels produced in Fischer–Tropsch plants, increasing supply diversification.

The buildings sector, which encompasses residential and service buildings, is highly electrified, and this characteristic is maintained throughout the analysis period. Electricity remains the sector's main energy source, which can be used for lighting, heating and cooling, water heating, and the operation of electronic equipment, consolidating its role as the main driver of the sector's decarbonization.

The non-electrifiable segment, consisting mainly of consumers who use piped gas or LPG, tends to shift toward renewable alternatives, such as biomethane injected into the gas distribution network and green LPG. This substitution allows for significant reductions in emissions associated with energy use in the sector. The WM pathway brings forward the market penetration of biofuels to a greater extent.

Transport

The transport sector plays an important role in reducing national emissions. Energy consumption in passenger transport between 2020 and 2040 undergoes a gradual transition toward electrification, both in public transport and private motor vehicles, reflecting the increased supply of electric and hybrid vehicles and progress in the adoption of transport modes that can be electrified.

Ethanol finds other ways to maintain its role in the sector, with increasing use in hybrid vehicles and fuel cell pathways, leveraging the country's existing infrastructure and technological familiarity with this biofuel. At the same time, the introduction of advanced biofuels, such as green diesel and green gasoline, becomes essential for reducing emissions in certain transport modes.

Electrification plays an important role in both scenarios, with more rapid introduction under the WM scenario. In any case, achieving these results requires investments in expanding charging and refueling infrastructure, particularly public charging points and stations compatible with electric and hybrid vehicles, as well as promoting the technological development of national electrification and biofuel pathways.

Regarding energy consumption in freight transport, although diesel continues to play an important role throughout the period, its share gradually declines as it is progressively replaced by less carbon-intensive alternatives, alongside the adoption of efficiency measures in the sector.

In the short term, complementary actions, such as improvements in road infrastructure, optimized logistics, and good driving practices, play an important role in reducing fuel consumption and increasing energy efficiency in freight transport. Advanced biofuels become even more important for mitigating emissions from freight transport, particularly green diesel and hydrogen, which gain ground, albeit on different scales, toward the end of the analysis period. Furthermore, there is growing potential for electric trucks powered by batteries or hydrogen or ethanol fuel cells, contributing to the diversification of technological pathways for decarbonization.

Regarding urban mobility and passenger transport, improvements in infrastructure, network optimization, the expansion of high-capacity public transport, and investments in sidewalks and bicycle lanes contribute to reducing fuel consumption and increasing energy efficiency.

Industry

The industry sector accounts for a significant share of the country's energy consumption and direct GHG emissions. Until 2030, little change is observed in energy consumption in the industry sector, with a gradual decline in the share of fossil fuels, which falls to approximately 40% of total consumption over this period.

It should be noted that emissions of PFCs, HFCs, $NF_{3,}$ and SF_6 were not projected under the WM and WAM scenarios and, therefore, are not included in the projected emissions totals.

From 2035 onward, changes in the sector accelerate, with an increasing share of renewable energy sources and growing electrification of industrial energy consumption. Under the WM scenario, progress in the electrification of processes that can be electrified becomes evident. Sustainable fuels gain prominence from 2030 onward. Biomethane accounts for 100% of the natural gas consumption share under the WM scenario and reaches significant levels in all scenarios, reinforcing its strategic role in replacing fossil fuels and reducing industrial emissions.

By 2040, the pathways begin to diverge more markedly. Increased electrification and the expanded use of biofuels play a decisive role in reducing emissions, while carbon capture becomes necessary to mitigate emissions from industrial processes that are more difficult to decarbonize. Furthermore, the substitution of inputs with biomaterials contributes to net emissions reduction in certain segments.

LULUCF

The LULUCF (Land Use, Land-Use Change and Forestry) sector shows a clear downward trend in emissions over the period analyzed, particularly CO_2 emissions, which play a decisive role in the country's emissions balance.

CO_2 emissions decrease continuously, becoming negative from 2035 onward, indicating a reversal in the net balance: the sector shifts from a carbon source to a carbon sink. This trend results directly from the expansion of forest and native vegetation areas, combined with reduced deforestation and increased restoration actions.

Non-CO_2 emissions (CH_4 and N_2O) remain stable and at low levels in the sector, without compromising the net negative result achieved through CO_2 removals.

Agriculture

The agriculture sector maintains relatively stable CH_4 and N_2O emissions, with a slight downward trend through 2040, resulting from the increasing adoption of low-emission practices, such as crop-livestock-forestry integration (CLFI), intensive finishing, manure management, efficient fertilizer use, and genetic improvements.

Increased productivity per hectare contributes to freeing up land, which favors the expansion of native vegetation areas and integrated systems. Between 2025 and 2040, significant progress is made in the restoration of pastures and the establishment of planted forests, replacing degraded areas. Integrated systems (CLI and CLFI) continue to expand, increasing productivity without expanding the agricultural frontier. The integration of crop production, livestock farming,

and forestry is becoming established as a key mitigation strategy, promoting synergies between environmental conservation and economic competitiveness.

In agriculture, from 2035 onward, conventional systems decline while high-productivity and double-cropping systems expand, driven by advances in biotechnology and management practices; demand for bioenergy and bioproducts (ethanol, biogas, and forest biomass) increases significantly, driving the use of agricultural land for integrated and bioenergy production systems.

By 2040, the agroforestry mosaic becomes consolidated, with more diversified land use balancing production and restoration. Under the WAM scenario, the proportion of forest and agroforestry areas increases steadily.

The replacement of extensive monocultures and degraded pastures with integrated systems reflects a territorial reorganization in which agricultural areas simultaneously perform environmental and productive functions.

Until 2030, non-forest changes predominate, such as agricultural soil management and pasture restoration. After 2030, native vegetation restoration and agroforestry systems take the lead, accounting for most carbon removals.

Brazilian livestock farming undergoes structural changes, shifting from extensive systems to integrated systems and intensive (feedlot) finishing. Until 2030, the share of integrated systems increases, gradually replacing traditional pastures. After 2035, feedlot-based intensive finishing gains momentum, increasing productivity and reducing methane emissions per unit of output.

However, these advances require balanced land-use management, as high-productivity and bioenergy crops are more water- and nutrient-intensive, requiring integrated water resources and environmental planning. Furthermore, this increased demand for bioenergy feedstocks makes it necessary to expand areas of monocultures dedicated to production, particularly planted forests for biofuel production through pathways such as Fischer–Tropsch, combined with carbon capture and storage.

Waste

GHG emissions from the municipal solid waste (MSW) sector between 2020 and 2040 are the same under both scenarios, as a sector-specific simulation was used as the basis for the MSW pathway.

Throughout the period, emissions decline steadily as a result of three main structural measures considered: the closure of open dumps and controlled landfills, biogas recovery at sanitary landfills, and an increase in the amount of dry waste sent for recycling.

Regarding GHG emissions from wastewater treatment, differences between the scenarios are marginal until 2030, reflecting the continuation of current management and treatment practices. From 2035 onward, the WM scenario incorporates a greater number of mitigation measures, enabling larger emissions reductions than under the WAM scenario. This trend intensifies through 2040, when the sector exhibits lower emission levels under the WM scenario than under the WAM scenario.

3.6.5 Final considerations

In light of the above, it should be emphasized that the model results should be interpreted as the result of an optimized combination of technologies and investments, serving as inputs for policymaking and the prioritization of investments needed to make it feasible.

The scenarios presented were generated using a national model with an integrated perspective, which is essential for identifying an optimal economy-wide result, particularly in the Brazilian context, given that the country's net emissions targets are economy-wide and not restricted to specific sectors.

The model results should not be interpreted as a forecast, although projections of GHG emissions and removals are a very useful tool for exploring and identifying potential strategic actions to ensure that the total volume of GHGs emitted over a given period is consistent with a country's climate target, and provide important insights for assessing the impact of mitigation policies and measures on future trends in GHG emissions and removals.

Despite the uncertainties associated with the use of integrated models - including the inherent limitations of IAMs; the full implementation of public policies within the established timeframes; the feasibility of deploying new technologies at the estimated costs and within the projected timeframes; the volatility of national and international scenarios; and the failure to incorporate the adverse impacts of climate change itself - the BLUES model was used to support the Brazilian government's decision-making on NDC targets, as it represents the best available scientific knowledge.

However, considering the points discussed in the preceding paragraphs and the fact that Brazil has not identified a projection as a baseline in its NDCs, the scenarios should not be taken into account to track progress in the implementation and/or achievement of its NDCs, as provided for in paragraph 93 of Decision 18/CMA.1.

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Appendix 3

Areas for improvement in reporting on national circumstances and institutional arrangements

ID#	Reporting requirement	Description of the area for improvement with a recommendation or encouragement	Answer
8.1	Specified in paragraph 59 of the MPGs	*Brazil did not report in its BTR1 on the national circumstances relating to climate profile relevant to progress in implementing and achieving its NDC. During the review, the Party provided information on its climate profile. Brazil encompasses equatorial (semi-arid), tropical and subtropical climate zones, with the tropical and subtropical climates covering 81.4 and 13.7 per cent of the national territory respectively and the remaining 4.9 per cent of the territory having an equatorial climate. The TERT recommends that the Party report in its BTR on the national circumstances relating to climate profile relevant to progress in implementing and achieving its NDC.*	Resolved. The recommendation was addressed by including the relevant information in section 3.1 of Chapter 3.
8.2	Specified in paragraph 62 of the MPGs	*Brazil did not report information on stakeholder engagement related to the implementation and achievement of its NDC. During the review, Brazil provided information on its national process for updating the National Plan on Climate Change, which is informed by robust scientific knowledge and broad intersectoral and government–society dialogue, with comprehensive participation by government agencies at different levels, the private sector, civil society and the scientific community. The TERT recommends that the Party provide information in its BTR on stakeholder engagement related to the implementation and achievement of its NDC.*	Resolved. The recommendation was addressed by including the information in section 3.1.1 of Chapter 3.

Areas for improvement regarding the description of the nationally determined contribution under Article 4 of the Paris Agreement, including updates

ID#	Reporting requirement	Description of the area for improvement with a recommendation or encouragement	Answer
9.1	Specified in paragraph 64(a–c) of the MPGs	*Brazil did not clarify whether its NDC targets for 2025 and 2030 are fixed-level targets. Brazil also did not report in its BTR1 whether its NDC targets are single or multi-year targets. In addition, Brazil reported in its BTR1 a single time frame of implementation (2020–2030) for its NDC target years 2025 and 2030 and did not clarify whether this applies to the targets for both 2025 and 2030. During the review, Brazil explained that the targets for 2025 and 2030 are fixed on the basis of national GHG inventory data for the base year (2005). While the inventory estimates may be subject to recalculations for future submissions owing to methodological improvements, the targets will remain unchanged and will not be affected by potential future revisions of the base-year inventory data. The Party explained that its targets are single-year targets and that the NDC implementation period is 2020–2025 for the 2025 target and 2020–2030 for the 2030 target.* *The TERT recommends that the Party indicate in the BTR that its targets for 2025 and 2030 are fixed and not dependent on the base-year emission level in 2005 for tracking the achievement of the NDC in 2025 and 2030. The TERT also recommends that the Party clarify in its BTR that its NDC targets are single-year targets and report in its BTR a time frame of implementation specifically for its 2025 NDC target*	Resolved. The recommendation was addressed by including the relevant information in Table 3.1 of Chapter 3.

Areas for improvement in reporting on the information necessary to track progress made in implementing and achieving its nationally determined contribution under Article 4 of the Paris Agreement

ID#	Reporting requirement	Description of the area for improvement with a recommendation or encouragement	Answer
10.1	Specified in paragraph 65 of the MPGs	*Brazil described in CTF table 1 that, for measuring progress in implementing its NDC, it used an indicator that establishes the ratio of total net GHG emissions in 2025 and 2030 respectively to the total net GHG emissions reported for the base year (2005). However, the TERT noted that the values reported for 2020–2022 in CTF tables 4.3 and 4.4 are the percentage reduction in total net GHG emissions in those years compared with the 2005 level. During the review, Brazil clarified that the description of the indicator for measuring progress in implementing its NDC in CTF table 1 should explain that it represents the percentage change between total net GHG emissions in the base year and the target year. The TERT recommends that the Party correct the description of the indicator for tracking progress in implementing the NDC in CTF table 1, explaining that it represents the percentage change between total net GHG emissions in the base year and the target year.*	Resolved. The recommendation was addressed by including the relevant information in CTF1 of BTR2 and Table 3.2 of Chapter 3.
10.2	Specified in paragraph 71 of the MPGs	*In CTF table 3, Brazil reported on the accounting approach used for its NDC targets, including how it is consistent with Article 4, paragraphs 13–14, of the Paris Agreement. Brazil intends to use GHG inventory data to measure progress towards the achievement of its NDC. However, Brazil reported "NA" in four rows in CTF table 3 related to information on accounting for its first NDC and its consistency with decision 4/CMA.1. During the review, Brazil explained that, although the reporting of the four specific items in CTF table 3 is optional for its first NDC, it provided information related to this in its BTR1.* *The TERT encourages the Party to report information in CTF table 3 on how accounting for its first NDC is consistent with decision 4/CMA.1 or explain why it is not possible to do so.*	Resolved. This encouragement was addressed by including the relevant information in CTF3 of the BTR2 and Table 3.3 of Chapter 3.
10.3	Specified in paragraph 74(a) of the MPGs	*In CTF table 3, Brazil did not report when the NDC target for 2025 will be accounted for in the description of the accounting approach for its NDC targets.* *During the review, Brazil explained that it will account for its 2025 target in its BTR3, which is expected to be submitted in 2028, along with the NIR, for which 2026 will be the latest reporting year.* *The TERT recommends that the Party report when the NDC target for 2025 will be accounted for in the description of the accounting approach for its NDC targets in CTF table 3.*	Resolved. The recommendation was addressed by including the relevant information in CTF3 of BTR2 and Table 3.3 of Chapter 3.

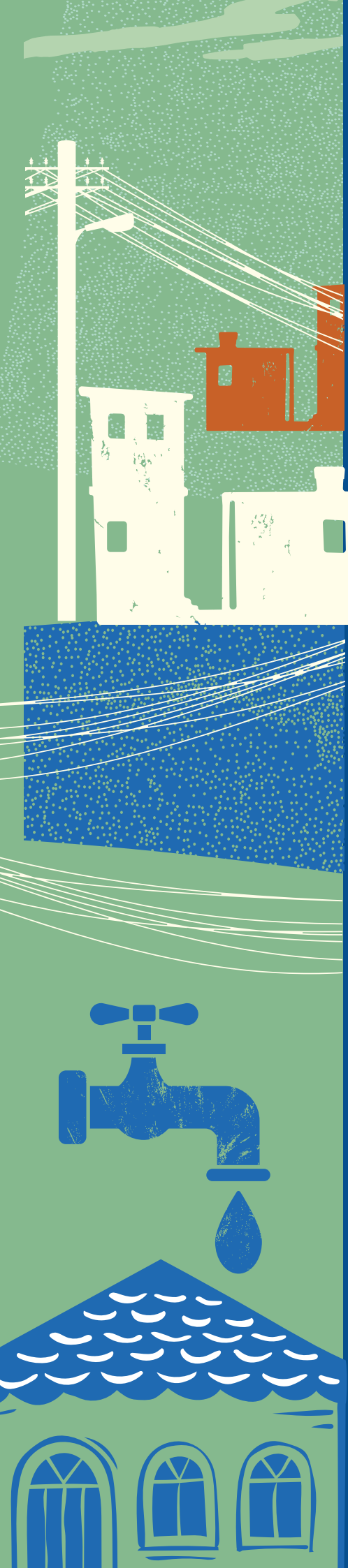
Areas for improvement in reporting on mitigation policies and measures, actions and plans, including those with mitigation co-benefits resulting from adaptation actions and economic diversification plans, related to implementing and achieving a nationally determined contribution under Article 4 of the Paris Agreement

ID#	Reporting requirement	Description of the area for improvement with a recommendation or encouragement	Answer
11.1	Specified in paragraph 83 of the MPGs	*Brazil did not report in its BTR1 or CTF table 5 on costs of each action, policy and measure reported or how the mitigation actions interact with each other, as appropriate.* *During the review, Brazil explained that this information was not included in the BTR1 owing to lack of systematically available data on the costs and a structured national assessment of the interactions between mitigation actions.* *The TERT encourages Brazil to report in its BTR on costs of each action, policy and measure reported and how the mitigation actions interact with each other, as appropriate, or explain why it did not report this information.*	Resolved. The encouragement was addressed by including the relevant information in Tables 3.5 to 3.12 of Chapter 3.
11.2	Specified in paragraph 85 of the MPGs	*Brazil did not report estimates of expected and achieved GHG emission reductions for any of its actions and PaMs in tabular format, except for achieved GHG emission reductions for Procel, the National Electricity Conservation Program. The Party applied the provided flexibility with respect to reporting this information.* *In the BTR1 and during the review, Brazil indicated the application of the flexibility, clarified its capacity constraints and provided estimated time frames for improvements in relation to those capacity constraints.* *The TERT encourages the Party to estimate, to the extent possible, expected and achieved GHG emission reductions for its actions and PaMs and report them in CTF table 5.*	Resolved. The PaMs mentioned in the encouragement are no longer listed as measures with significant impact due to the new configuration established by the Climate Plan. Accordingly, the expected and achieved emission reductions were reported for the Climate Mitigation Plan, the national instrument for achieving the NDC targets, in section 3.4 of Chapter 3.
11.3	Specified in paragraph 86 of the MPGs	*Brazil did not report a complete description of the methodologies and assumptions used to estimate the achieved GHG emission reductions for the mitigation action Procel.* *During the review, Brazil explained that the emission reductions for the mitigation action Procel were estimated using the average EF for the national electricity grid. The estimates are based on net energy savings and only CO_2 emissions were considered. It also explained that the observed*	Resolved. The description of the methodology for estimating the expected and achieved emission reductions under the Climate Mitigation Plan, the national instrument for achieving the NDC targets, was reported in section 3.4 of Chapter 3.

ID#	Reporting requirement	Description of the area for improvement with a recommendation or encouragement	Answer
		annual variation in GHG emission reductions is due to changes in the hydrological regime, which affects the annual average EFs for the national electricity grid, given its significant reliance on hydroelectric power. *The TERT recommends that the Party, to the extent available, provide a clear and complete description of the methodologies and assumptions used to estimate the expected and achieved GHG emission reductions or removals due to each action, policy and measure for which the Party has estimated expected or achieved GHG emission reductions.*	
11.4	Specified in paragraph 88 of the MPGs	*Brazil did not identify its actions and PaMs that influence GHG emissions from international transport. During the review, Brazil explained that in the BTR1 it could not identify any actions or PaMs that directly influence GHG emissions from international transport and, as such, did not report this information.* *The TERT encourages the Party to identify its actions and PaMs that influence GHG emissions from international transport or explain why it has not done so (e.g. if the Party does not have any policy or action influencing GHG emissions from international transport).*	Resolved. The encouragement was addressed by including the relevant information in Table 3.10 of Chapter 3.
11.5	Specified in paragraph 89 of the MPGs	*Brazil did not provide information about how its actions and PaMs are modifying longer-term trends in GHG emissions and removals. During the review, Brazil explained that this information was not included in the BTR1 owing to the lack of a consolidated national assessment of the long-term effects of PaMs on GHG emission and removal trends. The TERT encourages the Party to provide, to the extent possible, information about how its actions and PaMs are modifying longer-term trends in GHG emissions and removals.*	Resolved. The encouragement was addressed by including the relevant information in section 3.4 of Chapter 3.
11.6	Specified in paragraph 90 of the MPGs	*Brazil did not provide detailed information on the assessment of the economic and social impacts of its response measures. During the review, Brazil explained that this assessment was not included in the BTR1 owing to the lack of consolidated national information on the topic.* *The TERT encourages the Party to provide, to the extent possible, detailed information on the assessment of the economic and social impacts of its response measures.*	Resolved. The encouragement was addressed by including the relevant information in Tables 3.5 to 3.12 of Chapter 3.

Areas for improvement in projections of greenhouse gas emissions and removals

ID#	Reporting requirement	Description of the area for improvement with a recommendation or encouragement	Answer
13.1	Specified in paragraphs 6 and 92 of the MPGs	*Brazil did not report projections pursuant to paragraphs 93–101 of the MPGs. The Party applied the provided flexibility with respect to reporting projections in accordance with paragraphs 92, 95 and 102 of the MPGs. The Party indicated in the BTR1 that it applied flexibility with respect to these paragraphs of the MPGs and provided its estimated time frame for improving its reporting. The Party explained in the BTR1 that, at the time of the approval of the BTR1, the Government of Brazil was in the process of analysing and validating the results of the GHG emission projections and the duly completed and validated projections will be submitted in the BTR2. However, the Party did not clarify its capacity constraints in relation to reporting projections.* *During the review, Brazil identified its lack of technical and institutional capacity to develop projections on the basis of modelling results. The Party explained that it lacked sufficient time to enable a comprehensive and inclusive approval process for the projections that would have required the involvement of multiple stakeholders to properly understand, analyse and validate the results before the BTR1 submission deadline.* *The TERT encourages the Party to report projections pursuant to paragraphs 93 101 of the MPGs. The TERT recommends that the Party concisely clarify its capacity constraints in relation to reporting projections when it does not report projections because it applies the relevant flexibility.*	Resolved. This encouragement was addressed by reporting the projections in section 3.6 of Chapter 3.



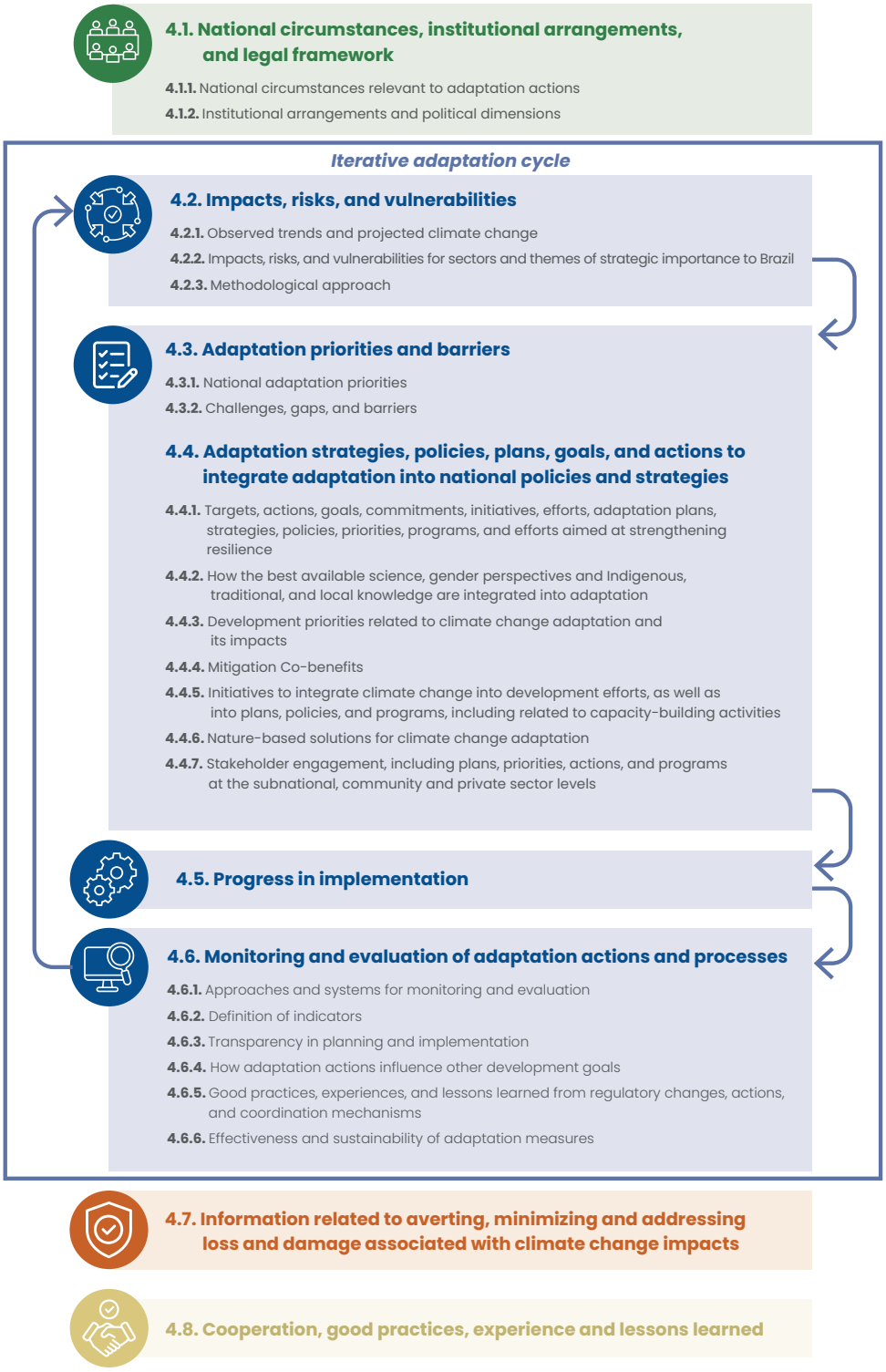
CHAPTER 4

Information related to climate change impacts and adaptation, pursuant to Article 7 of the Paris Agreement

This chapter constitutes Brazil's Adaptation Communication, submitted as a component of the Fifth National Communication and the Second Biennial Transparency Report, in accordance with Article 7, paragraphs 10 and 11, of the Paris Agreement, Decision 9/CMA.1 and Decision 18/CMA.1.

MAP OF CHAPTER 4

Information related to climate change impacts and adaptation, pursuant to Article 7 of the Paris Agreement – is structured around the stages of the iterative adaptation cycle (UNFCCC, 2024), complemented by contextual elements and information related to averting, minimizing and addressing loss and damage, as well as outcomes, experiences and cooperation. The chapter's structure aims to comply with the Modalities, Procedures, and Guidelines (MPGs) established in Decision 18/CMA.1. Below is a map of the Chapter, which helps guide the reader through this structure.



4.1. National circumstances, institutional arrangements and legal framework

4.1.1. National circumstances relevant to adaptation actions

Information on Brazil's biogeophysical, demographic, economic and infrastructural characteristics is detailed in **Chapter 1, National context,** of this Report. Additional information is provided below regarding the circumstances related to the country's adaptive capacity and vulnerabilities in the context of climate change.

The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR6) emphasizes that Brazil is among the countries that are highly exposed and vulnerable to the impacts and risks associated with climate change. This high vulnerability results from the interaction of multiple factors (Figure 4.1), which, combined with Brazil's climate diversity and vast territory, of approximately 8.5 million km^2, further increase the complexity of the challenges related to climate change adaptation. Among the country's main characteristics in relation to climate impacts, the following stand out:

i. Shortages of housing and of basic infrastructure, such as basic sanitation, particularly in urban areas, especially in *favelas*, urban peripheries, and precarious urban settlements, which increase the population's exposure and sensitivity to extreme weather events (Coelho *et al.*, 2024);

ii. The importance of agricultural activities for food production, income generation, and exports, making this strategic economic sector sensitive to changes in climate patterns (Lapola *et al.*, 2014; Martinelli and Filoso, 2008);

iii. The presence of watersheds that are heavily used for multiple purposes and affected by water pollution (ANA – National Water and Basic Sanitation Agency (Agência Nacional de Águas e Saneamento Básico), 2026);

iv. The presence of the world's largest contiguous tropical rainforest, which, in addition to harboring high biodiversity and sociocultural diversity, plays a fundamental role in regional and global climate and hydrological regulation (Maffi, 2005; Mittermeier *et al.*, 1997);

v. The high dependence on water resources for electricity generation and the vast territorial extent of the transmission and distribution system, which make them vulnerable to extreme events (ANA, 2024b);

vi. The high levels of poverty and socioeconomic inequalities across regions and population groups, which limit access to basic services, healthcare, education, and income-generating opportunities, thereby increasing the vulnerability of these populations to climate impacts (Fiocruz, n.d.; CEDEPLAR – Center for Development and Regional Planning (Centro de Desenvolvimento e Planejamento Regional)/MMA - Ministry of the Environment and Climate Change (Ministério do Meio Ambiente e Mudança do Clima)/UNFPA, 2017; Darela *et al.*, 2016; Pinho *et al.*, 2014);

vii. The high level of cultural diversity and the presence of tangible and intangible cultural heritage that depends on nature and ecosystems, in a context of land pressures on Indigenous, Quilombola, and traditional territories and violence against environmental activists (Brando *et al.*, 2025);

viii. Deforestation and changes in land use and land cover, which contribute to ecosystem degradation, affect water availability and reduce the capacity to adapt to climate change (Coelho *et al.*, 2024);

ix. The extensive coastline, characterized by high population density and intense economic activity, with areas susceptible to sea-level rise, coastal erosion, and extreme events (Leal F.º *et al.*, 2018).

Figure 4.1 Factors of Brazil's vulnerability to climate change



Source: Based on Viola and Franchini (2014); Leal Fº *et al.* (2018); Lapola *et al.* (2014); Martinelli and Filoso (2008); Maffi (2005); Mittermeier *et al.* (1997); CEDEPLAR/MMA/UNFPA (2017); Darela *et al.* (2016); Pinho *et al.* (2014); Coelho *et al.* (2024); Brando *et al.*, 2025; ANA, 2025a, 2026.

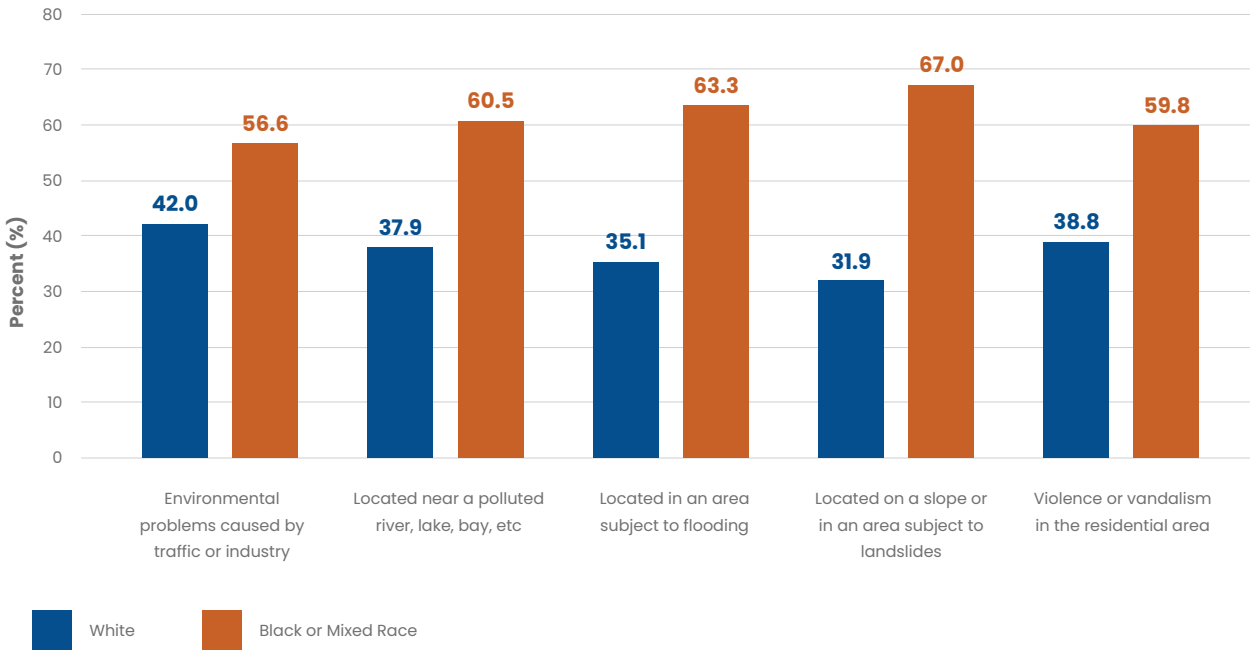
Among the climate-related risks already affecting the country, extreme heat stands out, as its occurrence and intensity are becoming increasingly significant for the Brazilian population. Heat waves can have an impact on human health, agricultural productivity, and other economic activities, with effects that vary across different territories and population groups. Between 2000 and 2019, it is estimated that approximately 120,000 deaths in Brazil were attributable to exposure to heat waves (Brasil, 2026c). These effects reflect the interaction between heat exposure and pre-existing vulnerability conditions, such as age, socioeconomic conditions, and territorial characteristics. The impacts on human health and the factors that influence their distribution are discussed in greater detail in **section 4.2.2, Impacts, risks, and vulnerabilities for sectors and themes of strategic importance to Brazil**.

Precipitation-related events (whether due to excess or scarcity) are the main triggers of the physical processes that place populations and their economic activities at risk in Brazil (Brasil, 2021). Some regions of the country have steep terrain and experience heavy rainfall, which increases the risk of landslides. The impact of climate change is considered one of the factors contributing to increased disaster risks in the country (Brasil, 2016a).

The impacts of climate change on the Brazilian population and economy, however, do not stem solely from physical and climate factors. Socioeconomic, demographic, and territorial characteristics significantly influence the vulnerability of populations and systems, determining their capacity to anticipate, respond to, and recover from the adverse effects of climate events. These vulnerabilities are also compounded by ethnic-racial and territorial inequalities and environmental racism[2], which affect exposure to climate risks and access to resources, services, and conditions necessary for adaptation in different ways, especially among the Black population, Indigenous Peoples, and traditional peoples and communities, including Quilombola communities, traditional *terreiro* peoples and communities and those of African origin, and Roma peoples (Coelho *et al.*, 2024; Darela *et al.*, 2016; Pinho *et al.*, 2014; IBGE, 2026). With regard to infrastructure, a vulnerability factor is the location of housing in risk areas. The process of urban expansion, characteristic of the last 60 years, has resulted in the concentration of the most vulnerable population in areas that are spatially more susceptible to risks. With settlements established without adequate urban planning, low-income communities have settled near rivers and on hills, and often without basic sanitation (Di Giulio *et al.*, 2019; Saito *et al.*, 2019).

Exposure to risk varies among different population groups. Black and mixed-race populations, who are among the lowest-income families and those most affected by violence, are also more exposed to risk situations, living in areas near polluted watercourses and areas prone to fluvial flooding and landslides (Figure 4.2).

Figure 4.2 Proportion of people according to the assessment of risk situations, by color or race (2017-2018)[3]



Source: IBGE – Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística), 2026.

2 SDG 18 – Ethnic-Racial Equality, adopted in the Brazilian context of the 2030 Agenda, establishes targets and indicators to promote ethnic-racial equality and address inequalities that particularly affect the Black population and Indigenous Peoples.

3 The figure reproduces the categorization presented in the original source (IBGE, 2026). Although the text presents disaggregated information for the Indigenous population, this population is not presented as a specific category in the original figure. The absence of this disaggregation in the graph does not imply an absence of differences in exposure and vulnerability conditions among color or race groups.

Another infrastructure deficit that contributes to climate vulnerability is basic sanitation. In 2025, 29.6% of households lacked access to the sewer system, with more pronounced regional differences: The North and Northeast regions had the lowest coverage rates, at 30.6% and 52.4%, respectively, while the Southeast region had the highest, at 90.7% (IBGE, 2026). Children, the Black population[4] and Indigenous Peoples are the population groups with the least access to sanitation infrastructure, with children aged 0 to 4 being the most affected, especially in the North and Northeast regions, which have the worst indicators (IBGE, 2024c). In addition, the proportion of the population living in households with sewage collection through a sewer system, stormwater drainage system or septic tank varies significantly between different racial groups: 91.8% among people of yellow color or race, 83.5% among people of white color or race, 75.0% among people of Black color or race, 68.9% among people of brown color or mixed-race and 29.9% among people of Indigenous color or race (IBGE, 2024c).

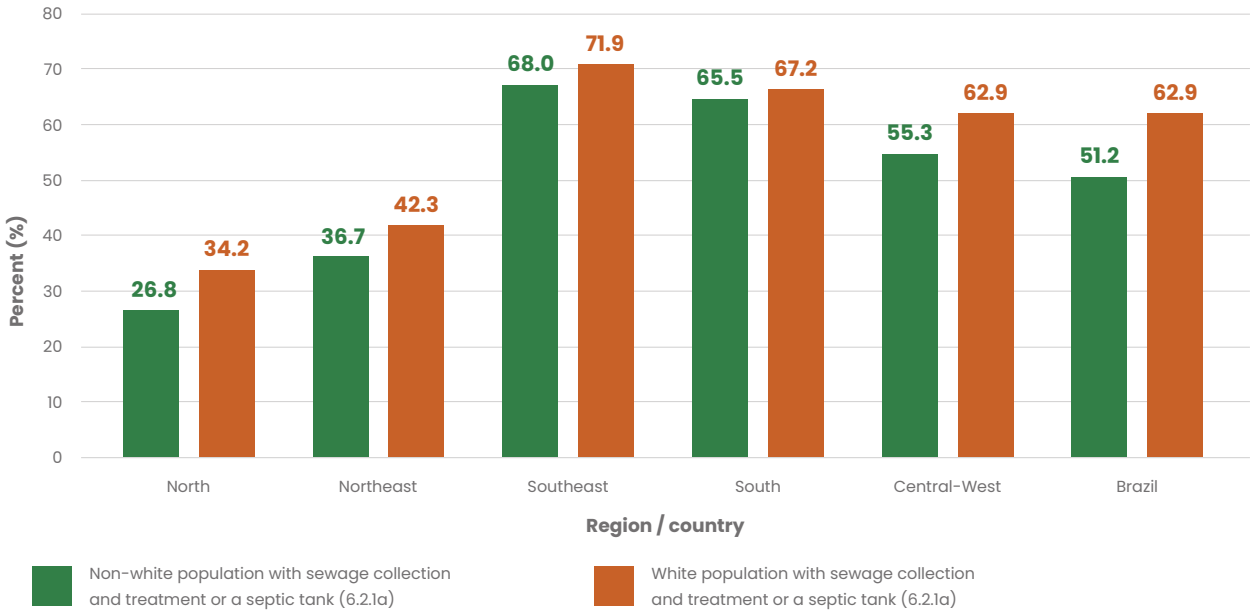
Coverage is lower when, in addition to collection, adequate sewage treatment is taken into account, as shown by Sustainable Development Goals (SDGs) indicator 6.2.1a (Proportion of population using safely managed sanitation services).[5] This is an important consideration because there are cases of cities with a high sewage collection rate but a low percentage of wastewater treated. Thus, the proportion of population using safely managed sanitation services in Brazil was 59.9% in 2023 (IBGE, 2024c).

When breaking down sanitation data by race or color and region (Figure 4.3) in 2022, it can be seen that, in all regions, the white population had higher percentages of indicator 6.2.1a (62.9%) compared to the non-white population (51.2%), reflecting structural inequalities in access to sanitation services. This disparity is even greater in some regions, such as the North (white 34.2%, non-white 26.8%), the Northeast (white 42.3%, non-white 36.7%) and the Central-West (white 62.9%, non-white 55.3%). The Northeast has the largest number of non-white people without access to sanitation services (more than 25 million), accounting for 45% of the national deficit, followed by the Southeast (more than 13 million) and the North (10 million). Even in regions with greater sanitation coverage, racial and territorial inequalities remain a challenge to achieving universal access to sanitation services (ANA, 2025a).

4 According to the Racial Equality Statute, the Black population consists of all people who self-identify as Black or mixed-race, as per the color or race category used by the Brazilian Institute of Geography and Statistics (IBGE), or who use a similar self-definition (Brasil, 2010).

5 According to the UN, SDG indicator 6.2.1a considers the proportion of the population using safely managed sanitation services, defined by the organization as the population using an improved sanitation facility at home that is not shared with other households and where excreta are treated and safely disposed of *in situ* or removed and treated off-site. Improved sanitation facilities include indoor plumbing systems that carry wastewater from bathrooms to public sewer systems, as well as septic tanks or rudimentary systems, all of which include treatment. The calculation of the proportion of the population using safely managed sanitation services (Indicator 6.2.1a) took into account the population residing in households with private toilets connected to the sewer system or to septic tanks (alternative solutions) and the respective effluent treatment systems.

Figure 4.3 Access to safely managed sanitation services among the white and non-white populations in the regions and nationwide (in %), in 2022, according to SDG indicator 6.2.1a



Source: ANA, 2025a.

The persistence of these vulnerabilities highlights the need for adaptation strategies that integrate urban planning, socio-environmental justice, and climate resilience. In this regard, there is still a lack of recognition of Nature-based Solutions as instruments capable of reducing risks associated with fluvial flooding, landslides, and heat islands, while strengthening cities' adaptive capacity and contributing to the development of urban territories that are more resilient to climate change (BRASIL, 2025t; WRI BRASIL, 2024). Given their significant role in thermal comfort and drainage, vulnerability in cities is also influenced by the lack of green spaces. In Brazil, the average percentage of households with trees in their immediate surroundings is 66.5%, though there are large territorial disparities. States such as Mato Grosso do Sul exceed 90%, while others, such as Sergipe, are below 40%. With regard to the number of trees, 20.2% of households had 1 to 2 trees, 13.5% had 3 to 4 trees, and 32.9% had more than 5 trees (IBGE, 2025b). When tree coverage is analyzed within *favelas*, the difference is much greater: only 35% of households have one or more trees (IBGE, 2025c), demonstrating the existence of unequal spaces within cities.

Also relevant to adaptation is the capacity of populations and territories to cope with increased disaster risks. In cities, this capacity is closely related to urban policies, municipal public investment capacity, population income and management of urban services aimed at minimizing the occurrence or the impacts of disasters. However, these characteristics are not fully observed in the country, indicating that most municipalities still have a low response capacity. The existence of zoning and land use planning legislation is an instrument that generally has moderate levels of compliance, demonstrating the importance of improving urban territory management in most Brazilian municipalities, including by reducing the exposure of the population living in risk areas (AdaptaBrasil, 2026n).

Political and institutional capacity is essential for preventing disasters and responding to them. In Brazil, this situation is marked by challenges related to coordination among different levels of government, a lack of resources, and limited infrastructure in many regions. Although the country has made progress with regard to national risk management policies, local implementation remains limited. The country has a low proportion of municipalities with contingency plans, early warning systems, risk management actions and institutions, among other measures (AdaptaBrasil, 2026o). Research carried out in 2020 by the IBGE showed, for example, that although 76% of Brazilian municipalities have institutions that perform the role of Civil Defense, only 21% have a person exclusively responsible for this duty and only 17% have resources provided for in the Annual Budget Law, demonstrating that, in practice, the capacity of these institutions to act is reduced (IBGE, 2021).

The demographic profile of the Brazilian population also reflects vulnerability factors. Among the observed and future trends is the rapid aging of the population. According to the IBGE, the proportion of the total population comprised of older people rose from 11.3% in 2012 to 16.6% in 2025. In terms of sex, women make up the majority of the population, at 51.2%, while men account for 48.8%; starting with the 30-to-34 age group, women become the majority in the country (IBGE, 2024a).

The higher proportion of women in the Brazilian population reflects an important layer of vulnerability, as they are disproportionately affected by climate change, even more so if other factors, such as poverty, are taken into account. **Section 4.2.2. Impacts, risks, and vulnerabilities for sectors and themes of strategic importance to Brazil** explores the factors that increase the risk for this population group, as well as for those defined by color, race, and ethnicity, and also for children and adolescents.

Among the public facilities that are important for adaptive capacity, healthcare facilities stand out, since the greater their service capacity, the better able they will be to respond to society's needs, both under normal conditions and during extreme events. However, the level of healthcare provision in Brazil reveals significant regional inequalities, as the North and Northeast regions have a considerably lower number of healthcare facilities than the other regions, contributing to climate injustice (AdaptaBrasil, 2026p).

Vulnerabilities manifest differently according to the characteristics of each territory. In 2022, 87.4% (177.7 million) of the Brazilian population lived in urban areas (IBGE, 2024a), and 54.8% (111.3 million people) lived within a maximum distance of 150 km from the coast (IBGE, 2024b). On the coastline, in addition to the high concentration of population and urban centers, various economic activities that are relevant to the country may be affected, such as tourism and maritime transportation. Given the different conditions of exposure, access to public services, housing, income, and territorial integration, traditional peoples and communities living in these regions who depend on natural resources for their ways of life and livelihoods, such as Roma peoples, fishers and shellfish gatherers, among other groups, are the most affected by gradual climate changes, such as rising temperatures and rising sea level (see Box 4.7).

In rural areas, low education levels reflect a context of greater local vulnerability. Among the rural population aged 5 or older, 13% have less than 1 year of schooling and 21% have between 1 and 4 years (Table 4.1). At the regional level, it is found that the North and Northeast have higher percentages than the other regions (CONTAG - National Confederation of Agricultural Workers (Confederação Nacional dos Trabalhadores na Agricultura), 2025). Another finding shows that, in 2024, about 15% of the Brazilian rural population aged 15 and older could not read or

write. Although progress was made in literacy rates between 2012 and 2024, during which time the proportion of the literate rural population rose from approximately 80% to 85%, significant regional disparities persist. In 2024, the literacy rate stood at about 96% in the South, while in the Northeast it remained at approximately 79%, a difference of 17 percentage points. The region remained below the national average throughout the period analyzed, highlighting the persistence of territorial inequalities in access to literacy for the rural population (CONTAG, 2025).

Table 4.1 Distribution of the rural population, aged 5 and older, by education level, in Brazil and in its Major Regions (2024)

Education Level	Total	North	Northeast	Southeast	South	Central-West
Total individuals (in millions)	24.108	3.445	11.809	4.568	3.245	1.040
Less than 1 year of schooling	13%	12%	17%	8%	7%	10%
1 to 4 years of schooling	21%	23%	22%	19%	16%	19%
5 to 8 years of schooling	27%	27%	25%	31%	31%	27%
9 to 11 years of schooling	15%	16%	15%	16%	16%	16%
12 to 15 years of schooling	21%	19%	19%	22%	25%	23%
16 years or more of schooling	3%	3%	2%	5%	5%	5%

Source: CONTAG (2025), with data from PNADC - Continuous National Household Sample Survey (Pesquisa Nacional por Amostra de Domicílios Contínua)/IBGE and compiled by DIEESE - Inter-Union Department of Statistics and Socioeconomic Studies (Departamento Intersindical de Estatística e Estudos Socioeconômicos).

Extreme and slow-onset weather events affect food production of both large-scale producers, who have greater recovery capacity, and family and subsistence farmers, who lack resources and preparedness. As described in **Chapter 1, National context,** agricultural activity in Brazil is of great economic importance and is also highly dependent on climate factors.

There are estimated to be more than 5 million agricultural establishments, 3.9 million of which, or 77%, are family farming establishments, accounting for 23% of the total area (80.9 million hectares) of all agricultural establishments in the country (IBGE, 2019). Production from family farmers, who supply local and regional markets with a diverse range of products (Brasil, 2025h), accounts for 60% of the Gross Value of Production (GVP) of vegetables, 48% of the harvested area for beans, 17% for maize, and 16% for rice, accounting for 25%, 17%, and 12% of the GVP for these crops, respectively (IBGE, 2019, cited in Brasil, 2025h, p. 11), and also stands out in the production of cassava, sugarcane, coffee, wheat, castor beans, fruit, vegetables, dairy cattle, beef cattle, sheep, goats, swine, and poultry (Embrapa - Brazilian Agricultural Research Corporation (Empresa Brasileira de Pesquisa Agropecuária), 2026). In 2017, the value of this production was

BRL 107 billion, equivalent to 23% of all Brazilian agricultural production, and accounted for 67% (about 10.1 million people) of the workforce employed in the sector (IBGE, 2019).

Despite their importance, family farmers are quite vulnerable, as they have low levels of education, limited access to credit, and use less irrigation. Nationwide, only 9.6% of family farms have irrigation systems. In terms of area, this percentage is even lower, at 3.7%, with some critical regions, such as the semi-arid region, where only 2% of the area is irrigated. The education level of family farmers in general is low, with 26.4% being unable to read, 18% never having attended school and only 2.7% having higher education (IBGE, 2019).

Food insecurity, which takes into account production conditions as well as availability and access, has been declining in recent years, but is still relevant. In 2023, it affected 21.2 million households, with 3.1 million experiencing severe food insecurity; in 2024, those figures fell to 18.9 million and 2.5 million, respectively. The data also highlight the need to pay close attention to the sex and color or race of the head of household. In 2024, three out of five households with food insecurity were headed by women. In terms of color or race, people of mixed race were the heads of household in more than half of the cases of food insecurity (54.7%), followed by white people (28.5%) and Black people (15.7%) (IBGE, 2025d).

For food and nutrition security to be effective, there must be an organizational structure in place at the state and municipal levels, in coordination with the federal government. In 2024, according to data from the IBGE, 26 Federative Units (FUs)[6] had an organizational structure in place to address food and nutrition security policy, either in the form of a dedicated department (1) or a division under another department (25). A State Plan for Food and Nutrition Security was found in 17 FUs; 26 FUs reported having a State Food and Nutrition Security Council, and 25 had a Chamber or Inter-sectoral Government Body for Food and Nutrition Security (CAISAN – Interministerial Chamber for Food and Nutrition Security (Câmara Interministerial de Segurança Alimentar e Nutricional)), one of which was inactive[7]. The State Conference on Food and Nutrition Security was held between 2019 and 2023 in 24 FUs. Only three States reported having a Food and Nutrition Security Fund: Ceará, Paraíba, and Santa Catarina (IBGE, 2025e).

With regard to municipalities, 51% (2,826) had some type of structure in place to address food security policy: 2.3% (64) had a structure in the form of a dedicated municipal department; 7% (199) in the form of a department combined with another policy area; and 87% (2,460) in the form of a division under another department. It was found that a Municipal Food and Nutrition Security Plan was in place in only 7.1% (394) of the municipalities[8]. Just over half, 51.4% (2,851), reported having a Municipal Food and Nutrition Security Council, but it was active in only 1,826 municipalities. Of the 1,358 municipalities that reported having a CAISAN, 837 (61.6%) stated that it was active. Between 2019 and 2023, the Municipal Conference on Food and Nutrition Security was held by 22.9% (1,267) of the municipalities. Only 2.8% (155) had a Municipal Food and Nutrition Security Fund (IBGE, 2025e), an important mechanism for advancing policies and programs in the sector.

6 The State of Rondônia did not participate in the survey.

7 Goiás did not have one, and the one in Espírito Santo was inactive.

8 This percentage was much lower than the one recorded in 2023, which was 18.8% (1,048). This decline can be explained by examining the respondents' explanations for the inconsistencies identified by the data collection monitoring and data management system. Most municipalities claimed that the information provided in 2023 was incorrect.

Another relevant characteristic related to the country's adaptive capacity and vulnerabilities in the context of climate change concerns its water resources. Brazil has approximately 12% of the Earth's surface freshwater, unevenly distributed across twelve river basins throughout its territory (ANA, 2019). Of the 250,000 m^3/s of water that flows through Brazilian territory on average, for example, nearly 80% is found in the Amazon basin (ANA, 2026). Brazil's basins are used for various purposes, such as irrigation, human and animal water supply, industrial use, energy generation, mining, aquaculture, navigation, tourism and leisure. Currently, the primary use of water, in terms of volume, is for irrigation, with more than 1,056.30 m^3/s being used (ANA, 2026). These multiple uses of water represent a vulnerability factor, since water crises that have occurred in various regions demonstrate that a watershed's vulnerability extends beyond its water availability and natural characteristics; it is also related to high demand and water quality (Brasil, 2021).

Electricity generation in the country is highly dependent on hydropower plants, which accounted for 55.3% of the domestic electricity supply in 2024 (EPE – Energy Research Office (Empresa de Pesquisa Energética), 2025), making it vulnerable to changes in precipitation patterns. The Brazilian Interconnected System (SIN, Sistema Interligado Nacional) allows energy to be transferred between regions, taking advantage of the diversity of the hydrological regimes of the basins, which enables complementarity between areas with different wet and dry periods (ONS – National Electric System Operator (Operador Nacional do Sistema Elétrico), 2026a). Thermoelectric plants, located close to the main load centers, are activated according to hydrological conditions, and help to manage water stocks in the reservoirs of the hydropower plants to guarantee future supply (ONS, 2026a).

Water is also used in the production of biomass. The country is one of the world's largest producers of ethanol and biodiesel, with large-scale production of vehicle fuel and generation of bioelectricity for the SIN from surplus sugarcane bagasse at distilleries (Vidal, 2022; IEA, 2023). Forest biomass maintains a significant share in Brazil's energy matrix, especially through the use of firewood and charcoal for energy purposes. Ethanol is produced from sugarcane and maize, which has gained prominence by reaching 25% of national production in 2025 (EPE, 2026). Biodiesel in Brazil is produced exclusively to meet domestic demand, which is driven by the legal requirement to blend a minimum percentage of biodiesel into diesel fuel (Brasil, 2014).

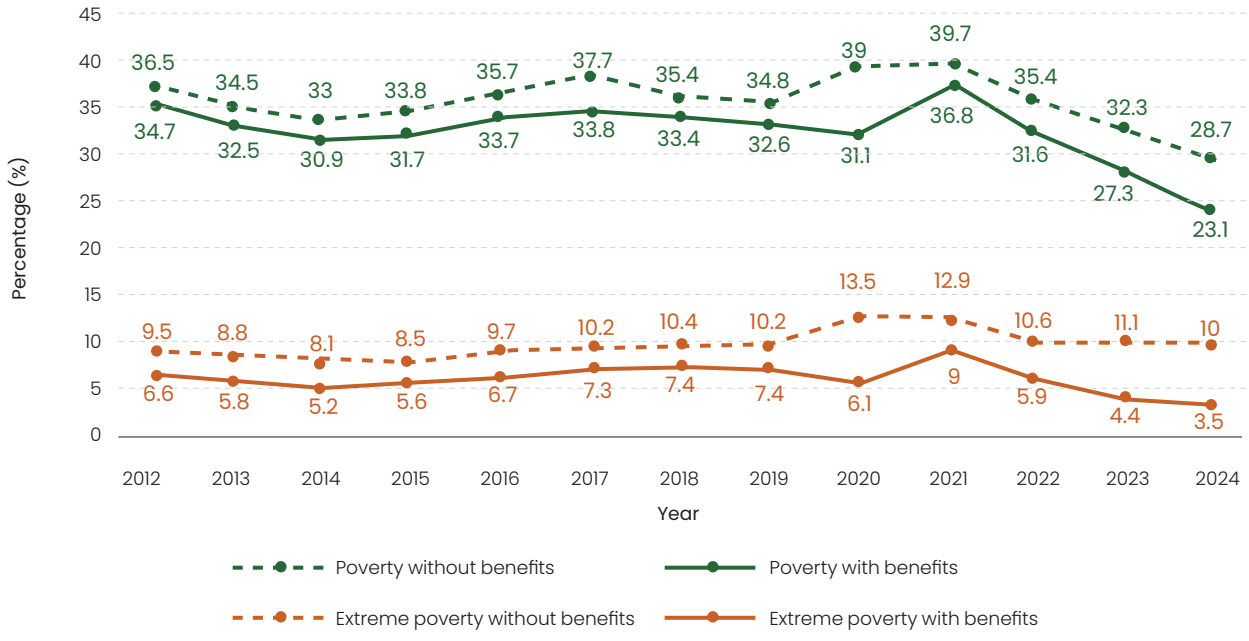
Finally, the importance of socioeconomic vulnerability in the country's adaptation agenda needs to be highlighted. Brazil is among the world's largest economies in terms of Gross Domestic Product (GDP), but it has high levels of inequality, which become even more evident when data are disaggregated by income, gender, race, and major regions (Brasil, 2024d).

The poverty and extreme poverty rates fell from 34.7% and 6.6% in 2012 to 23.1% and 3.5% in 2024, respectively, the lowest rates since 2012, when the time series for the PNADC/IBGE survey began (Figure 4.4). Both rates have shown a steady decline since 2021; in 2023, for the first time, the poverty rate fell below 30% and the extreme poverty rate below 5%, reaching their lowest levels in 2024. Poverty and extreme poverty were unevenly distributed across different groups and regions, with reductions observed in all of them, but particularly in the North and Northeast, where they declined most sharply (IBGE, 2025a).

Although poverty and extreme poverty[9] decreased between 2022 and 2024, racial and gender disparities remain striking. In 2024, around 25.8% of Black people and 29.8% of mixed-race people were living in poverty, which are much higher rates than those found among the white population (15.1%), highlighting the persistence of deep social and economic inequalities in Brazil. Poverty rates were higher in households headed by Black women, without a spouse and with children under 14 years of age, where 63.5% of household members were living in poverty and 11.5% were living in extreme poverty. Around 24% of women in the country were living below the poverty line in 2024, with 30.4% of Black women, compared to 15.5% of white women (IBGE, 2025a).

The federal government's social programs play a significant role in reducing poverty and extreme poverty. They accounted for 74.8% of the household income of people living in extreme poverty in 2024, while income from employment accounted for only 20.6% for this group. Among poor households, social benefits made up 31.8% of their income, compared to 56.8% from employment. According to IBGE, the absence of these social programs would have significantly exacerbated the situation, increasing the proportion of people living in poverty from 23.1% to 28.7% and increasing extreme poverty from 3.5% to 10% (Figure 4.4). Furthermore, income inequality, as measured by the Gini Index[10], would have been 7.5% higher, rising from 0.504 to 0.542 (Figure 4.5), underscoring the importance of these social policies in reducing poverty and promoting a more equitable society (IBGE, 2025a).

Figure 4.4 Proportion of people, by selected *per capita* household income brackets and receipt of benefits from social programs (in %) - Brazil, 2012-2024

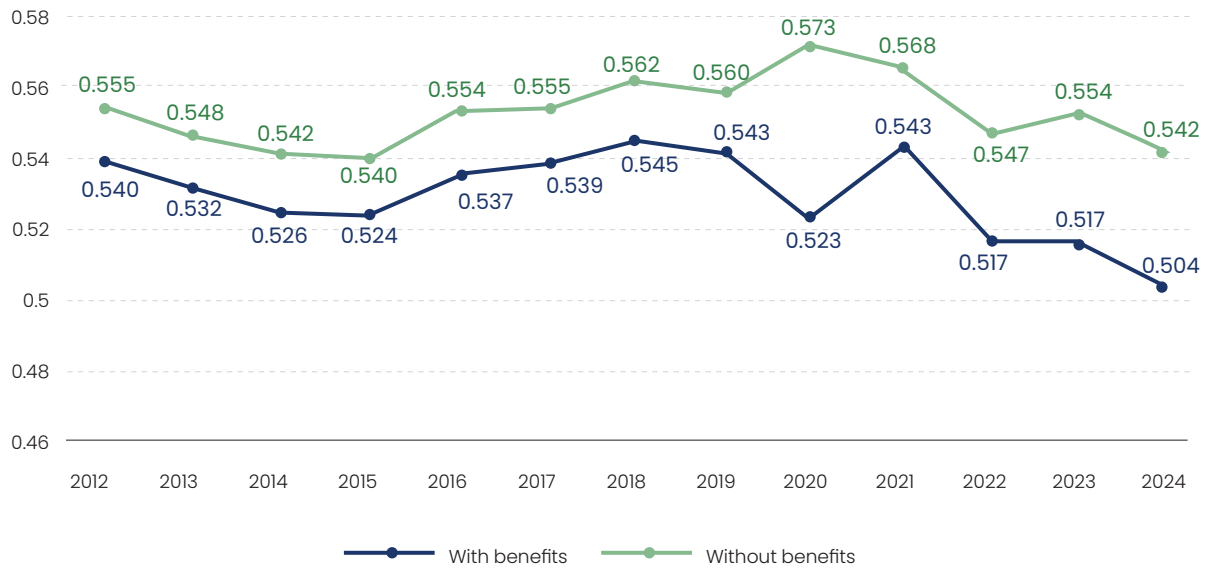


Source: IBGE, 2025a.

9 The World Bank considers workers living in households with *per capita* household income below the monetary thresholds of USD 6.85 and USD 2.15, based on 2017 purchasing power parity (PPP), to be poor and extremely poor, respectively (IBGE, 2025e).

10 See Gini Index in 1.2 Population and Socioeconomic Characteristics.

Figure 4.5 Gini index of per capita household income with and without benefits from social programs – Brazil, 2012-2024[11]



Source: IBGE, 2025a.

Key: (1) Benefits from social programs include: *Bolsa Família* (Family Allowance), Continuous Cash Benefit (BPC, *Benefício da Prestação Continuada*), Emergency Aid, and other government social programs. (2) Simulated exercise with household income *per capita* without benefits from social programs.

With regard to households receiving benefits from social programs in 2024, an analysis by color or race also reveals differences, with a higher percentage of Black (34.0%) and mixed-race (36.9%) people living in households receiving benefits from social programs compared to white people (17.7%) (IBGE, 2025a).

4.1.2. Institutional arrangements and political dimensions

The strengthening of Brazil's climate governance and recent developments in climate policy planning and coordination instruments are presented in **Box 1.2. Strengthening of Brazilian climate governance,** in section **1.4, Institutional arrangements and political dimensions.** This section, therefore, focuses on the institutional arrangements and legal framework specifically related to climate change adaptation, highlighting the main institutions and instruments that support the implementation of this agenda in Brazil.

The adaptation agenda follows the frameworks and guidelines of the National Policy on Climate Change (PNMC, Política Nacional sobre Mudança do Clima), established by Law No. 12,187/2009, which provides for the implementation of adaptation measures at the different levels of government and the development of sectoral mitigation and adaptation plans. It also encompasses the institutions and roles included in the CIM – Interministerial Committee on Climate Change (Comitê Interministerial sobre Mudança do Clima), which, in 2023, determined the initiation of the development of the Climate Plan. Brazil's NDC submitted in 2023 gave

11 Note: Consolidated data on first visits for 2012-2019 and 2023-2024; and on fifth visits for 2020-2022. Continuous National Household Sample Survey 2012-2024.

greater prominence to adaptation, updating previous NDCs by incorporating the guidelines and National Adaptation Goals proposed by the Climate Plan, identified as the basis for implementing mitigation and adaptation targets. More details about the PNMC, the CIM, the NDC, and the Climate Plan are provided in section **1.4, Institutional arrangements and political dimensions.**

The implementation of this agenda involves a wide range of federal institutions, each with complementary responsibilities for coordination, planning, production of information, risk assessment, formulation of sectoral policies and disaster management. In the area of **climate policy coordination**, key institutions include the National Secretariat for Climate Change (SMC, Secretaria Nacional de Mudança do Clima)/MMA and the Secretariat for Strategic Policies and Programs (SEPPE, Secretaria de Políticas e Programas Estratégicos)/MCTI – Ministry of Science, Technology and Innovation (Ministério da Ciência, Tecnologia e Inovação), in addition to the interministerial bodies for climate governance (Dataframe 4.1).

In the **production and dissemination of climate and risk information**, key institutions include the National Institute for Space Research (INPE, Instituto Nacional de Pesquisas Espaciais), the National Institute of Meteorology (INMET, Instituto Nacional de Meteorologia), the National Center for Monitoring and Early Warnings of Natural Disasters (CEMADEN, Centro Nacional de Monitoramento e Alertas de Desastres Naturais) and AdaptaBrasil MCTI, which support risk assessment, planning, and decision-making for adaptation. In the area of **risk and disaster management**, the National Secretariat for Civil Protection and Defense (SEDEC, Secretaria Nacional de Proteção e Defesa Civil/MIDR - Ministry of Integration and Regional Development (Ministério da Integração e do Desenvolvimento Regional)) and the National Center for Risk and Disaster Management (CENAD, Centro Nacional de Gerenciamento de Riscos e Desastres) perform duties related to prevention, preparedness, response, and recovery.

The adaptation agenda is also implemented by institutions responsible for **policies and services directly related to climate risks**. Those include the National Water and Basic Sanitation Agency (ANA), in the area of water security; the Ministry of Integration and Regional Development (MIDR), responsible, among other duties, for the National Water Security Policy and for infrastructure actions and for ensuring water security; the Ministry of Cities, particularly regarding urban development and city adaptation policies; the Ministry of Agriculture and Livestock (MAPA, Ministério da Agricultura e Pecuária), in the areas of agricultural production and risk management; the Ministry of Health, with regard to health protection and the reduction of risks associated with climate change; the Ministry of Indigenous Peoples (MPI, Ministério dos Povos Indígenas), regarding the protection of Indigenous Peoples and their territories; and institutions responsible for policies on biodiversity, infrastructure, energy, transport, tourism, cultural heritage, and economic development.

Adaptation implementation also requires coordination among the Federal government, the states, the Federal District and the municipalities. In this context, climate federalism initiatives, such as AdaptaCidades, aim to support subnational entities in the development and implementation of adaptation strategies and plans. The 16 Sectoral and Thematic Adaptation Plans (Brasil, 2025t) are, in turn, key instruments for translating national goals into priorities, objectives, targets, and specific actions for different sectors and themes.

Dataframe 4.1 shows the main federal institutions involved in the adaptation agenda, their responsibilities and the key instruments related to the implementation of this agenda. These details provide an overview of the assignment of responsibilities and the interfaces between the different areas of government.

Dataframe 4.1 Main institutions and arrangements related to climate change adaptation in Brazil

Institution / unit	Role in the adaptation agenda	Main instruments, initiatives or interfaces
National Secretariat for Climate Change (SMC, Secretaria Nacional de Mudança do Clima/MMA)	Formulation, coordination and implementation of climate policy; interministerial and federal coordination; coordination of the national adaptation agenda.	Climate Plan 2024-2035; support for state and municipal adaptation strategies.
Secretariat for Strategic Policies and Programs (SEPPE/MCTI), Department of Climate and Sustainability (DECLS, Departamento para o Clima e Sustentabilidade) and General Coordination of Climate Science (CGCL, Coordenação-Geral de Ciência do Clima)	Technical and scientific coordination of climate policy; production, systematization, and dissemination of scientific knowledge for climate policies; assessment of impacts, vulnerabilities and risks.	Climate Plan; AdaptaBrasil; Rede Clima; National Communications, BURs and BTRs; DataClima+.
National Institute for Space Research (INPE, Instituto Nacional de Pesquisas Espaciais)	Data generation, climate modeling and scenarios; environmental monitoring; assessment of impacts, risks and vulnerabilities.	AdaptaBrasil; Center for Weather Forecasting and Climate Studies (CPTEC, Centro de Previsão de Tempo e Estudos Climáticos); climate projections; monitoring systems.
National Institute of Meteorology (INMET, Instituto Nacional de Meteorologia)	Weather and climate observation, monitoring, and forecasting; issuance of warnings and information for risk management.	National observation systems; weather forecasts and warnings; information to support agriculture, health, water resources and civil defense.
National Center for Monitoring and Early Warnings of Natural Disasters (CEMADEN, Centro Nacional de Monitoramento e Alertas de Desastres Naturais)	Monitoring of hazards and risks; issuance of warnings and information for the prevention of and preparedness for extreme events.	Geohydrological warnings; drought monitoring; risk bulletins; early warning systems.
National Secretariat for Civil Protection and Defense (SEDEC/MIDR)	Coordination of civil protection and defense; prevention, preparedness, response, and recovery; federative coordination.	National System for Civil Protection and Defense (SINPDEC, Sistema Nacional de Proteção e Defesa Civil); National Plan for Civil Protection and Defense (PN-PDC, Plano Nacional de Proteção e Defesa Civil) 2025-2035; instruments for recognition and support to states and municipalities.

Institution / unit	Role in the adaptation agenda	Main instruments, initiatives or interfaces
National Center for Environmental and Climate Emergencies (CENEAC, Centro Nacional de Emergências Ambientais e Climáticas/IBAMA - Brazilian Institute of the Environment and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis))	Prevention, preparedness, risk management, and response to environmental emergencies, including events related to climate change.	Environmental risk management; operational plans and procedures; emergency response and support for environmental restoration.
National Water and Basic Sanitation Agency (ANA)	Water resources management, hydrological monitoring, and promotion of water security; reduction of vulnerability to droughts and extreme hydrological events.	National Water Resources Plan; National Water Security Plan; National Hydrometeorological Network; Pact for Water Governance.
National Secretariat for Water Security (SNSH, Secretaria Nacional de Segurança Hídrica/MIDR)	Formulation and implementation of policies and investments related to water security; infrastructure; and reduction of vulnerabilities resulting from droughts and floods.	National Water Security Plan; São Francisco River Integration Project; water infrastructure and revitalization of watersheds.
Department of Cities Adaptation to Climate Transition and Digital Transformation (DAC, Departamento de Adaptação das Cidades à Transição Climática e Transformação Digital/ SNDUM – National Secretariat for Urban and Metropolitan Development (Secretaria Nacional de Desenvolvimento Urbano e Metropolitano)/Ministry of Cities)	Responsible for formulating the national urban climate adaptation agenda; guidance on the incorporation of climate adaptation into urban policies at national level.	Climate Adaptation Plan – Cities; *Capacidades* (Programa Nacional de Capacitação das Cidades (National Cities Capacity-Building Program)); AdaptAÇÃO Project; guidelines and methodologies for municipalities, instruments of the City Statute.
National Secretariat for Urban Peripheries (SNP, Secretaria Nacional de Periferias/Ministry of Cities)	Works in urban territories most vulnerable to climate change impacts (*favelas*, urban communities, and precarious settlements), seeking to integrate the reduction of socio-territorial inequalities with climate adaptation and disaster risk management through public policies focused on social participation and climate justice.	*Periferia Viva* (Live Urban Periphery) Program

Institution / unit	Role in the adaptation agenda	Main instruments, initiatives or interfaces
Department of Risk Mitigation and Prevention (DPR, Departamento de Mitigação e Prevenção de Risco/SNP/ Ministry of Cities)	Coordinates disaster risk reduction actions in vulnerable urban territories through structural and nonstructural measures; environmental risk management, climate risk studies and mapping; integration of adaptation into planning and investments; support for the implementation of nature-based solutions.	Municipal Risk Reduction Plans; Community Risk Reduction and Climate Adaptation Plans.
Department of Sustainability and Special Projects (Departamento de Sustentabilidade e Projetos Especiais/Ministry of Cities)	Integration of sustainability into the policies, programs, and projects of the Ministry of Cities, contributing to the incorporation of environmental and climate aspects into the planning and implementation of urban projects.	Ministry of Cities Sustainability Agenda; tracking and monitoring of the Ministry's project portfolio.
National Executive Committee of the ABC+ Plan (CENABC, Comissão Executiva Nacional do Plano ABC+/ MAPA)	Coordination, monitoring and evaluation of adaptation and resilience policies for agriculture.	ABC+ Plan 2020-2030; resilient production systems; climate risk management.
Standing Committee on Climate Emergency, Water Security, Renewable Energy and Energy Sovereignty (CPEC, Comitê Permanente de Emergência Climática, Segurança Hídrica, Energias Renováveis e Soberania Energética/CONDRAF - National Council for Sustainable Rural Development (Conselho Nacional de Desenvolvimento Rural Sustentável))	Participatory coordination of the climate agenda in sustainable rural development; strengthening of the resilience of family farming and rural territories.	Climate Plan; adaptation policies for family farming; water security and energy sovereignty.
General Coordination of Climate Change and Health Equity (CGCLIMA, Coordenação-Geral de Mudanças Climáticas e Equidade em Saúde/DVSAT – Department of Environmental Health and Occupational Health Surveillance (Departamento de Vigilância em Saúde Ambiental e Saúde do Trabalhador)/SVSA – Secretariat of Health and Environmental Surveillance (Secretaria de Vigilância em Saúde e Ambiente)/ MS - Ministry of Health (Ministério da Saúde))	Coordination of AdaptaSUS monitoring and evaluation, in permanent coordination with the responsible units; integration of climate variables into health policies; surveillance, prevention and strengthening of the response capacity of SUS – Brazilian National Health System (Sistema Único de Saúde).	Climate Adaptation Plan – Health (AdaptaSUS); National Situation Room for Climate-Related Health Emergencies.

Institution / unit	Role in the adaptation agenda	Main instruments, initiatives or interfaces
Department of Climate Justice of the Ministry of Indigenous Peoples (DEJUC, Departamento de Justiça Climática/MPI - Ministry of Indigenous Peoples (Ministério dos Povos Indígenas))	Coordination of the adaptation agenda for Indigenous Peoples and incorporation of the perspectives, rights, and knowledge of Indigenous Peoples into the climate adaptation and climate justice agenda.	Climate Adaptation Plan – Indigenous Peoples; interinstitutional coordination; National Council for Indigenous Policy (CNPI, Conselho Nacional de Política Indigenista) and Management Committee of the National Policy for Territorial and Environmental Management of Indigenous Lands (CG-PNGATI, Comitê Gestor da Política Nacional de Gestão Territorial e Ambiental de Terras Indígenas) as bodies for participation and governance.
National Foundation of Indigenous Peoples (Funai, Fundação Nacional dos Povos Indígenas)	Work on the protection and territorial and environmental management of Indigenous Lands and support for the implementation of adaptation and resilience measures for Indigenous Peoples.	Climate Adaptation Plan – Indigenous Peoples; land demarcation and territorial protection; territorial and environmental management; prevention of and response to climate emergencies.
Secretariat for Indigenous Health (SESAI, Secretaria de Saúde Indígena/MS)	Integration of the climate dimension into Indigenous health policies and strengthening of the capacity to prevent, prepare for, and respond to climate emergencies affecting Indigenous Peoples.	Climate Adaptation Plan – Indigenous Peoples; Indigenous healthcare; Special Indigenous Health Districts (DSEI, Distritos Sanitários Especiais Indígenas); coordination with healthcare networks.
General Coordination of Climate Actions and Gender (CGAC, Coordenação-Geral de Ações Climáticas e Gênero/SENAIP – National Secretariat for Intersectoral and Interfederative Coordination and Political Participation (Secretaria Nacional de Articulação Intersetorial e Interfederativa e Participação Política)/Ministry of Women)	Incorporation of the gender perspective, social participation, and climate justice into climate policies.	Cross-Cutting Strategy on Women and Climate; participatory processes and capacity-building actions.
Undersecretariat for Sustainability (SUST, Subsecretaria de Sustentabilidade)/Ministry of Transport	Integration of sustainability, resilience and adaptation into the planning, implementation and management of land transport infrastructure.	Climate Plan; risk studies and assessments; resilience criteria for transport infrastructure.

Institution / unit	Role in the adaptation agenda	Main instruments, initiatives or interfaces
General Coordination of Sustainability (CGSUS, Coordenação-Geral de Sustentabilidade/Ministry of Ports and Airports)	Incorporation of the climate dimension into the planning and management of port and airport infrastructure; strengthening of operational resilience.	Climate risk studies; resilience criteria; integration of adaptation into planning and investments.
Department of Quality, Sustainability and Climate Actions (DEQUA, Departamento de Qualidade, Sustentabilidade e Ações Climáticas)/Ministry of Tourism	Integration of sustainability, risk management and adaptation into the policies for tourism; strengthening of the resilience of tourist destinations.	Quality and sustainability management instruments; capacity-building; Cadastur - Register of Tourism Service Providers (Cadastro de Prestadores de Serviços Turísticos); sustainable practices.
Department of New Economies (DNOVA, Departamento de Novas Economias/SEV – Secretariat for Green Economy, Decarbonization, and Bioindustry (Secretaria de Economia Verde, Descarbonização e Bioindústria)/MDIC - Ministry of Development, Industry, Trade and Services (Ministério do Desenvolvimento, Indústria, Comércio e Serviços))	Incorporation of climate risks and economic resilience into industrial policies; mobilization of financial and regulatory instruments.	Sustainable finance; financing instruments; New Industry Brazil (Nova Indústria Brasil); Climate Plan.
National Council for Industrial Development (CNDI, Conselho Nacional de Desenvolvimento Industrial)	Coordination of industrial policy and integration of climate risk management and production chain resilience.	New Industry Brazil (NIB, Nova Indústria Brasil); financial and regulatory instruments; industrial development strategies.
Undersecretariat for Ecological Transformation (STE, Subsecretaria de Transformação Ecológica/MF - Ministry of Finance (Ministério da Fazenda))	Integration of the climate dimension into economic and financial policies; mobilization of resources for adaptation and resilience.	Ecological Transformation Plan; Brazilian Sustainable Taxonomy; climate finance mechanisms and sustainable finance.
Council for Sustainable Economic and Social Development (CDESS, Conselho de Desenvolvimento Econômico Social Sustentável)	Coordination between the government and society for the formulation of sustainable development policies, incorporating the climate dimension.	Social participation; dialogue among the government, the productive sector and civil society; inputs for sustainable development policies.

Source: Compiled by the authors.

With regard to the legal framework, as stated in Chapter 1, National context, adaptation has increasingly been incorporated into recently developed sectoral policies. Of particular note is the approval of guidelines for the development of climate change adaptation plans, with the aim of implementing measures to reduce the vulnerability and exposure to risks of environmental, social, economic, and infrastructure systems in the face of the current and expected adverse effects of climate change (Brasil, 2024a).

According to this legal instrument, adaptation plans will establish measures to include climate change risk management in existing sectoral and thematic public plans and policies and local and national development strategies, and will also be integrated into plans that include the mitigation of greenhouse gas emissions. Funding for the implementation of local adaptation plans (at municipal, district and state level) can be provided through the National Climate Change Fund (FNMC, Fundo Nacional sobre Mudança do Clima), among other funding sources.

The legislation also reinforces the importance of establishing economic, financial and socio-environmental public policy instruments that ensure the viability and effectiveness of adaptation and the adoption of nature-based solutions (NbS) as part of the strategies, integrating adaptation and mitigation outcomes. The promotion of research, development, and innovation is another element included in the instrument's guidelines.

4.2. Impacts, risks and vulnerabilities

This section provides a summary of observed trends and projected climate change, as well as the main impacts, risks and vulnerabilities associated with climate change in Brazil.

The characterization of observed and projected climate change trends was based on the analysis of time series and climate projections, using multiple observational databases and climate modeling products, supplemented by statistical analyses and temperature and precipitation indicators, as well as ocean variables.

The analysis of impacts, risks and vulnerabilities was based on the methodological approach adopted by the Climate Adaptation Plan and the IPCC's conceptual framework for climate risk. The main sources of information were the Sectoral and Thematic Adaptation Plans, AdaptaBrasil MCTI, and the most up-to-date scientific literature; the themes were organized according to the nine (9) National Adaptation Goals, whose role in structuring this analysis is presented in **section 4.2.2, Impacts, risks, and vulnerabilities for sectors and themes of strategic importance to Brazil**. The methodological approach adopted is detailed in **section 4.2.3. Methodological approach.**

4.2.1. Observed trends and projected climate change

Brazil's first BTR provided an overview of the main climate change trends that had been observed for various climate indicators across the country. Additionally, data and references were systematically compiled to characterize the future climate change signal associated with 14 climate-related hazards across the country's five regions, also taking into account the uncertainties identified in the studies.

In order to provide more robust and up-to-date information, the results presented in the previous BTR served as the basis for refining the analyses, allowing them to be expanded to include new territorial dimensions and climate indicators, including oceanic variables. In addition, an assessment of future scenarios was conducted based on a set (*ensemble*) of CMIP6 global climate models.

While previous results were summarized in tabular format, in this update they are presented using maps covering all of Brazil, highlighting the geographic distribution of current and projected changes in the selected temperature and precipitation indicators. In a country of continental proportions, spatial information is essential for a better understanding of the distribution of current and projected climate-related changes.

The following are the key messages from the results of the analyses:

Current climate change trends

- An increasing trend in mean maximum temperatures has been observed in Brazil over the past 43 years.
- The years 2023 and 2024 were the warmest years of the available time series, with mean maximum temperatures exceeding the reference climatology by more than 2ºC.
- The rise in temperature was most pronounced in the Pantanal and Cerrado biomes.
- Changes in precipitation patterns show high spatial heterogeneity across Brazil and greater uncertainties associated with the availability, quality, and coverage of the available data.
- The annual variation in mean precipitation showed a decrease across much of the Northeast and Southeast, but an increase in the South.
- The results indicate an increase in the number of consecutive dry days, primarily in the Central-West and Southeast regions, especially in the states of Minas Gerais, Goiás and Mato Grosso, as well as in the southern portion of the Amazon.
- Extreme rainfall had a more pronounced increase in the North, along the Northeast coast, and in the South.
- The mean sea level anomaly (SLA) in Brazil's Coastal-Marine System rose by 0.11 m between 1993 and 2023, while the sea surface temperature (SST) anomaly showed an average increase of 0.35ºC.

Future projections

- A widespread and progressive increase in temperature is projected throughout Brazil, intensifying with increasing levels of global warming.
- Annual maximum temperatures are expected to rise significantly, especially in the Central-West, North, and inland regions of the country, with increases that could exceed 5ºC in high-emission scenarios, in addition to an increase in the duration and extent of heat waves.
- As with maximum temperatures, the increase in minimum temperatures is widespread, though to a lesser extent.
- From 2ºC of global warming, a decrease in precipitation is projected in the North region (particularly in the Amazon), while an increase is projected in the South, resulting in a climatic dipole, with a contrasting pattern between the two regions.

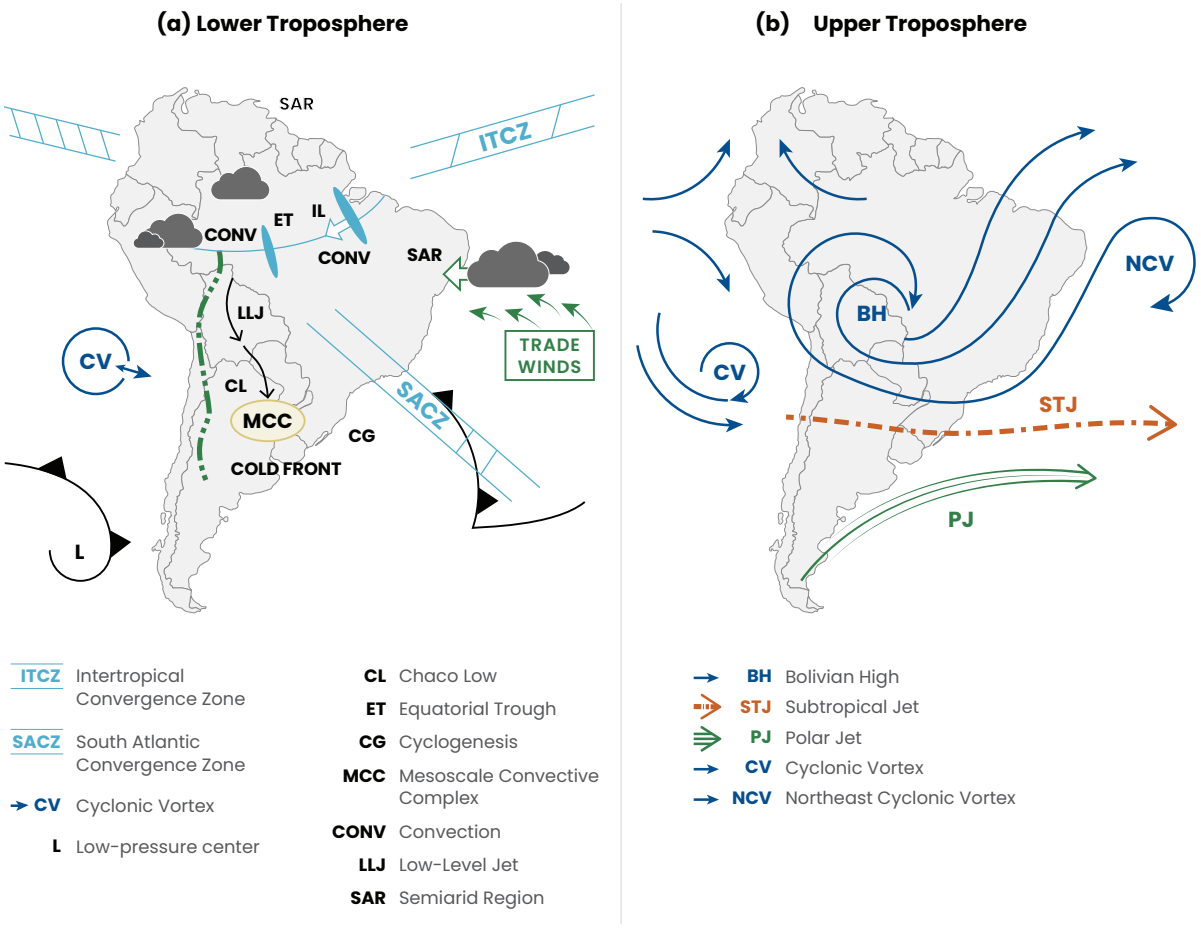
- Projections indicate a simultaneous intensification of opposing extremes, with longer dry periods and more intense heavy rainfall events.
- An increase in the number of consecutive dry days (CDD) is expected, with greater impacts in the Northeast, Central-West and North regions and the largest increases in the Pantanal, Caatinga and Cerrado, indicating a trend toward longer dry spells in these regions. The Amazon also shows an increase, suggesting a potential intensification of water seasonality. In the Atlantic Forest, the increases are more moderate, while the Pampa shows smaller variations with greater uncertainty.
- An increase in the intensity of extreme rainfall (Rx1day and Rx5day) is projected across nearly the entire country, with the increase being most pronounced in the South. Continued warming of the sea surface along the Brazilian coast is projected.
- Mean sea level is projected to rise by 20-30 cm during the 2041-2060 period in the high-emissions scenario.

In summary, the projections presented confirm that ongoing global warming is not limited to increases in mean temperatures, but triggers a series of interconnected changes throughout the climate system. The increasing frequency and intensity of extreme events, the intensification of the hydrological cycle, sea level rise, and changes in the oceans demonstrate the extent and severity of the projected climate change. These findings underscore the urgency of rapid, deep, and sustained mitigation and adaptation actions, as each additional increase in global warming increases multiple and simultaneous risks, with direct impacts on ecosystems, societies, and economies on a global scale.

4.2.1.1. Brazilian climate context

Brazil's climate is influenced by a set of large-scale atmospheric and oceanic systems that modulate the spatial and temporal distribution of temperature and precipitation. Among the main mechanisms are the Intertropical Convergence Zone (ITCZ), the South Atlantic Convergence Zone (SACZ), and the South American Monsoon System (SAMS), as well as systems associated with lower- and upper-level atmospheric circulation, such as jet streams, cyclonic vortices, cold fronts, and low-pressure centers. Figure 4.6 shows a schematic representation of these systems, highlighting their influence in the lower and upper troposphere.

Figure 4.6 Schematic representation of the main atmospheric systems that influence the climate of South America and Brazil (a) in the lower troposphere and (b) in the upper troposphere



Note: The systems highlighted include the Intertropical Convergence Zone (ITCZ), the South Atlantic Convergence Zone (SACZ), trade winds, cold fronts, the Chaco Low, the Low-Level Jet, the Bolivian High, the Northeast Brazil Cyclonic Vortex, and the subtropical and polar jets, which play a role in organizing atmospheric circulation and the regional distribution of precipitation.

Source: adapted from Satyamurty *et al.* (1998).

The ITCZ is a convergence zone of the trade winds near the equator, characterized by intense convection and high precipitation rates. Its seasonal position has a strong influence on the rainfall regime in the North and Northeast regions of Brazil (Hastenrath, 1991; Nobre and Shukla, 1996). The SACZ, in turn, is a system typical of the austral summer, characterized by a band of clouds and precipitation that extends from the Amazon toward the Central-West and Southeast of the country to the central region of the South Atlantic Ocean, and is fundamental to the distribution of rainfall in these regions (Kodama, 1992, 1993; Carvalho et al., 2004). The SAMS is a seasonal atmospheric circulation system associated with differential warming between the continent and the ocean, responsible for the intensification of rainfall during the rainy season, particularly in the Amazon, Central-West, and Southeast regions (Mechoso et al., 2005; Liebmann and Mechoso, 2011; Marengo et al., 2012; Silva and Kousky, 2012).

In addition to the natural variability associated with these systems, Brazil's climate has been progressively influenced by external forcings related to global climate change. These changes interact with atmospheric and oceanic mechanisms, amplifying or altering regional

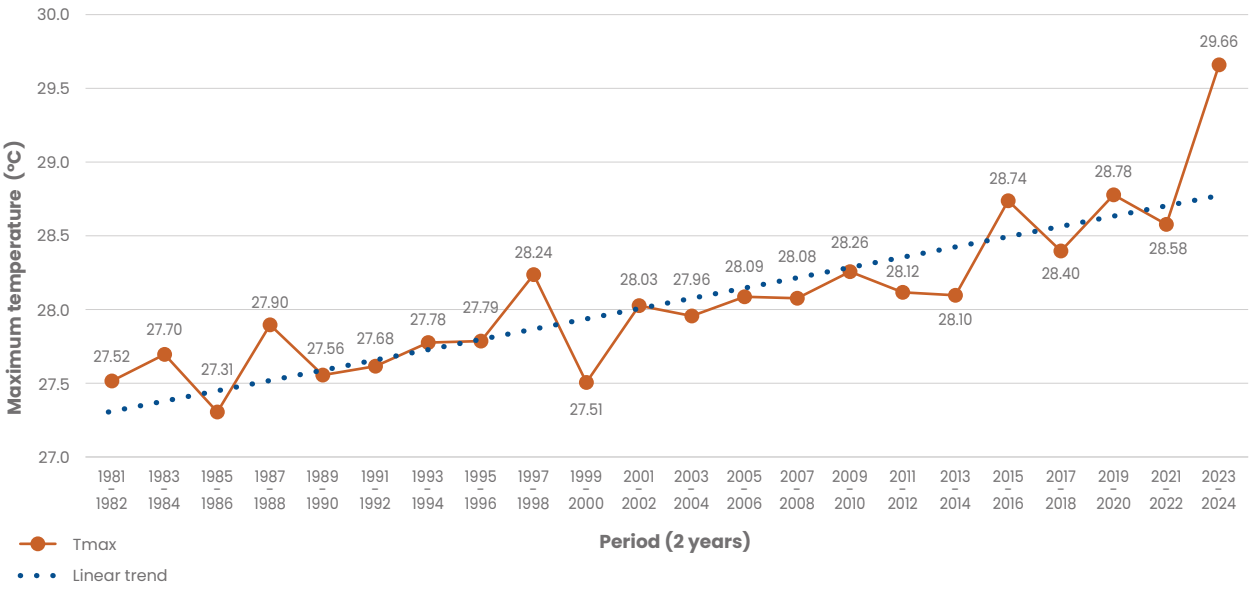
temperature and precipitation patterns, which underscores the importance of analyzing the trends observed in recent decades.

According to IPCC assessments, warming of the climate system is unequivocal, as evidenced by increases in global mean temperatures, changes in precipitation patterns, glacier retreat, and sea level rise (IPCC, 2021). In Brazil, the observed data indicate consistent trends toward rising temperatures, as well as regional changes in rainfall regime, including intensification of extreme events such as prolonged droughts and episodes of heavy rainfall. These observational records provide the empirical basis for assessing ongoing climate change. The analyses conducted on current and future trends in Brazilian territory are presented below.

4.2.1.2. Current climate change trends

The trends observed in recent decades show important changes in Brazil's climate patterns. Annual mean maximum temperatures across the territory ranged from 27.3°C to 29.7°C over the period of 1981-2024, showing an upward trend over the years, as shown in Figure 4.7, which presents two-year mean maximum temperatures.

Figure 4.7 Annual mean maximum temperature for Brazil between 1981 and 2024 (°C)

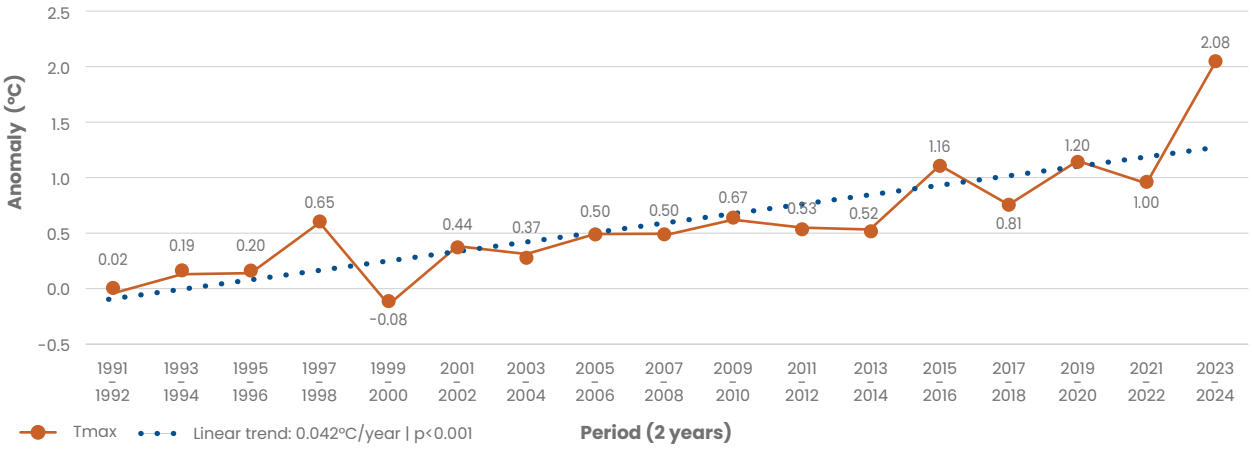


Source: Compiled by the authors based on ERA5 data.

When considering the anomalies[12], that is, differences in maximum temperature (Tmax) relative to the reference climatology (1961 to 1990), a statistically significant upward trend (p-value < 0.001) is observed, estimated at 0.04°C per year between 1991 and 2024, with warming intensifying in recent decades. Between 2011 and 2024, the approximate warming trend was 1°C. The years 2023 and 2024 were the warmest in the time series, with mean maximum temperature exceeding 2°C relative to the historical period (Figure 4.8 and Figure 4.9).

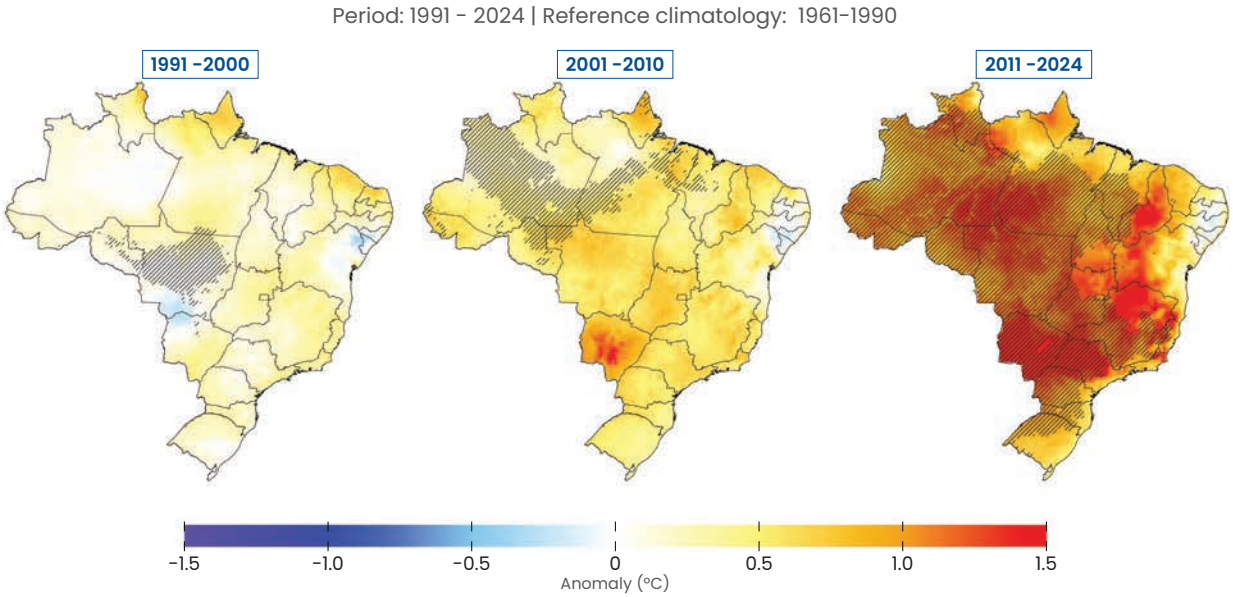
12 For the purposes of this report, an anomaly is the difference between observed conditions and the expected historical mean for a specific location and period.

Figure 4.8 Anomaly in the annual mean maximum temperature for Brazil (°C) for the period 1991-2024 relative to 1961-1990



Source: Compiled by the authors based on ERA5 data.

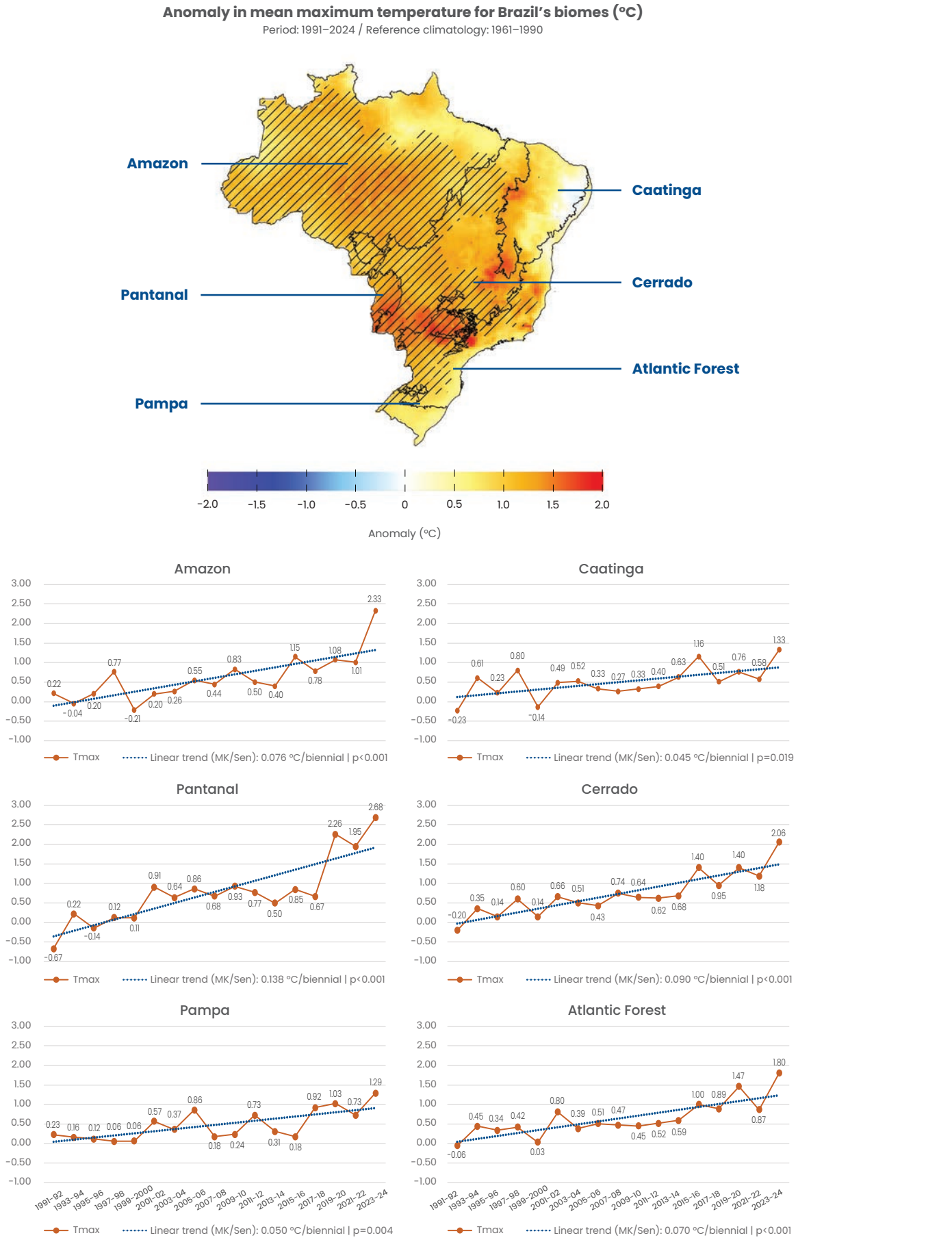
Figure 4.9 Anomaly in mean maximum temperature by period for Brazil (°C). The hatched areas on the map indicate where the results were statistically significant (p-value < 0.05)



Source: Compiled by the authors based on ERA5 data.

An increase in the maximum temperature was observed throughout the country, with positive trends over the period analyzed. The magnitude of these trends, however, varies spatially, indicating regional differences in the intensity of the observed warming. The highest rates of increase were observed in the Pantanal (+0.14°C/year), followed by the Cerrado (+0.09°C/year), the Atlantic Forest (+0.07°C/year), and the Amazon (+0.076°C/year). The Caatinga (+0.045°C/year) and the Pampa (+0.05°C/year) showed the lowest trend rates, although they were still positive (Figure 4.10).

Figure 4.10 Anomalies in mean maximum temperature in Brazilian biomes for the period 1991-2024, relative to 1961-1990. The hatched areas in the graphs indicate statistical significance



Source: Compiled by the authors based on ERA5 data.

The warming trend is corroborated by analyses from INMET, based on its network of meteorological observations (**section 7.1, Research and systematic observation**). The results indicate a clear and continuous warming trend, especially since the early 2000s, with positive temperature anomalies. Of the 10 highest annual mean temperatures in Brazil, based on the 1961-2025 period, only two were recorded before the last decade - 1998 and 2012 (Table 4.2). The mean temperature in 2025 was the seventh highest in the time series, while 2024 recorded the highest mean temperature (INMET, 2026).

Table 4.2 Ranking of the 10 highest annual mean temperatures in Brazil, for the period 1961-2025

Rank	Year	Annual Mean Temperature (°C)
1	2024	25.02
2	2023	24.92
3	2015	24.89
4	2019	24.83
5	2016	24.66
6	1998	24.61
7	2025	24.56
8	2017	24.48
9	2012	24.45
10	2020	24.43

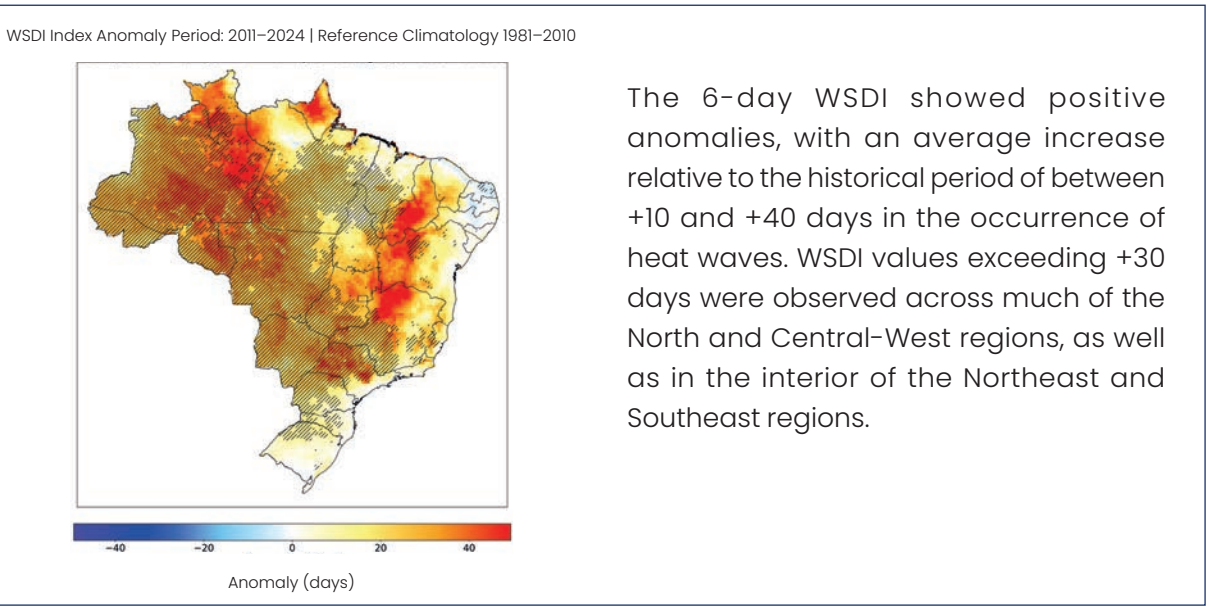
Source: INMET, 2026.

In addition to the increase in mean temperature, temperature extremes also show a worsening trend across the country. To assess heat wave events of varying durations, two indices were considered: the WSDI[13], defined for events with a minimum duration of 6 days, and an adaptation of the index for events with a minimum duration of 3 days[14] (WSDI3d). The results are shown in the following maps:

13 The WSDI is obtained by computing only those days that make up heat waves of at least X consecutive days in which the maximum temperature was higher than the 90th percentile of the maximum temperature (centered on an X-1-day moving window) of the reference period.

14 Analyses were conducted for the WSDI for 3 days, considered a period with the potential for significant impacts on health and other systems, and for 6 days, which is more commonly used in meteorology.

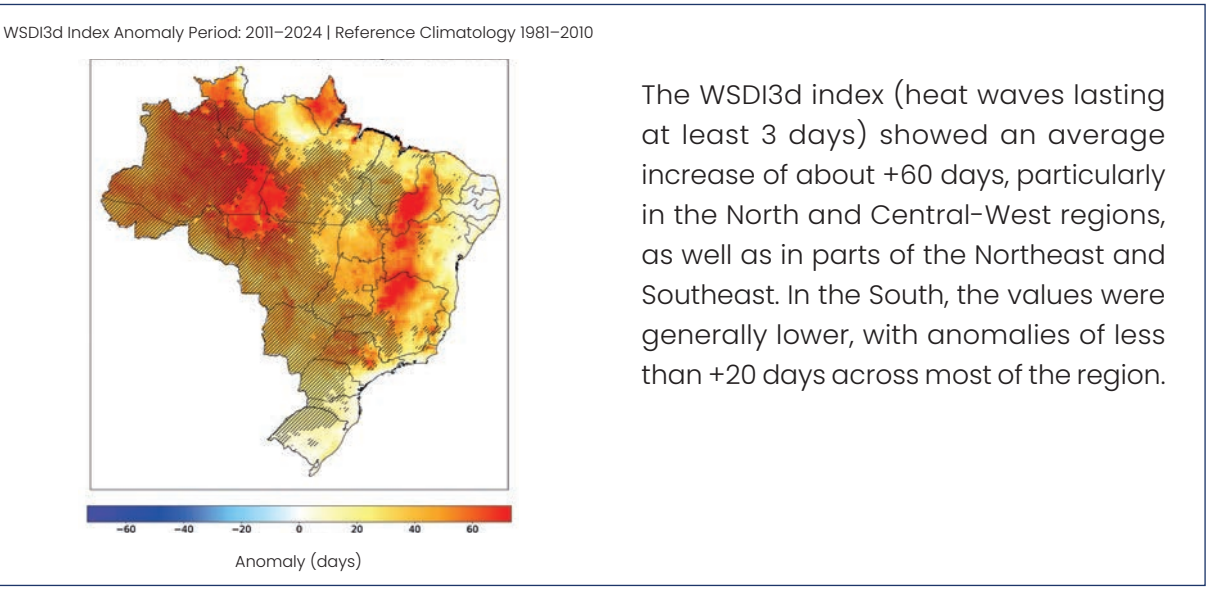
Figure 4.11 Map showing the 6-day WSDI anomaly of the 2011-2024 period relative to the 1981-2010 reference climatology



The 6-day WSDI showed positive anomalies, with an average increase relative to the historical period of between +10 and +40 days in the occurrence of heat waves. WSDI values exceeding +30 days were observed across much of the North and Central-West regions, as well as in the interior of the Northeast and Southeast regions.

Note: The hatched areas on the anomaly map indicate where the results were statistically significant (p-value < 0.05).
Source: Compiled by the authors based on ERA5 data.

Figure 4.12 Map showing the 3-day WSDI anomaly of the 2011-2024 period relative to the 1981-2010 reference climatology



The WSDI3d index (heat waves lasting at least 3 days) showed an average increase of about +60 days, particularly in the North and Central-West regions, as well as in parts of the Northeast and Southeast. In the South, the values were generally lower, with anomalies of less than +20 days across most of the region.

Note: The hatched areas on the anomaly map indicate where the results were statistically significant (p-value < 0.05).
Source: Compiled by the authors based on ERA5 data.

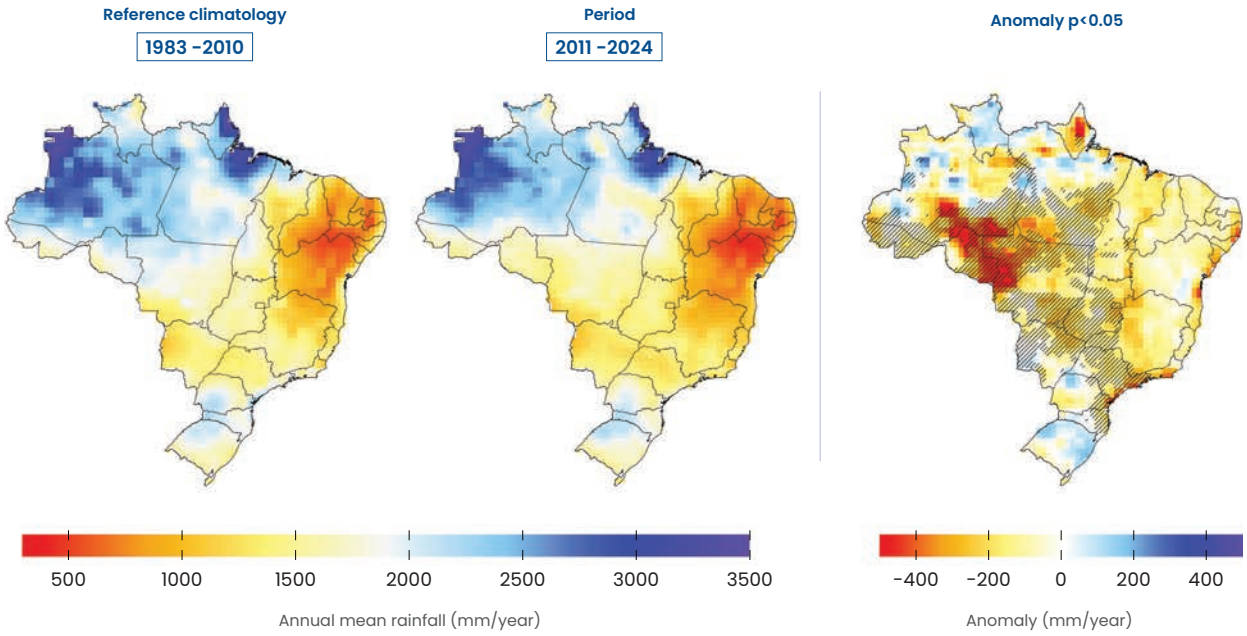
To analyze trends in total precipitation patterns, two datasets were used, taking into account the spatial variability of precipitation in Brazil and the uncertainties associated with its representation across the country. GPCP v3.3 integrates satellite precipitation estimates with in situ rain gauge measurements, to which calibration procedures are applied, at a spatial resolution of 0.5° × 0.5°, and is available at monthly temporal resolution from 1983 to the present (Huffman et al.,

1995, 2025). CHIRPS data, in turn, combine satellite observations with a denser network of in situ rain gauge measurements, using spatial interpolation techniques and regional corrections, and have a higher spatial resolution (0.05° × 0.05°), with data available at daily temporal resolution from 1981 to the present (Funk et al., 2015). Further details on the methodology can be found in section **4.2.3. Methodological approach.**

The anomaly for the 2011-2024 period, relative to the reference climatology (1983-2010), indicated that rainfall in Brazil ranged from -400 to +400 mm/year. According to the GPCP dataset, the largest negative anomalies, on the order of -400 mm/year, were concentrated mainly in areas of southern Amazonas State, Amapá, Rondônia, and Mato Grosso, as well as along sections of the coast of the Southeast and Northeast Regions. Decreases ranging from -100 to -300 mm/year were prevalent in parts of the Central-West and the interior of the Northeast, as well as in the Southeast. In contrast, the largest positive anomalies (+200 to +400 mm/year) occurred in the state of Rio Grande do Sul and in areas of the North region (Figure 4.13).

In the CHIRPS rainfall anomaly dataset (Figure 4.14), the negative values, which indicate reduced rainfall, were concentrated mainly over the Northeast and Southeast regions of Brazil. Although the GPCP and CHIRPS products show spatial differences due to factors such as different spatial resolutions, which are quite significant for the Amazon and central Brazil, both indicate areas with reduced precipitation, such as in the Northeast, the coast of Rio de Janeiro, and Amapá, and areas with positive anomalies, such as in Rio Grande do Sul and parts of the North coast, reinforcing the need to interpret rainfall results using multiple datasets. The following figures show the spatial distribution of the anomaly in mean annual accumulated rainfall for the analysis conducted using the two datasets, where it can be observed that statistical significance ($p < 0.05$) is limited across the country.

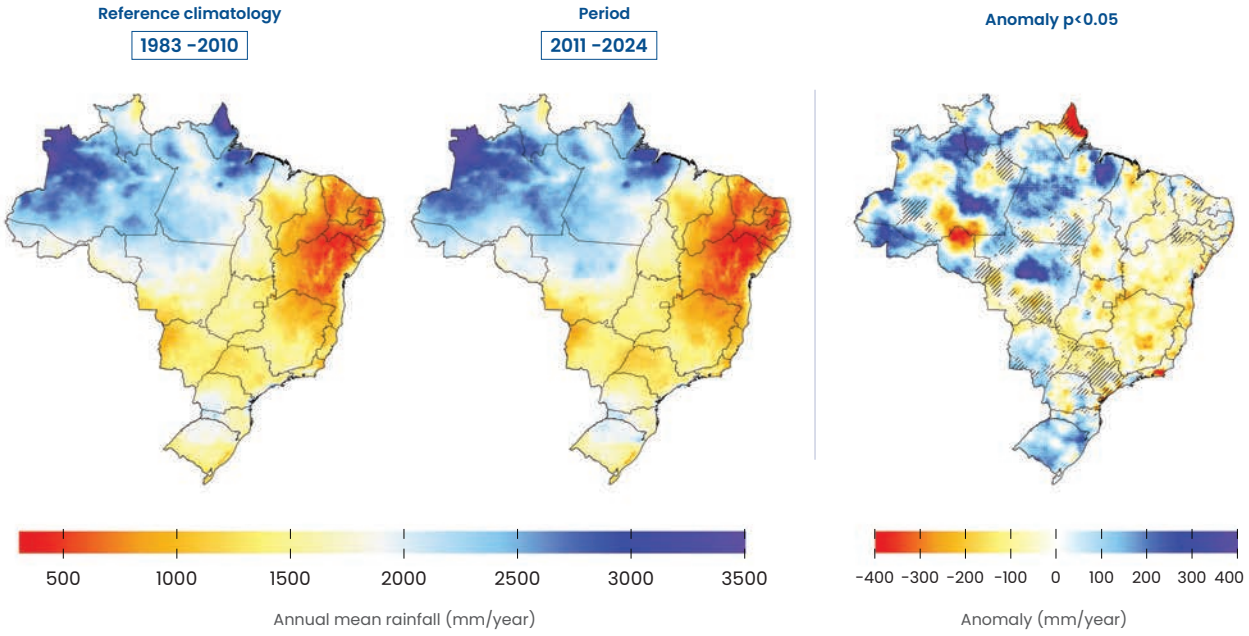
Figure 4.13 Annual accumulated rainfall anomaly for Brazil relative to 1983-2010 based on GPCPv3.3 data



Note: The hatched area indicates statistical significance ($p < 0.05$).

Source: Compiled by the authors based on GPCPv3.3 data.

Figure 4.14 Rainfall anomaly for Brazil relative to 1983-2010 based on CHIRPS data



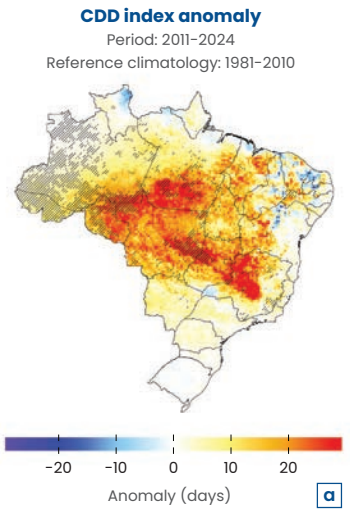
Note: The hatched area indicates statistical significance ($p < 0.05$).

Source: Compiled by the authors based on CHIRPS data.

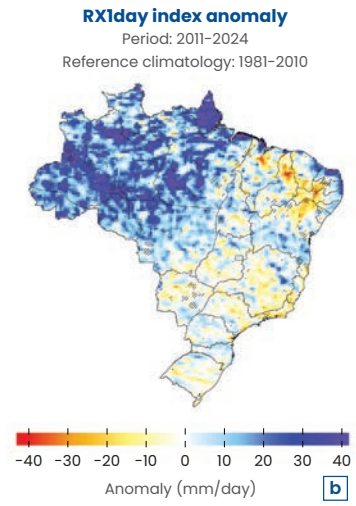
Changes in rainfall patterns, therefore, vary considerably across Brazil and are subject to greater uncertainty due to the quality and coverage of the available data. To better assess how climate change is affecting these patterns, other indices that reflect temporal distribution and changes in intensity need to be analyzed. Figure 4.15 shows the anomaly for the last decade (2011-2024) relative to the historical period of 1981-2010 for the CDD (number of consecutive dry days), RX1day and RX5day indices, using the CHIRPS database.

The RX1day index represents the highest accumulated rainfall in a single day throughout each year, and the RX5day index represents the highest accumulated rainfall over 5 consecutive days during a year. While RX5day measures the persistence of heavy rainfall (relevant to landslides and gradual flooding), RX1day is a key indicator of absolute extremes in intensity, being frequently used to monitor the risk of floods and flash floods, and to indicate the intensification of climate change. Increasing trends in RX1day indicate that storms are becoming more severe, even if total annual rainfall does not change substantially. Although the analysis of these indices indicates worsening trends in some regions, the results need to be interpreted with caution, as statistically significant trends were observed only in isolated parts of the country.

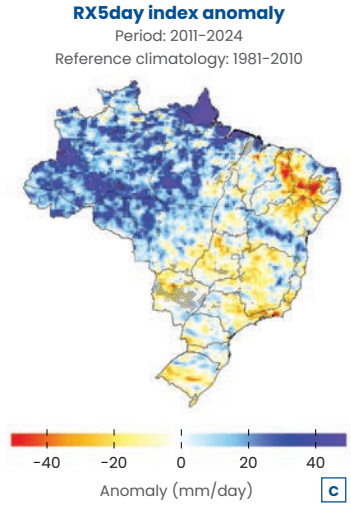
Figure 4.15 Maps showing anomalies in the CDD (a), RX1day (b), and RX5day (c) indices for the 2011-2024 period relative to the 1981-2010 reference climatology



Anomalies in the number of consecutive dry days (CDD) were most concentrated in the Central-West and Southeast regions, particularly in the states of Minas Gerais, Goiás, and Mato Grosso, as well as in the southern Amazon, where CDD values showed anomalies exceeding +20 days. This result suggests that the dry season may be getting longer in Brazil, especially in the central part of the country.



The highest concentrations of positive anomalies in the RX1day index, above +40 mm/day, are concentrated in the North, especially in the far north of the Amazon, and in parts of the Northeast, where more intense areas are observed.



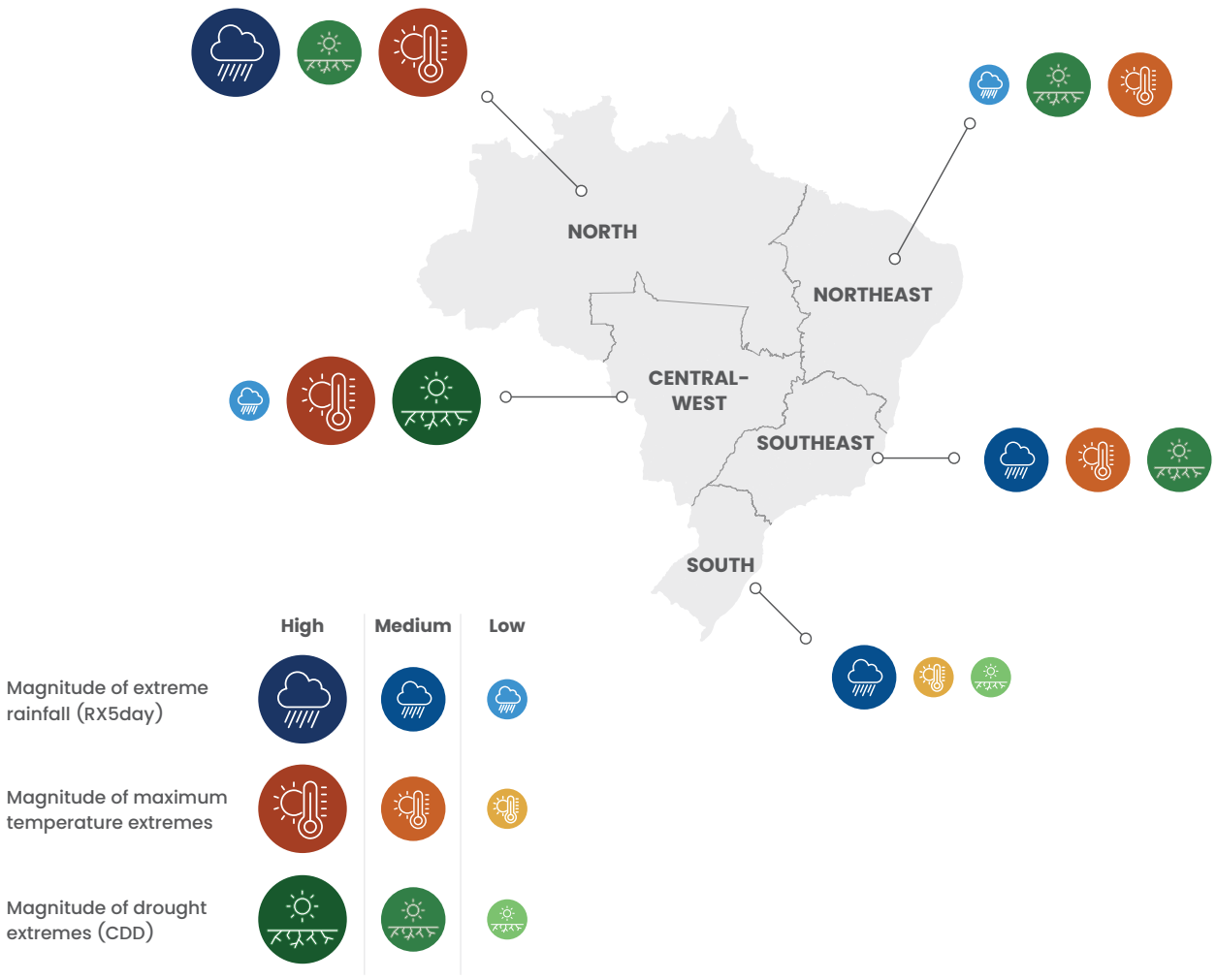
The largest positive RX5day anomalies, with values above +40 mm/day, were concentrated mainly in northern Brazil, particularly in the far north of the Amazon, and in areas of the Northeast, where well-defined areas of increased maximum five-day rainfall totals were observed.

Note: The hatched area indicates statistical significance ($p < 0.05$).

Source: Compiled by the authors based on CHIRPS data.

The trend results for the indices reflect large spatial variation across the country in the worsening of dry periods and rainfall extremes. Figure 4.16 shows a summary of the magnitude of the anomalies by region, showing that all regions exhibit changes in temperature and precipitation patterns, albeit to varying degrees.

Figure 4.16 Regional patterns of anomalies in climate extremes in Brazil



Source: Compiled by the authors.

Given the limitations related to data availability and coverage, statistical tests were conducted to assess the significance of the observed trends. Table 4.3 presents the results obtained, highlighting both positive and negative trends, as well as indicating those with statistical significance for the Brazilian biomes.

Table 4.3 Anomaly values and statistical significance of climate indicators for Brazilian biomes (1981-2024)

Variable	Unit	Amazon	Caatinga	Cerrado	Atlantic Forest	Pantanal	Pampa
PRCPTOT	mm/year	+0.28	-36.51	-84.87*	-67.47	-118.84*	-61.58
RX1day	mm/day	+7.83*	+1.11	+0.31	-0.41	-1.95	-1.63
RX5day	mm/day	+9.15	-0.81	-1.25	-2.32	-4.37	-5.04
CDD	days	+4.18*	+1.62	+7.24*	+1.50	-3.98*	+0.13
CWD	days	-4.31*	-1.79	-2.83*	-1.04	-3.02*	-0.49
WSDI	days	+5.87*	+4.66*	+7.60*	+4.21*	+9.14*	+1.74*
WSDI3d	days	+17.04*	+11.40*	+15.40*	+9.61*	+15.21*	+3.67*
Tmax	°C	+0.28*	+0.18*	+0.34*	+0.27*	+0.52*	+0.16*

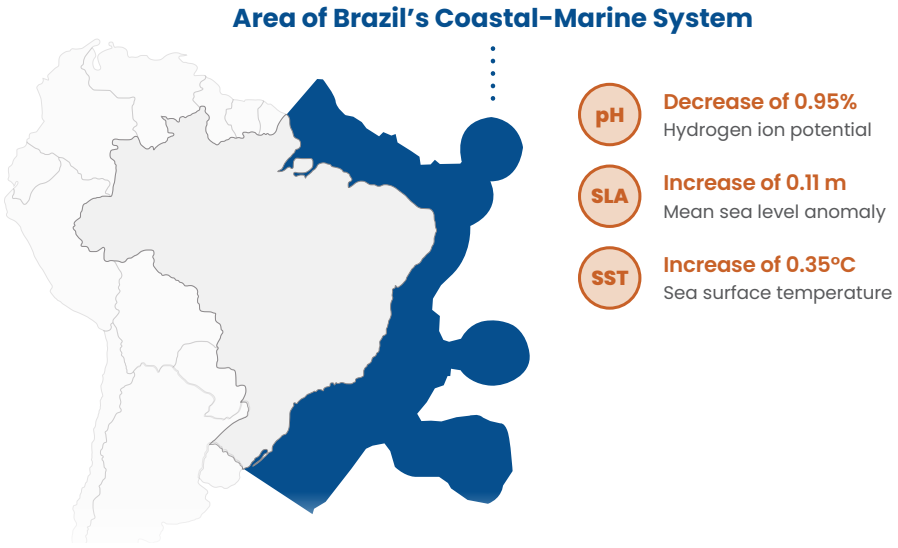
Notes: Values marked with an asterisk represent climate indices with statistically significant trends (p-value < 0.05).

Positive trend
Negative trend

Source: Compiled by the authors based on CHIRPS and ERA5 data.

Changes are also being observed in Brazil's Coastal-Marine System (Figure 4.17). Brazil is influenced by three major ocean currents: The Malvinas Current (MC), the Brazil Current (BC), and the North Brazil Current (NBC). The results show a downward trend in pH across all areas analyzed, which may indicate a regional process of ocean acidification. Between 1960 and 2020, the mean pH decreased from approximately 8.14 to 8.06 in the most recent decade, representing a 0.95% decrease relative to the beginning of the time series (Figure 4.18). However, it is important to note that this seemingly small decrease in the numerical pH value, which is measured on a base-10 logarithmic scale, corresponds to a 22% increase in the acidity of ocean waters. The acidification process poses a growing risk to Brazil's coastal and marine ecosystems, with potential impacts on biodiversity and ecosystem services, as will be detailed in section **4.2.2. Impacts, risks, and vulnerabilities for sectors and themes of strategic importance to Brazil**.

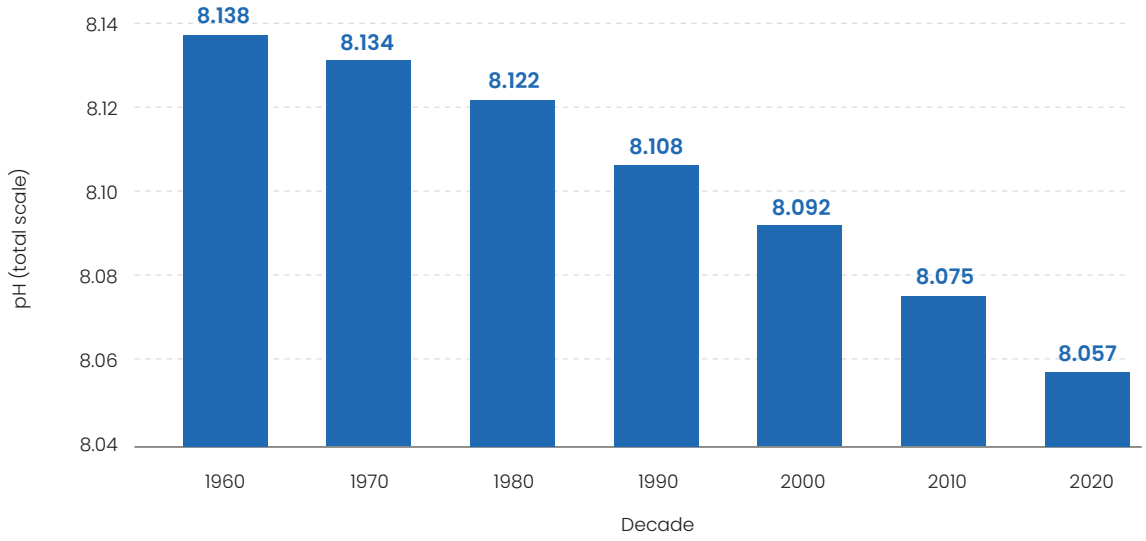
Figure 4.17 Trends in ocean variable changes in Brazil's Coastal-Marine System



Source: Compiled by the authors.

According to Cotovicz et al. (2022), acidification of the Atlantic Ocean adjacent to Brazil results from the combined effects of global and regional processes. The primary driver on a global scale is the increase in atmospheric CO_2 concentrations resulting from anthropogenic emissions, which intensifies CO_2 sequestration by the ocean and leads to a gradual decrease in the pH of seawater. At the regional and coastal scale, particularly along the Brazilian coast, acidification can be modulated by additional local processes, such as river discharge, organic matter inputs, biological respiration, degradation of coastal ecosystems, upwelling, and variations in ocean circulation. These factors can intensify or mitigate acidification in specific areas, characterizing the spatial and temporal variability of coastal acidification.

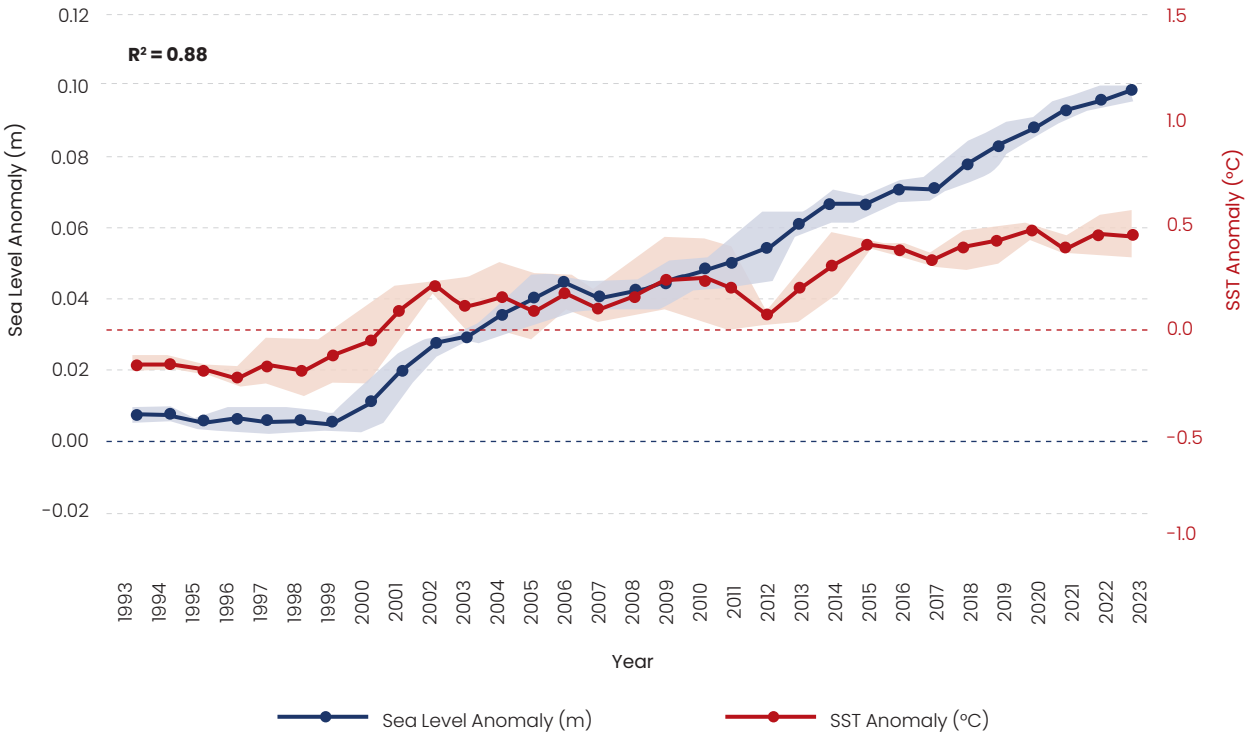
Figure 4.18 pH for Brazil's Coastal-Marine System area by decade starting in 1960



Source: Compiled by the authors based on Ocean *Carbon and Acidification Data System* (OCADS)

Another indicator of changes in coastal-marine dynamics is sea level. The mean sea level anomaly (SLA) in Brazil's Coastal-Marine System rose by 0.11 m between 1993 and 2023, while the sea surface temperature (SST) anomaly showed an average increase of 0.35°C. The strong statistical correlation between the two variables (R^2 = 0.88) may indicate that ocean surface warming contributed to sea level rise over the analyzed period (Figure 4.19).

Figure 4.19 Increase in mean sea level (SLA) and sea surface temperature (SST) for Brazil's Coastal-Marine System area for the 1993-2023 period



Source: Compiled by the authors based on NOAA SST V2 *High Resolution and COPERNICUS*.

According to studies on mean sea level rise, the main contributing factors are the dynamics associated with changes in mass resulting from the melting of Arctic and Antarctic glaciers, as well as changes in water density resulting from ocean warming (Cazenave et al., 2018; Chambers et al., 2017; Etcheverry et al., 2020). In this context, along the Brazilian coast, these global processes have taken place in different ways depending on regional characteristics of ocean circulation, water temperature, and the configuration of the continental shelf.

During 20 years of local monitoring of the Brazil Current (BC), more than 50% of the observed heat events occurred after 2019, indicating a potential regional warming trend. The detected heat anomalies affected deeper water layers, which may have significant consequences for biodiversity and ocean circulation (Ferreira et al., 2025).

Trends toward rising temperatures in inland waters have also been identified through studies in the Amazon. Satellite and remote sensing data for 24 lakes located in the central Amazon

were used to assess the period from 1990 to 2023. It was estimated that the mean surface water temperature in this region has increased at a rate of 0.6ºC per decade, reaching 0.8ºC per decade for some lakes. All water bodies analyzed showed positive statistical significance for temperature increase, with more frequent anomalies in the most recent decade (2013-2023) (Fleischmann et al., 2025).

4.2.1.3. Future climate change trends

The best tool for projecting future climate is climate models, which consist of computer codes that represent numerical approximations of mathematical equations based on the physical laws governing atmospheric motion and interactions with the surface, the oceans, and the components of the climate system. In the global context, our understanding of climate change has been shaped by internationally coordinated initiatives, notably the Coupled Model Intercomparison Project (CMIP), which brings together the efforts of various research centers to develop and compare climate models. In its most recent phase, CMIP6 provides an advanced set of simulations that incorporate improvements in the representation of the climate system's physical, chemical, and biogeochemical processes (Eyring *et al.*, 2016). These advances have enabled a better representation of climate processes and have increased the reliability of analyses of climate variability and changes in climate patterns at regional and global scales.

To obtain future projections, climate models are forced with greenhouse gas emission scenarios known as Shared Socioeconomic Pathways (SSPs), which represent different socioeconomic development pathways and their respective emission levels (Meinshausen et al., 2020). These scenarios range from low-emission pathways, associated with strict mitigation policies, to high-emission scenarios, characterized by rapid global economic growth, but with a high dependence on fossil fuels. These scenarios take into account projections of population, socioeconomic development, gross domestic product, energy uses and sources, among many other parameters; in other words, these scenarios attempt to depict the various possibilities for humanity's future development based on a range of indicators.

CMIP6 future projections indicate that global warming will continue throughout the 21st century, with its magnitude directly dependent on the emissions scenario adopted (IPCC, 2021). At the regional scale, including Brazil, a widespread increase in mean temperature, changes in precipitation patterns, and a greater frequency and intensity of climate extremes are expected.

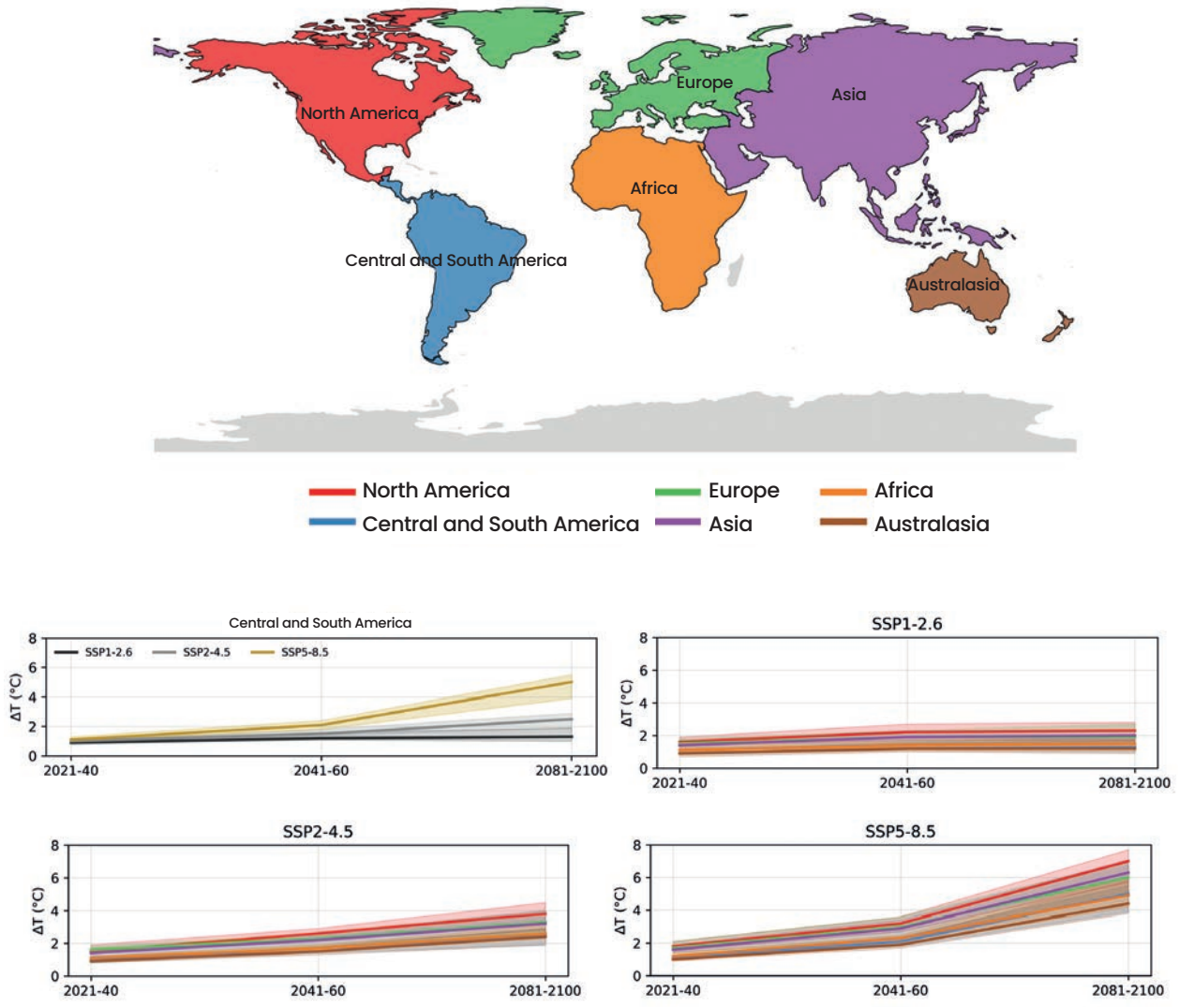
Figure 4.20 shows projections of the increase in global mean temperature throughout the 21st century for different regions of the world, according to CMIP6. The information was obtained directly from the IPCC Interactive Atlas, based on the time horizons defined by the IPCC itself: short term (2021-2040), medium term (2041-2060), and long term (2081-2100). These periods make it possible to assess the progression of global warming across different time scales, taking into account various greenhouse gas emission scenarios.

The three greenhouse gas emission scenarios (SSP1-2.6, SSP2-4.5, and SSP5-8.5) indicate progressive warming across all regions and periods analyzed, with the magnitude directly dependent on the scenario; that is, in the low-emissions scenario, warming remains more limited, while in the intermediate- and high-emissions scenarios, it intensifies significantly, particularly toward the end of the century.

Regional variability is also noteworthy, with greater warming in continental areas of the Northern Hemisphere, such as North America and Europe. On the other hand, the region of Central and South

America, highlighted in Figure 4.20, shows warming that is below the average for extratropical regions of the Northern Hemisphere – though still significant, reaching approximately 5°C by the end of the century in the SSP5-8.5 scenario.

Figure 4.20 Projections of increase in global mean temperature (ΔT, °C) for different regions of the world (North America, Central and South America, Europe, Africa, Asia, and Australasia), considering three CMIP6 greenhouse gas emission scenarios (SSP1-2.6, SSP2-4.5, and SSP5-8.5), for the 2021-2040, 2041-2060, and 2081-2100 periods



Note: The SSP1-2.6, SSP2-4.5, and SSP5-8.5 panels present the regional projections for each emission scenario, while the upper-left panel highlights the evolution of temperature in the Central and South America region.

Source: Adapted from results reported in the IPCC Atlas (IPCC 2022).

In this context, the analysis of climate indicators is essential for assessing changes not only in mean values but also in temperature and precipitation extremes. Indices that quantify the annual number of hot days, nights with high temperatures (also called tropical nights), heavy precipitation events, and consecutive dry periods allow for a more detailed assessment of climate risks (Zhang *et al.*, 2011). These indicators are widely used in impact, adaptation, and planning studies, providing inputs for the formulation of public policies and resilience strategies in the face of climate change.

The analyses are presented according to Global Warming Levels (GWLs) of 1.5°C, 2°C, and 3°C, associated with the SSP1-2.6, SSP2-4.5, and SSP5-8.5 emission scenarios, enabling a consistent assessment of climate impacts under different warming pathways.

Box 4.1 provides a brief description of the scenarios used. It also shows global warming levels of 1.5°C, 2°C, and 3°C relative to the pre-industrial period, highlighting that different scenarios may reach the same warming levels in different periods of the 21st century.

BOX 4.1 SSP SCENARIOS AND GLOBAL WARMING LEVELS (GWLS)

The SSP (Shared Socioeconomic Pathways) scenarios represent different future pathways of socioeconomic development and greenhouse gas emissions used in CMIP6/IPCC experiments. Each scenario combines assumptions about population growth, economic development, land use, technology, and climate policies, resulting in different levels of global warming over the twenty-first century.

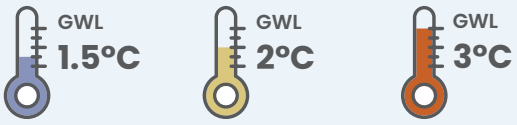
1. SSP SCENARIOS USED IN THIS STUDY

Three SSP scenarios were used, representing different levels of greenhouse gas emissions.

SCENARIO	TYPE OF EMISSIONS	MAIN CHARACTERISTICS
SSP 1-2.6	Low emissions	Low-emission scenario associated with stronger mitigation policies, focusing on sustainability and inclusion.
SSP 2-4.5	Intermediate emissions	Intermediate scenario characterized by moderate development and emissions, with climate policies evolving gradually.
SSP 5-8.5	High emissions	High-emission scenario associated with high dependence on fossil fuels, rapid economic growth, and less emphasis on climate policies.

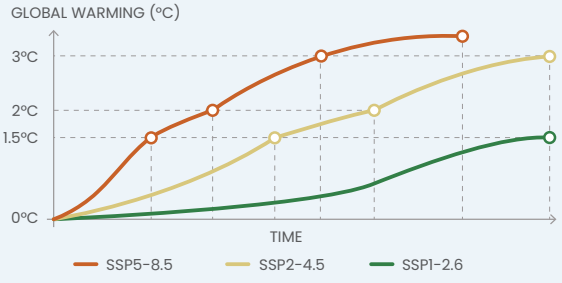
2. GLOBAL WARMING LEVELS (GWLs)

The analyses were organized according to global warming levels (GWLs) of 1.5°C, 2°C, and 3°C relative to the pre-industrial period.



GWLs correspond to the point at which global mean temperature reaches a given warming threshold, regardless of the specific year or emission scenario.

GWLs are reached at different times in each scenario.
Illustrative example of the evolution of global mean temperature relative to the pre-industrial period.



Each point indicates the time when the scenario reaches the respective GWL.

The results are presented in the form of spatial maps, highlighting the geographic distribution of projected changes for the selected temperature and precipitation indicators, including air temperature at 2 meters above ground level, precipitation, sea surface temperature, and mean sea level, based on the CMIP6 multi-model *ensemble*. These indicators make it possible to assess not only changes in mean climate values, but also changes in the intensity and duration of extreme events, providing an integrated view of the potential impacts of climate change. In addition, the results are summarized for Brazil's different regions and biomes, as shown in Figure 1.1, allowing for a comparative analysis and the identification of trends across different levels of warming. This integrated approach provides a comprehensive understanding of the projected changes, both spatially and regionally.

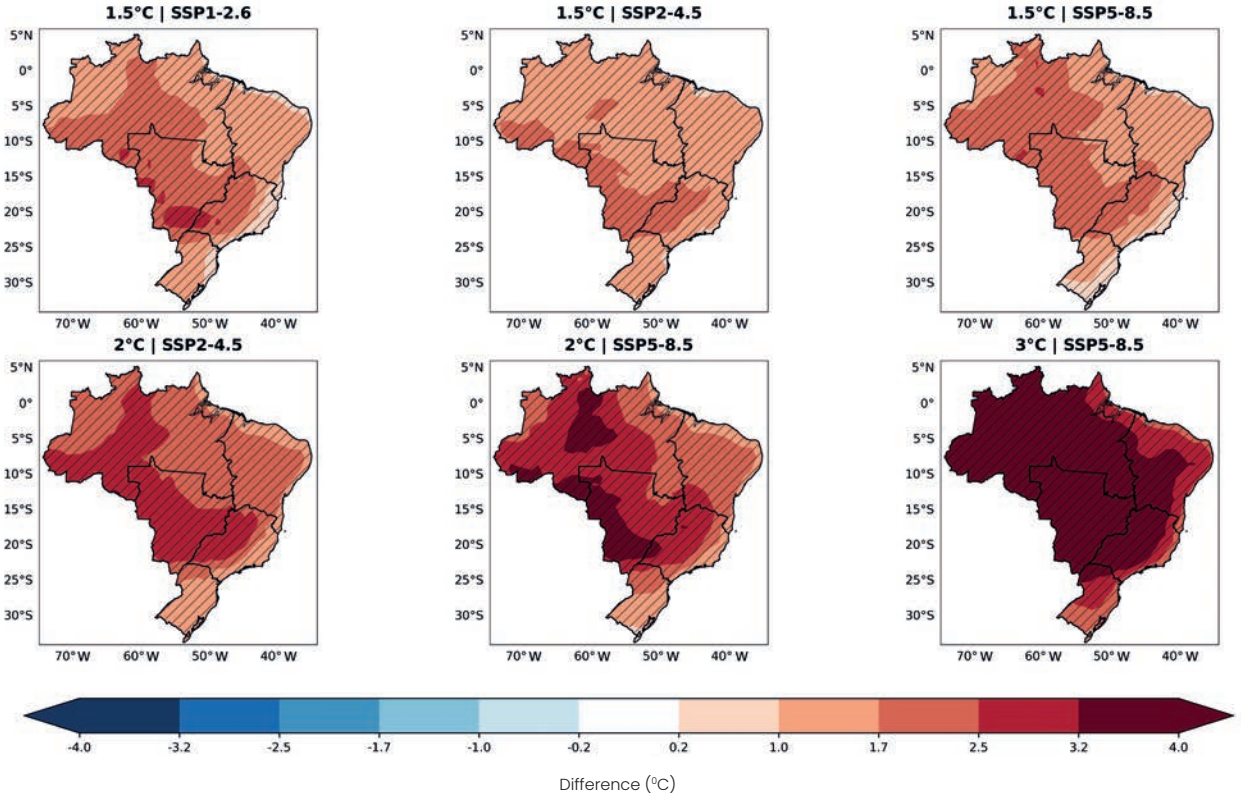
Different levels of global warming (1.5ºC, 2ºC, and 3ºC) and emission scenarios (SSP1-2.6, SSP2-4.5, and SSP5-8.5) were used, enabling a comparative analysis of different climate pathways. The combination of atmospheric and oceanic variables makes it possible to account for both continental and marine processes, thereby broadening our understanding of the projected changes in the climate of Brazil and its adjacent regions.

With regard to the indicators of temperature extremes, Figure 4.21 and Figure 4.22 show the highest annual maximum temperature (TXx) and the lowest annual minimum temperature (TNn), respectively. The results indicate a widespread increase in temperature extremes across Brazil, consistent across different scenarios and global warming levels. For both maximum and minimum temperatures, a pattern of increasing warming across the country is observed as global warming rises from 1.5ºC to 3ºC, with higher values in the high-emissions scenario (SSP5-8.5).

For the annual maximum temperature (TXx), warming is progressive and spatially heterogeneous. At a global warming level of 1.5ºC, temperature increases in Brazil are moderate (generally between 1ºC and 2ºC), with higher increases in the Central-West and North regions. It should be noted, however, that in some areas, the SSP2-4.5 scenario shows less intense warming signals than the SSP1-2.6 scenario. This behavior is associated with the fact that the 1.5ºC threshold is reached at different times in each emissions pathway. In SSP1-2.6, which is characterized by lower emissions and stabilization of warming over the course of the century, the 1.5ºC threshold is reached later than in SSP2-4.5. Thus, although both represent the same mean global warming, differences in the temporal evolution of the climate system and in regional responses may result in distinct warming patterns over Brazil.

As global warming reaches 2ºC and 3ºC, a significant intensification is observed in Brazil, with values exceeding 2.5ºC across large areas, particularly in the Amazon and inland Brazil. In the SSP5-8.5 scenario, this pattern is even more pronounced, with widespread extreme warming and values predominantly above 4ºC, indicating greater frequency and intensity of extreme heat events.

Figure 4.21 Projected changes in the highest maximum temperature (TXx) in Brazil, relative to the historical period (1983-2014), for the SSP1-2.6 (GWL 1.5°C), SSP2-4.5 (GWLs 1.5°C and 2°C), and SSP5-8.5 (GWLs 1.5°C, 2°C, and 3°C) scenarios, based on the CMIP6 multi-model *ensemble*



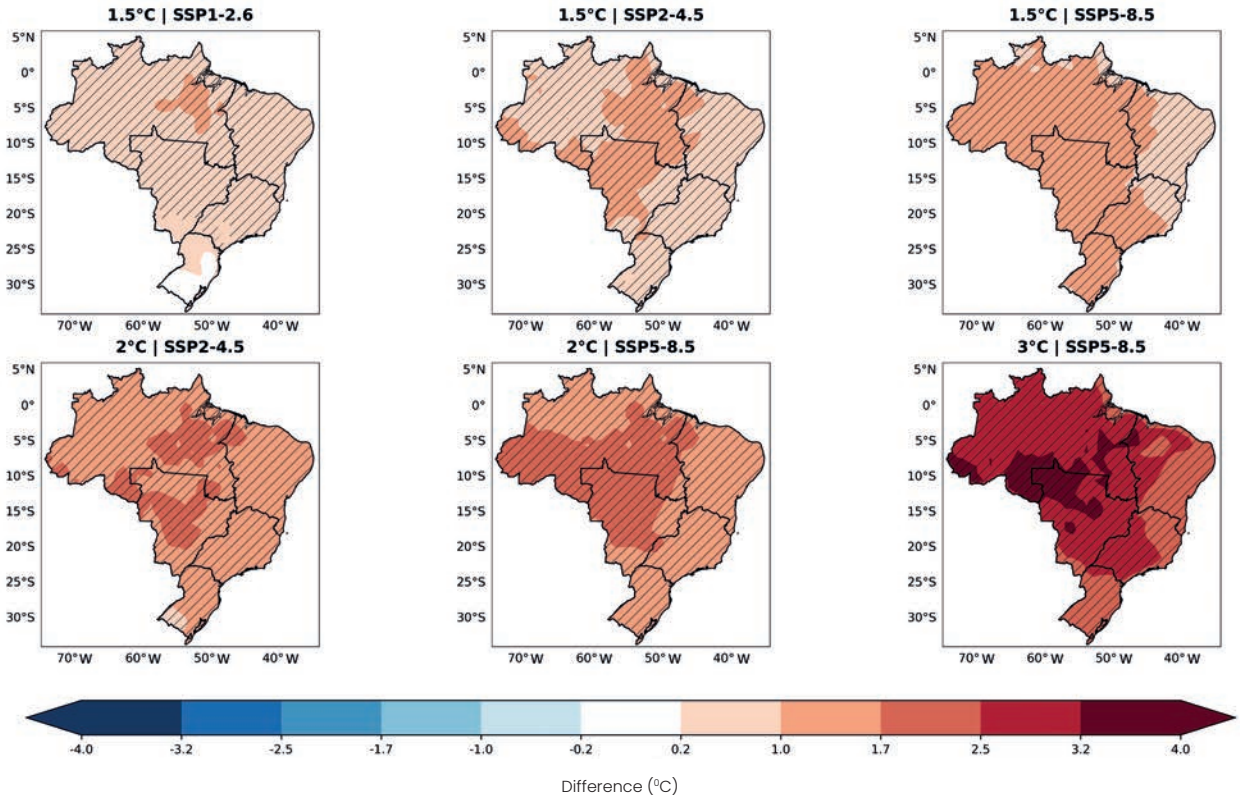
Note: The colors indicate the magnitude of the difference in °C, while the hatched areas represent regions where the changes are statistically significant at the 5% level (Welch's t-test, $p < 0.05$). The values are presented only for Brazil's land areas, and projections for the adjacent ocean areas are not shown.

Source: Compiled by the authors based on CMIP6 models.

Projections for the lowest annual minimum temperature (TNn) indicate a more moderate and heterogeneous pattern compared with the maximum temperature (Figure 4.22). For global warming levels of 1.5°C, a relatively uniform increase is observed across much of Brazil. In general, TNn exhibits lower warming intensity and greater spatial variability, indicating that the coldest nights do not respond uniformly to global temperature increase.

Overall, the results indicate that temperature extremes in Brazil tend to intensify with increasing global warming, although the response of minimum temperature is more heterogeneous and, in some cases, less pronounced than that of maximum temperature.

Figure 4.22 Projected changes in the lowest minimum temperature (TNn) in Brazil, relative to the historical period (1983-2014), for the SSP1-2.6 (GWL 1.5°C), SSP2-4.5 (GWLs 1.5°C and 2°C), and SSP5-8.5 (GWLs 1.5°C, 2°C, and 3°C) scenarios, based on the CMIP6 multi-model *ensemble*



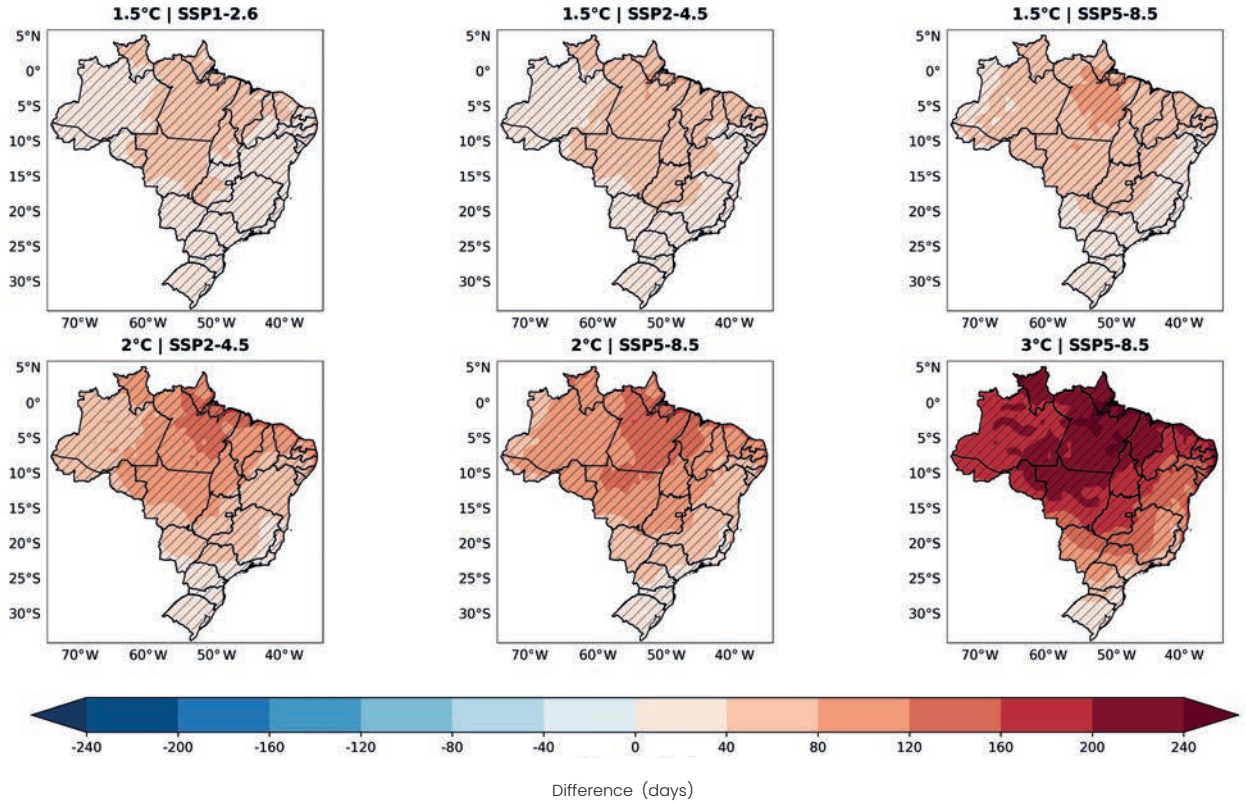
Note: The colors indicate the magnitude of the difference in °C, while the hatched areas represent regions where the changes are statistically significant at the 5% level (Welch's t-test, $p < 0.05$). The values are presented only for Brazil's land areas, and projections for the adjacent ocean areas are not shown.

Source: Compiled by the authors based on CMIP6 models.

In addition to the results for maximum and minimum temperature extremes, Figure 4.23 shows the projected changes in the WSDI (Warm Spell Duration Index), which is used to assess the persistence of heat events. This indicator corresponds to the number of days belonging to sequences of at least six consecutive days with maximum temperature above the 90th percentile of the reference climatology. Thus, positive values indicate an increase in the duration of persistent warm spells, suggesting a greater frequency and longer duration of heat waves in the country.

In the scenarios associated with the 1.5°C global warming level, the increases are still moderate and spatially heterogeneous, concentrated mainly in the Amazon and the Central-West region. At the 2°C global warming level, areas with increases exceeding 40 days are projected to expand, particularly in the North and Central-West regions and in parts of the Northeast. At the 3°C level, in the SSP5-8.5 scenario, the increase in the WSDI becomes substantially more intense and widespread, affecting a large part of the country. In the Amazon and the Central-West, the increases exceed 160 to 200 days, indicating a significant increase in the duration of exceptionally warm spells.

Figure 4.23 Projected changes in the Warm Spell Duration Index (WSDI) in Brazil, relative to the historical period (1983-2014), for the SSP1-2.6 (GWL 1.5ºC), SSP2-4.5 (GWLs 1.5ºC and 2ºC), and SSP5-8.5 (GWLs 1.5ºC, 2ºC, and 3ºC), based on the CMIP6 multi-model *ensemble*



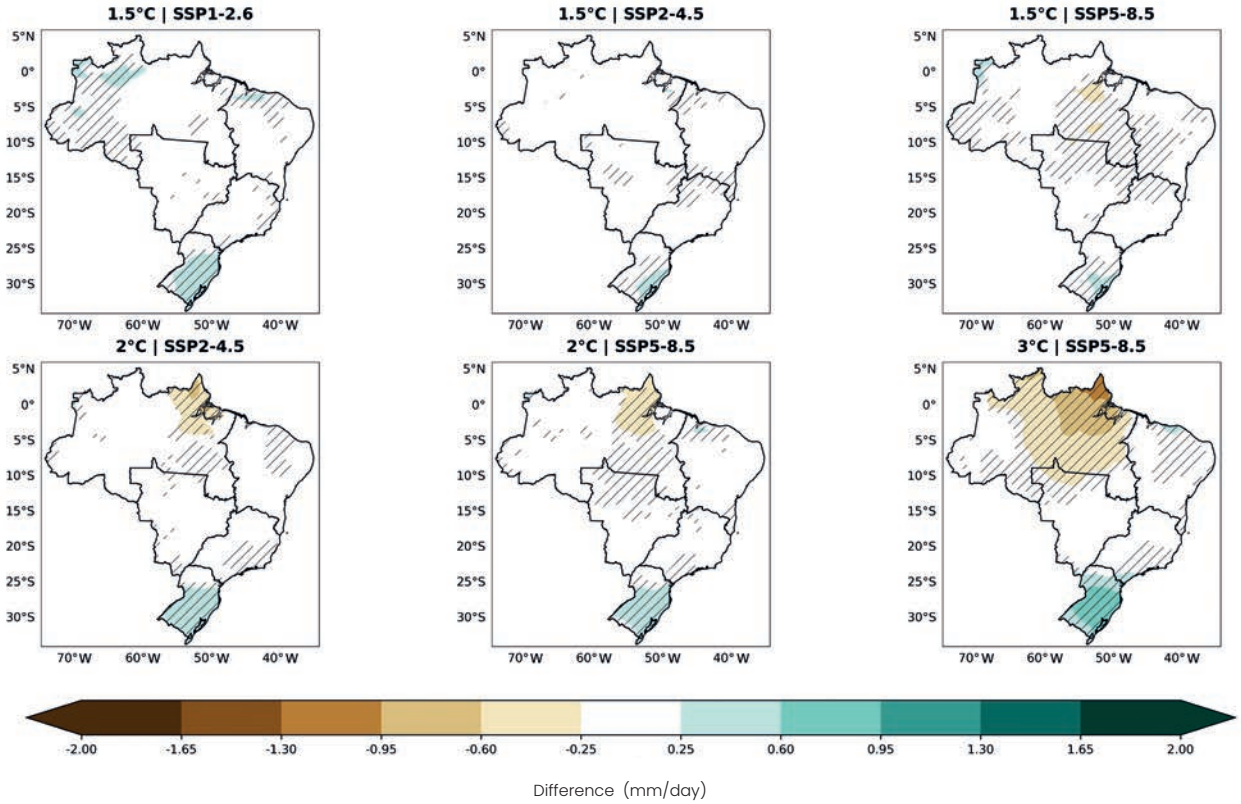
Note: The colors indicate the difference in the number of days, while the hatched areas represent statistically significant changes according to Welch's t-test ($p < 0.05$). The values are presented only for Brazil's land areas, and projections for the adjacent ocean areas are not shown.

Source: Compiled by the authors based on CMIP6 models.

With regard to precipitation indicators, the projected changes in annual mean precipitation, Consecutive Dry Days (CDD), annual maximum daily precipitation (Rx1day), and maximum precipitation accumulated over five consecutive days (Rx5day) are presented, based on the CMIP6 multi-model *ensemble.* These indicators make it possible to assess both the intensification of dry periods and the increase in heavy rainfall events, which are key factors for characterizing climate risks.

Projections of changes in mean annual precipitation (Figure 4.24) indicate a heterogeneous spatial pattern in Brazil. In general, there is a predominance of areas without statistically significant changes, especially in scenarios with lower global warming (1.5ºC), reflecting greater uncertainty associated with the response of mean precipitation to climate change. However, from a warming level of 2ºC, a dipole pattern emerges more clearly, characterized by reduced precipitation in the North region (especially in northern Amazon) and increased precipitation in Southern Brazil. This pattern intensifies at the 3ºC level in the SSP5-8.5 scenario.

Figure 4.24 Projected changes in mean annual precipitation in Brazil, relative to the historical period (1983-2014), for the SSP1-2.6 (GWL 1.5ºC), SSP2-4.5 (GWLs 1.5ºC and 2ºC), and SSP5-8.5 (GWLs 1.5ºC, 2ºC, and 3ºC), based on the CMIP6 multi-model *ensemble*

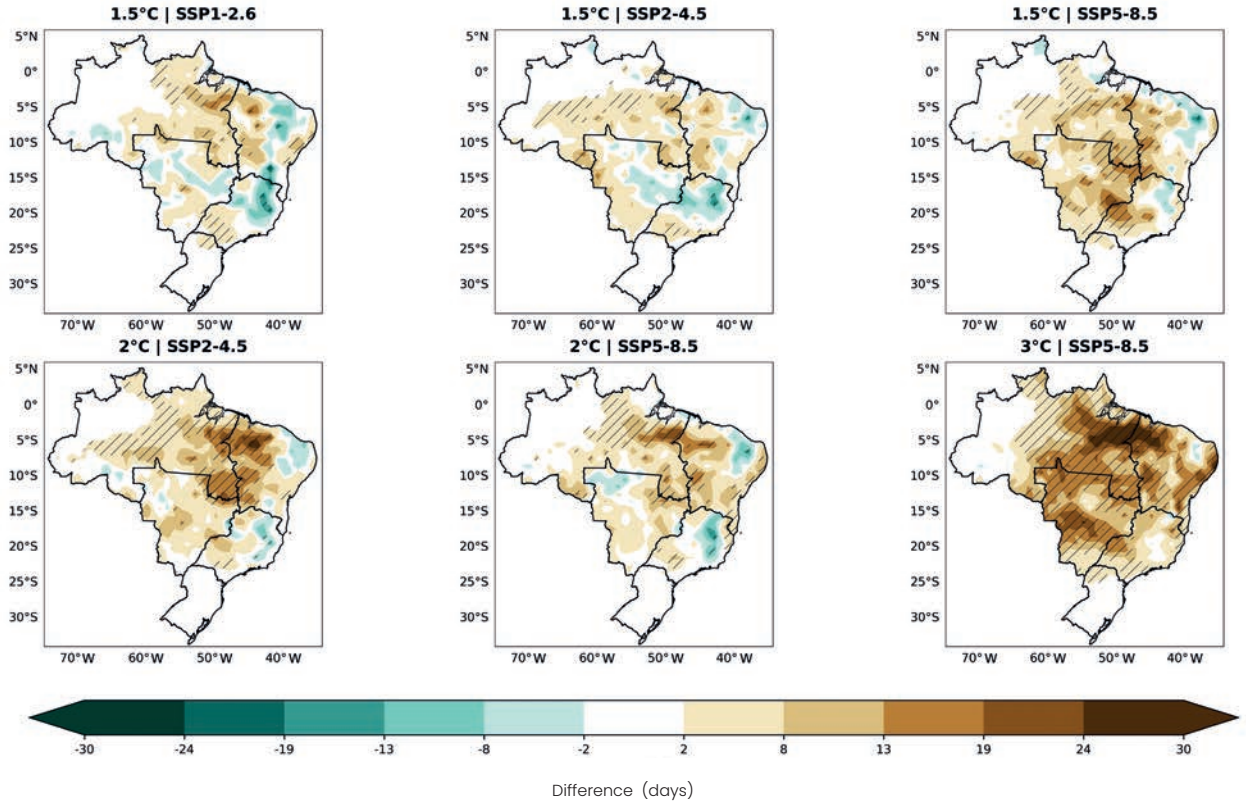


Note: The colors represent the mean difference in precipitation (mm/day), while the hatched areas indicate changes that are statistically significant at the 5% level (Welch's t-test, $p < 0.05$). The values are presented only for Brazil's land areas, and projections for the adjacent ocean areas are not shown.

Source: Compiled by the authors based on CMIP6 models.

CDD projections (Figure 4.25) indicate an increase in the duration of dry periods across much of Brazil, intensifying as global warming levels increase. In the SSP2-4.5 scenario, the increases are moderate and concentrated mainly in the North and Central-West regions and in part of the Northeast region, becoming more evident starting at the 2ºC level. It is noted that, for this level of global warming (2ºC) in the SSP5-8.5 scenario, the patterns are more fragmented and show less spatial consistency compared to SSP2-4.5. At the 3ºC level, a more robust signal of an increase in CDD emerges, with a more evident intensification in the Amazon and Central Brazil. This behavior suggests a nonlinear response of the indicator, possibly associated with more complex changes in rainfall dynamics in high-emission scenarios.

Figure 4.25 Projected changes in the maximum number of consecutive dry days (CDD) in Brazil, relative to the historical period (1983-2014), for the SSP1-2.6 (GWL 1.5ºC), SSP2-4.5 (GWLs 1.5ºC and 2ºC), and SSP5-8.5 (GWLs 1.5ºC, 2ºC, and 3ºC), based on the CMIP6 multi-model *ensemble*

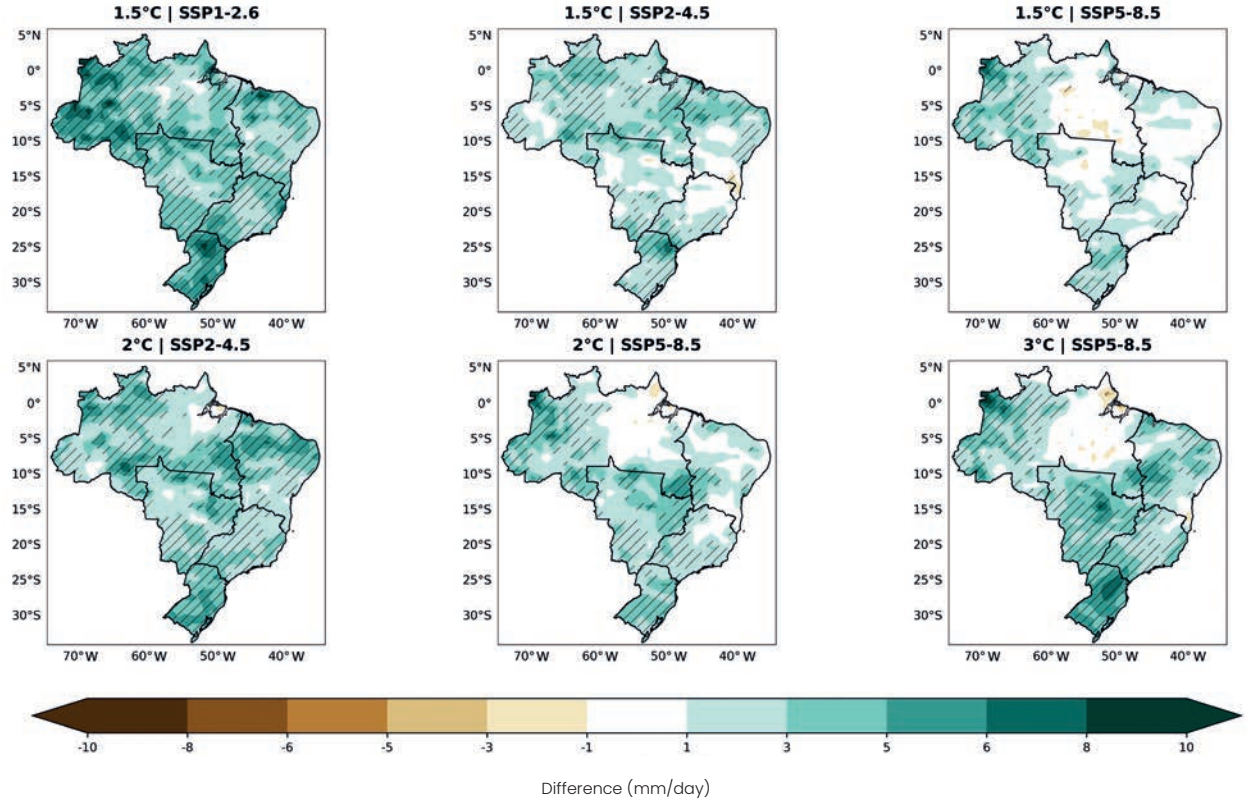


Note: The colors indicate the difference in the number of days, while the hatched areas represent regions with changes that are statistically significant at the 5% level (Welch's t-test, $p < 0.05$). The values are presented only for Brazil's land areas, and projections for the adjacent ocean areas are not shown.

Source: Compiled by the authors based on CMIP6 models.

The Rx1day projections (Figure 4.26) indicate a predominant trend toward an increase in the intensity of extreme daily rainfall across much of Brazil, although with significant variations among scenarios and global warming levels. In the SSP2-4.5 scenario, a progressive increase in values is observed as warming intensifies, with significant increases across virtually the entire country. In the SSP5-8.5 scenario, increases occur throughout virtually all of Brazil, with the exception of the eastern part of the North region; however, there is no statistically significant change. In all scenarios, the areas showing increases in the South and in parts of the Central-West and North exhibit statistically significant changes.

Figure 4.26 Projected changes in annual maximum daily precipitation (Rx1day) in Brazil, relative to the historical period (1983-2014), for the SSP1-2.6 (GWL 1.5°C), SSP2-4.5 (GWLs 1.5°C and 2°C), and SSP5-8.5 (GWLs 1.5°C, 2°C, and 3°C), based on the CMIP6 multi-model *ensemble*

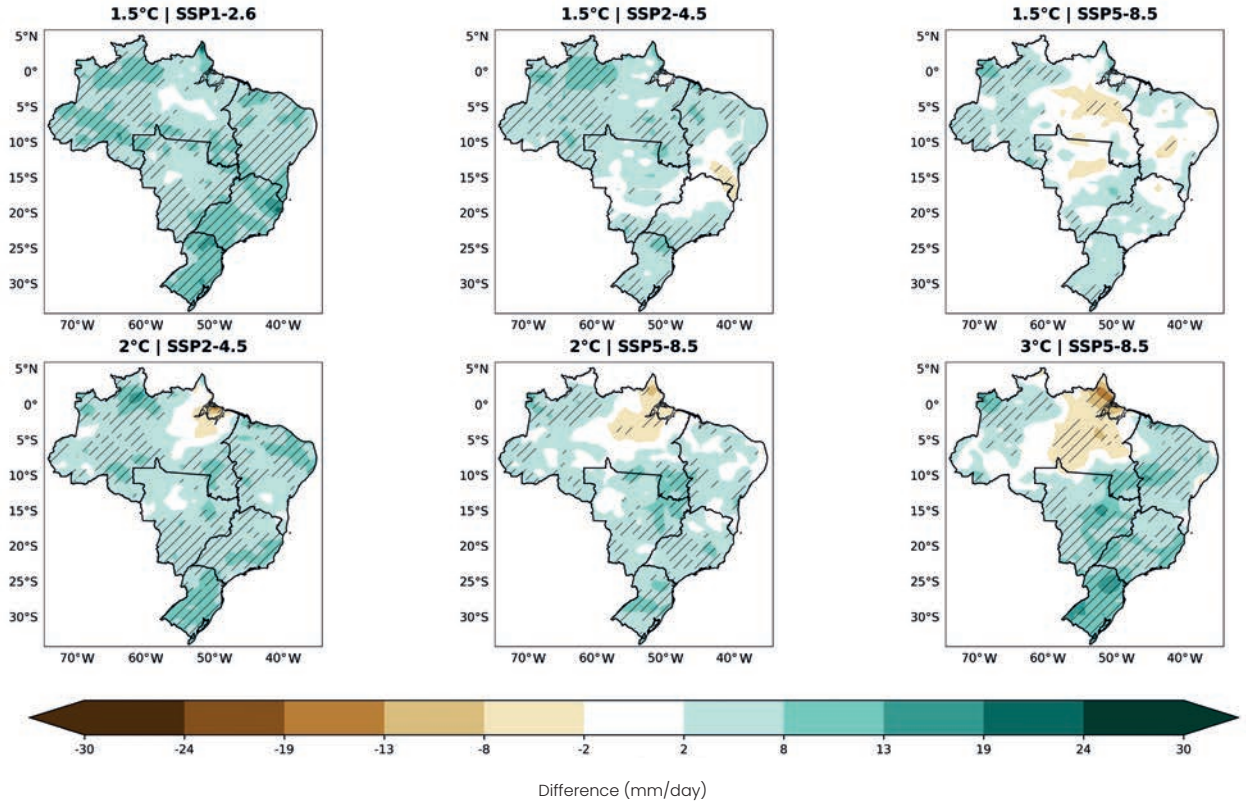


Note: The colors indicate the difference in mm, while the hatched areas represent regions with changes that are statistically significant at the 5% level (Welch's t-test, $p < 0.05$). The values are presented only for Brazil's land areas, and projections for the adjacent ocean areas are not shown.

Source: Compiled by the authors based on CMIP6 models.

The Rx5day projections (Figure 4.27) indicate a general trend toward an increase in the intensity of short-duration accumulated precipitation events, although with spatial variability and differences between scenarios. In the SSP2-4.5 scenario, a progressive increase is observed as global warming intensifies. In the SSP5-8.5 scenario, although the patterns are more heterogeneous, an increase is observed mainly in the South, Southeast, and Central-West regions and in parts of the North; however, in the North, the changes are minor or even involve localized decreases.

Figure 4.27 Projected changes in maximum accumulated precipitation over five consecutive days (Rx5day) in Brazil, relative to the historical period (1983-2014), for the SSP1-2.6 (GWL 1.5°C), SSP2-4.5 (GWLs 1.5°C and 2°C), and SSP5-8.5 (GWLs 1.5°C, 2°C, and 3°C), based on the CMIP6 multi-model *ensemble*



Note: The colors indicate the difference in mm, while the hatched areas represent regions with changes that are statistically significant at the 5% level (Welch's t-test, $p < 0.05$). The values are presented only for Brazil's land areas, and projections for the adjacent ocean areas are not shown.

Source: Compiled by the authors based on CMIP6 models.

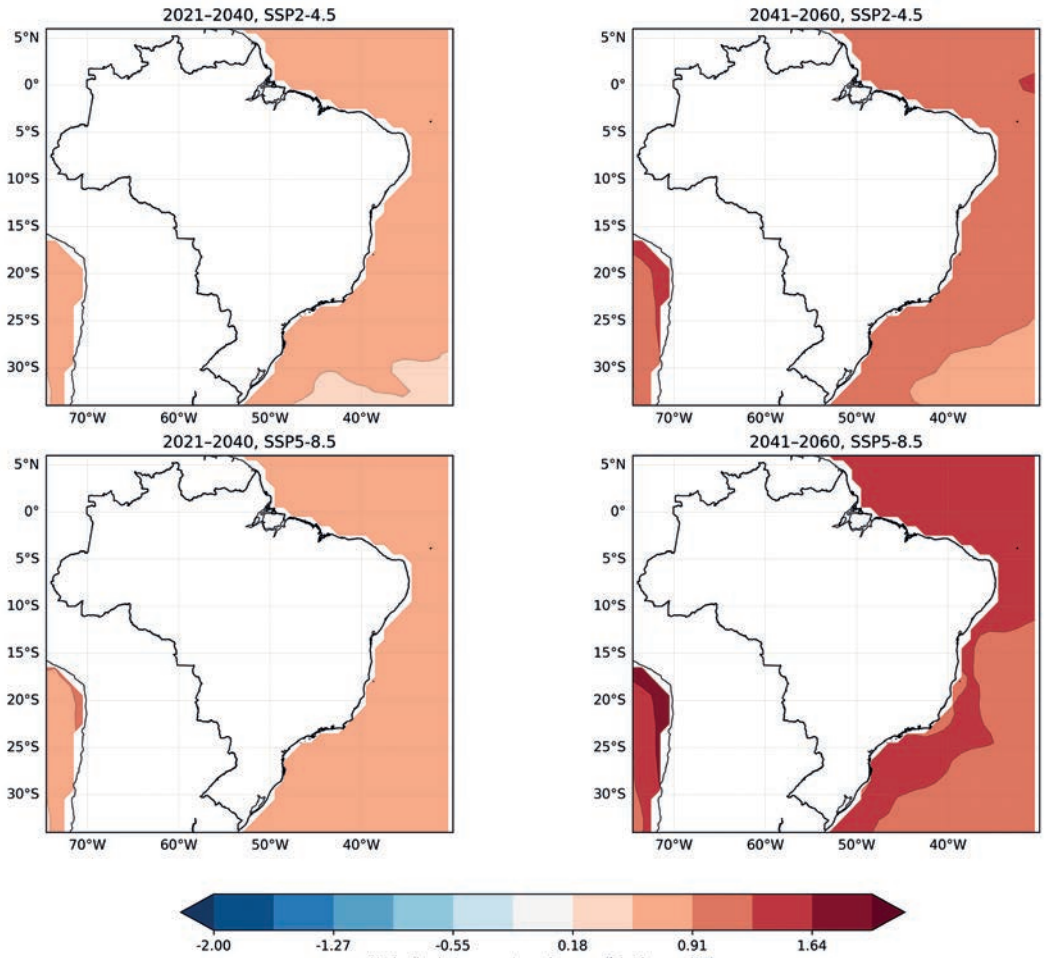
In general, the precipitation indicators analyzed show an increase in the variability of Brazil's rainfall regime, characterized by the simultaneous intensification of both dry and wet extremes. In addition, the analysis of mean precipitation shows a dipole pattern, starting at the 2°C global warming level, with a decrease in precipitation in the North and an increase in the South of Brazil.

The results also indicate a trend toward an increase in the duration of dry spells (CDD), especially in the North and Central-West regions, particularly at higher global warming levels. In turn, the indicators of extreme precipitation (Rx1day and Rx5day) point to an increase in the intensity of rainfall. The differences between scenarios indicate that, although SSP2-4.5 shows more consistent patterns of increased precipitation, SSP5-8.5 tends to exhibit greater spatial variability at intermediate global warming levels, with more pronounced signals only at the highest levels. Taken together, these results suggest a higher incidence of extreme events, prolonged droughts and heavy, extreme rainfall.

The results of the projected changes in sea surface temperature (SST, Figure 4.28) and mean sea level (Figure 4.29) along the Brazilian coast for the periods 2021-2040 and 2041-2060, in the SSP2-4.5 and SSP5-8.5 emission scenarios, relative to the historical period (1983-2014) and based on the CMIP6 multi-model *ensemble*, show that the increase in SST is more pronounced

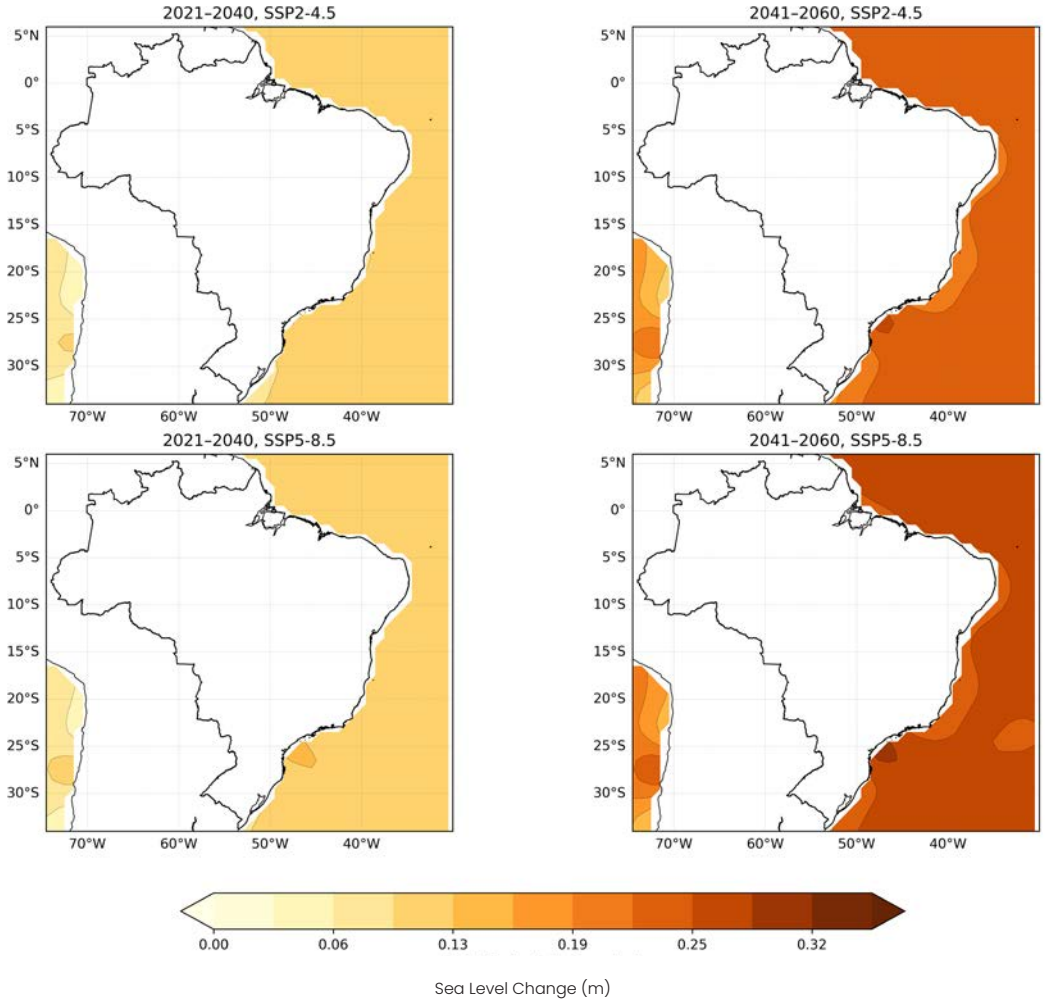
in the second period, particularly for the SSP5-8.5 scenario. Similarly, sea level rise is projected to be between 20 and 30 cm for this period, emphasizing that the greatest changes occur in the scenario with the highest GHG emissions.

Figure 4.28 Projected changes in sea surface temperature (SST, °C) around the Brazilian coast, relative to the historical period (1983-2014), for the 2021-2040 and 2041-2060 periods, under the SSP2-4.5 and SSP5-8.5 emission scenarios, based on the CMIP6 multi-model *ensemble*



Source: Compiled by the authors based on CMIP6 models.

Figure 4.29 Projected changes in mean sea level (m) along the Brazilian coast, relative to the historical period (1983-2014), for the periods 2021-2040 and 2041-2060, in the SSP2-4.5 and SSP5-8.5 emission scenarios, based on the CMIP6 multi-model *ensemble*



Source: Compiled by the authors based on CMIP6 models.

In summary, the projections presented in this section confirm that ongoing global warming is not limited to increases in mean temperatures, but triggers a series of interconnected changes throughout the climate system. The intensification of extreme events, the intensification of the hydrological cycle, sea level rise, and changes in the oceans demonstrate the extent and severity of the projected changes. These findings underscore the urgency of rapid, deep, and sustained mitigation and adaptation actions, as each additional increase in global warming increases multiple and simultaneous risks, with direct impacts on ecosystems, societies, and economies on a global scale.

Results by region in Brazil

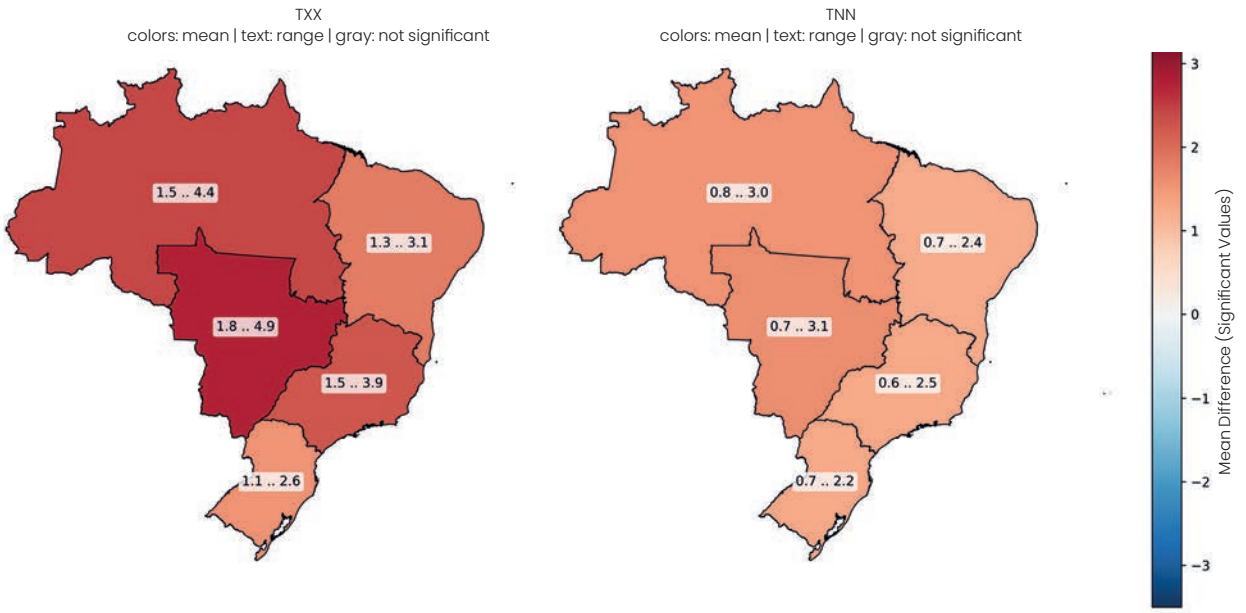
This section presents the results of the aggregated climate indicators for Brazil's five major regions (North, Northeast, Central-West, Southeast, and South), based on the CMIP6 multi-model *ensemble*. To obtain these results, all greenhouse gas emission scenarios were considered, but only the values that showed greater statistical significance were included. Regional analysis

allows for a more integrated overview of projected changes, facilitating comparisons between areas with distinct climate characteristics and highlighting relevant spatial patterns.

The results are presented through thematic maps, in which the colors represent the mean change in the indicators, while the numerical values indicate the range of projections considered statistically significant. Regions without a significant signal are highlighted separately, allowing for a more robust interpretation of the projected changes.

A combined analysis of the TXx and TNn indicators (Figure 4.30) shows a pattern of increasing temperature extremes across all regions of Brazil, with a statistically significant signal. In the case of annual maximum temperature (TXx), the largest increases are observed in the Central-West, Southeast, and North regions, with ranges reaching values above 5ºC, indicating an intensification of extreme heat events. The Northeast and South regions also show warming, although with slightly lower magnitudes. For annual minimum temperature (TNn), a widespread increase is observed across all regions, although with a lower magnitude compared with TXx. The largest increases are once again in the Central-West and in the North, while the South shows the smallest increases.

Figure 4.30 Projected changes in temperature extremes by region in Brazil, considering the maximum (TXx) and minimum (TNn) temperatures relative to the historical period (1983-2014), based on the CMIP6 multi-model *ensemble*



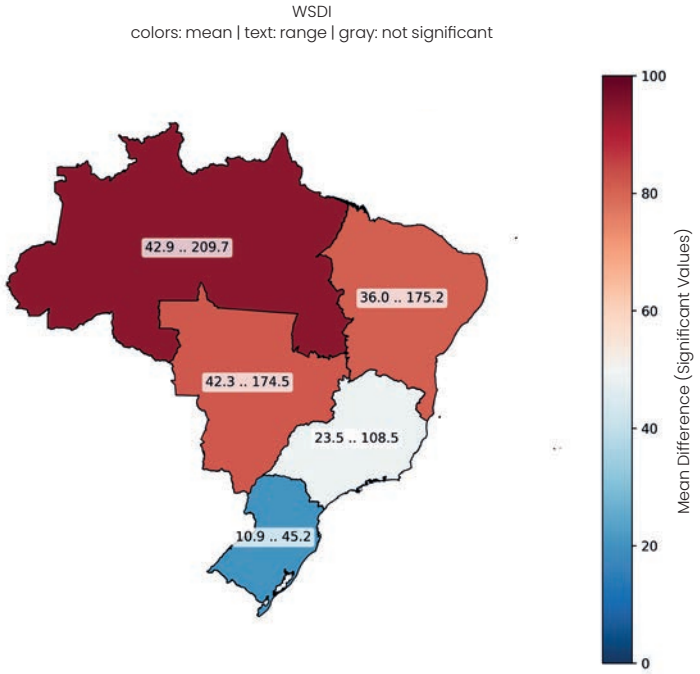
Note: The colors represent the mean difference in values that are statistically significant in each region, while the labels indicate the range of projections that are significant at the 5% level (Welch's t-test, $p < 0.05$).

Source: Compiled by the authors based on CMIP6 models.

Figure 4.31 shows an increase in the WSDI across all regions of Brazil, indicating longer durations of consecutive warm spells. The largest increases are observed in the North and Central-West regions, with ranges that can exceed 170 and 148 days, respectively. The Northeast also shows a significant increase, with maximum values exceeding 130 days. In the Southeast and South regions, the increases are more moderate, though still relevant. The Southeast shows ranges of

up to approximately 82 days, while the South has the smallest increases, with maximum values close to 33 days. Overall, the results indicate that heat waves are becoming more persistent in the country, with a more intense signal in tropical and continental regions.

Figure 4.31 Projected changes in the Warm Spell Duration Index (WSDI) relative to the historical period (1983-2014), based on the CMIP6 multi-model *ensemble*

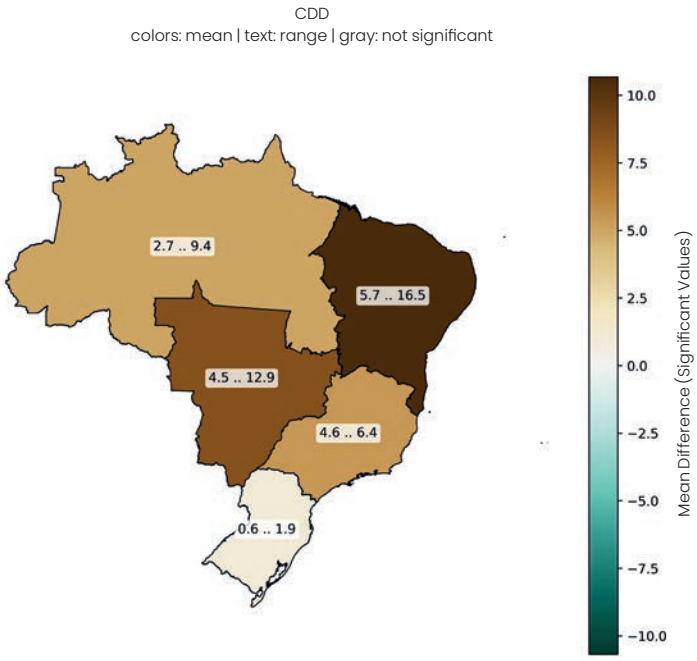


Note: The colors represent the mean difference in values that are statistically significant in each region, while the labels indicate the range of projections that are significant at the 5% level (Welch's t-test, $p < 0.05$).

Source: Compiled by the authors based on CMIP6 models.

A regional analysis of the CDD indicator (Figure 4.32) shows an increase in the duration of dry periods across most of Brazil, with significant differences among regions. The largest increases are projected for the Northeast and Central-West regions, with ranges reaching high values, indicating greater persistence of dry spells in these regions. The North and Southeast regions also show consistent increases, although to a slightly lesser extent, particularly in the Southeast. In the South region, the increases are more moderate, suggesting a less pronounced intensification of dry periods.

Figure 4.32 Projected changes in the maximum number of consecutive dry days (CDD) by region in Brazil, relative to the historical period (1983-2014), considering global warming levels and CMIP6 emission scenarios

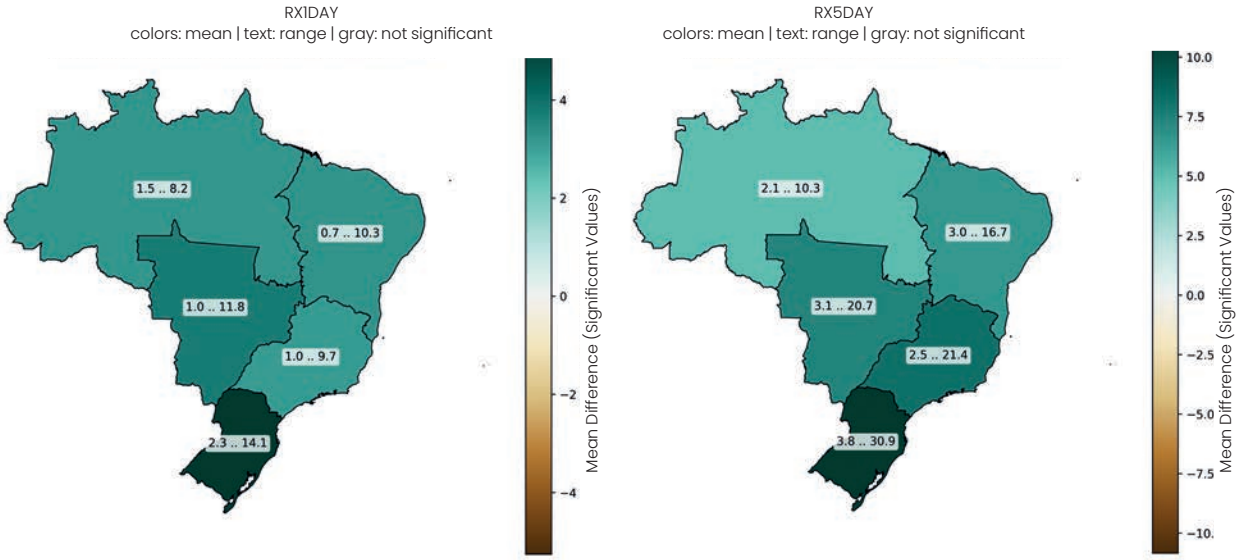


Note: The colors represent the mean difference in the *ensemble* for each region, while the values indicate the range of projections that are statistically significant at the 5% level (Welch's t-test, $p < 0.05$). Regions shown in gray indicate the absence of a significant signal.

Source: Compiled by the authors based on CMIP6 models.

The analysis of the Rx1day and Rx5day indicators (Figure 4.33) shows a pattern of intensification of extreme precipitation events across all regions of Brazil, with statistically significant increases. For Rx1day, an increase in maximum daily precipitation is seen, with higher values in the South. The ranges indicate moderate increases, with higher maximum values in the Central-West, Southeast, and Northeast, while the North shows slightly smaller increases. In the case of Rx5day, the increases are more intense and show a wider range of variation compared to Rx1day, indicating a more pronounced intensification of accumulated precipitation events over several days.

Figure 4.33 Projected changes in precipitation extremes by region in Brazil, considering maximum daily precipitation (Rx1day) and maximum accumulated precipitation over five consecutive days (Rx5day), relative to the historical period (1983-2014), based on the CMIP6 multi-model *ensemble*



Note: The colors represent the mean difference in values that are statistically significant in each region, while the labels indicate the range of projections that are significant at the 5% level (Welch's t-test, $p < 0.05$).

Source: Compiled by the authors based on CMIP6 models.

Results by biome

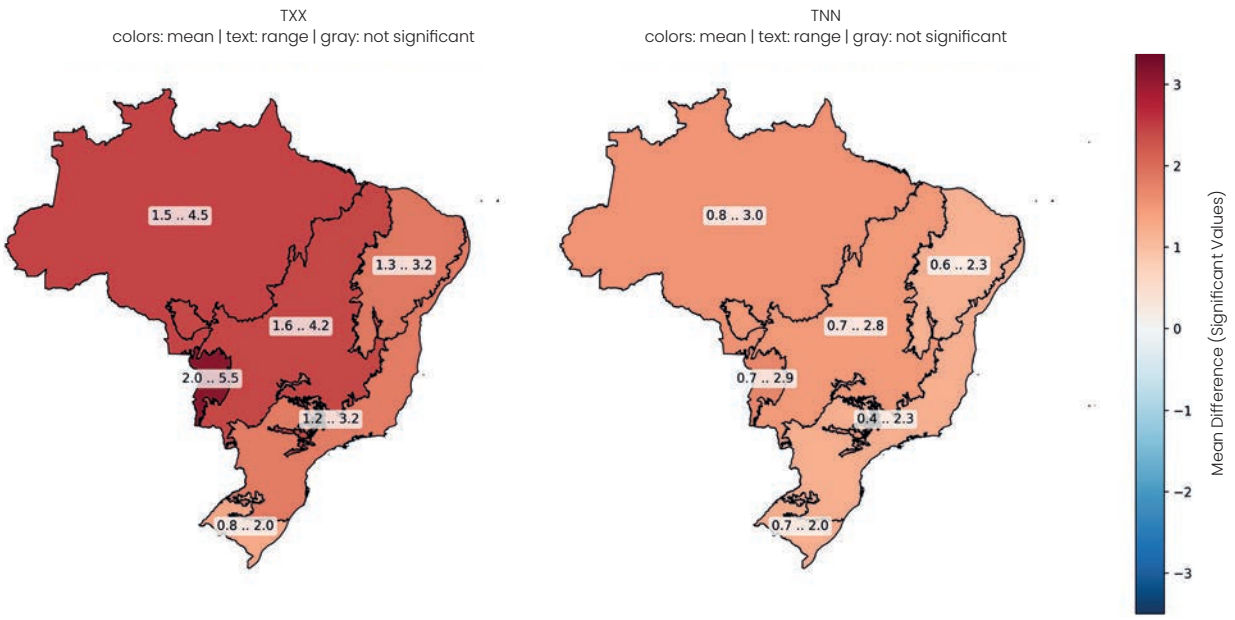
This section presents the results of the aggregated climate indicators for Brazil's biomes (Amazon, Cerrado, Caatinga, Atlantic Forest, Pampa, and Pantanal), based on the CMIP6 multi-model *ensemble*. To obtain these results, similarly to the methodology used for Brazil's regions, all greenhouse gas emission scenarios were considered, but only the values that showed greater statistical significance were included. The analysis by biome makes it possible to assess projected changes by considering ecological units with distinct climate and environmental characteristics, thereby contributing to a more integrated interpretation of potential impacts on ecosystems.

The results are presented through thematic maps, in which the colors represent the mean change in the indicators, while the labels indicate the range of statistically significant projections. Regions without a significant signal are shown separately, allowing for a more robust interpretation of the projected trends. This approach facilitates comparisons between biomes and the identification of consistent patterns of change in the various components of the climate system.

The combined analysis of the TXx and TNn indicators (Figure 4.34) shows a pattern of increasing temperature extremes across all Brazilian biomes, with a statistically significant signal. In the case of maximum temperature (TXx), the largest increases are observed in the Pantanal, Cerrado, and Amazon biomes, with ranges exceeding 5ºC, indicating an intensification of extreme heat events in these regions. The Atlantic Forest and the Caatinga have also experienced significant warming, while the Pampa has seen the smallest relative increases.

For the minimum temperature (TNn), the increase is equally widespread, though of a lesser magnitude compared to TXx. The largest increases occur in the Amazon, Cerrado, and Pantanal, while the Atlantic Forest, Caatinga, and Pampa biomes show more moderate values.

Figure 4.34 Projected changes in temperature extremes by biome in Brazil, considering the maximum (TXx) and minimum (TNn) temperatures, relative to the historical period (1983-2014), based on the CMIP6 multi-model *ensemble*

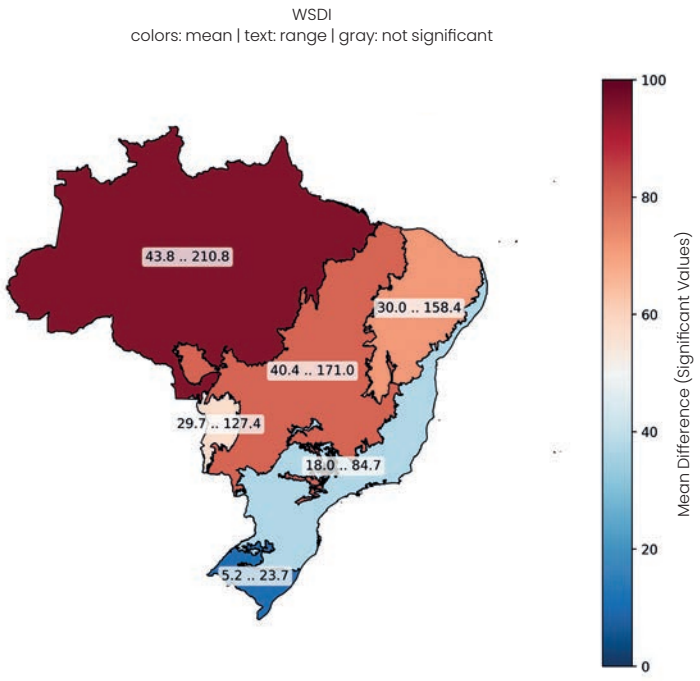


Note: The colors represent the mean difference in values that are statistically significant in each biome, while the labels indicate the range of projections that are significant at the 5% level (Welch's t-test, $p < 0.05$).

Source: Compiled by the authors based on CMIP6 models.

Figure 4.35 shows an increase in the WSDI across all Brazilian biomes, indicating a greater persistence of consecutive warm spells. The largest increases are observed in the Amazon and the Cerrado, with ranges exceeding 170 and 140 days, respectively. The Pantanal and the Caatinga have also seen significant increases, suggesting a sharp increase in the duration of heat waves in tropical and continental biomes. In the Atlantic Forest and the Pampa, the increases are more moderate, though still significant. The Atlantic Forest shows maximum values of around 62 days, while the Pampa records the smallest increases, with a maximum of around 13 days. Overall, the results indicate that the biomes of inland and northern Brazil are more vulnerable to persistent heat extremes.

Figure 4.35 Projected changes in the Warm Spell Duration Index (WSDI) relative to the historical period (1983-2014), based on the CMIP6 multi-model *ensemble*

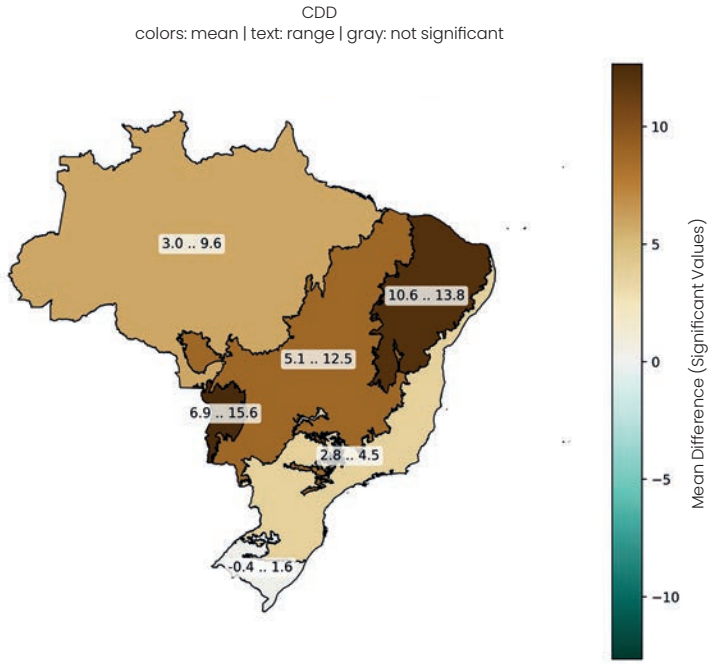


Note: The colors represent the mean difference in values that are statistically significant in each biome, while the labels indicate the range of projections that are significant at the 5% level (Welch's t-test, $p < 0.05$).

Source: Compiled by the authors based on CMIP6 models.

The results for the CDD indicator (Figure 4.36) show a pattern of increasing duration of dry periods in most Brazilian biomes, although there are important differences in the intensity and significance of the changes. The largest increases are observed in the Pantanal, Caatinga, and Cerrado, indicating a trend toward longer dry spells in these regions. The Amazon region also shows an increase, suggesting a potential intensification of water seasonality. In the Atlantic Forest, the increases are more moderate, while the Pampa shows smaller variations with greater uncertainty, including values close to zero.

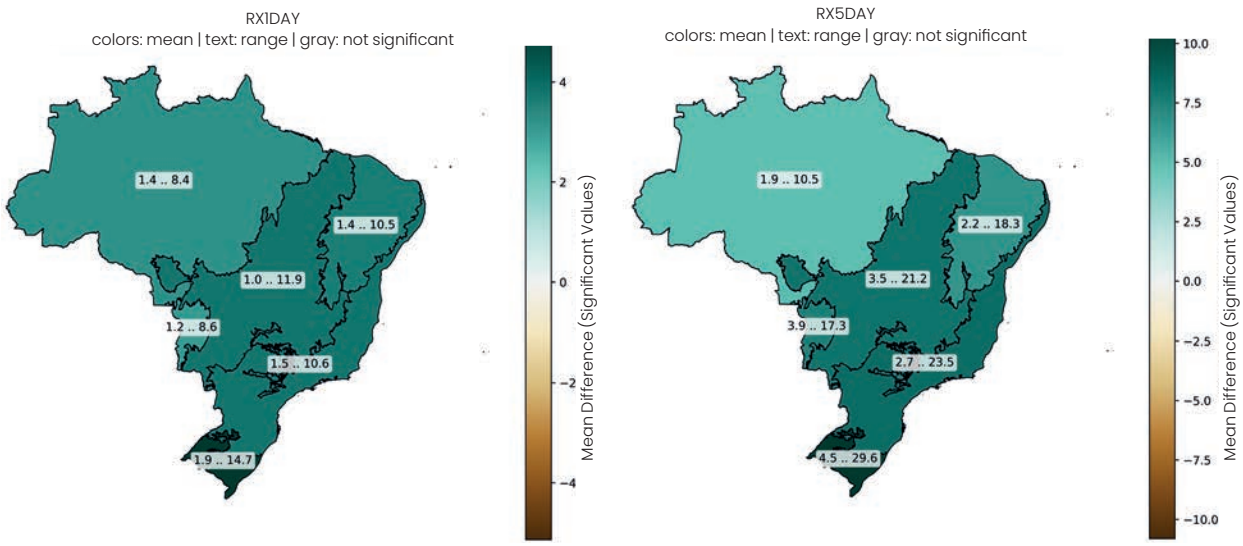
Figure 4.36 Projected changes in the number of consecutive dry days (CDD) by biome in Brazil, relative to the historical period (1983-2014), based on the CMIP6 multi-model *ensemble*



Note: The colors represent the mean difference in values that are statistically significant, while the labels indicate the range of projections that are significant. Gray areas indicate the absence of changes that are statistically significant at the 5% level (Welch's t-test, $p < 0.05$).
Source: Compiled by the authors based on CMIP6 models.

The analysis of the Rx1day and Rx5day indicators (Figure 4.37) shows a statistically significant increase in precipitation extremes across all Brazilian biomes, with higher magnitudes for Rx5day. This pattern indicates not only an increase in the intensity of isolated extreme events, but also a greater persistence of episodes of heavy rain over several days, particularly in the Pampa, Atlantic Forest, and Cerrado biomes.

Figure 4.37 Projected changes in precipitation extremes by biome in Brazil, considering maximum daily precipitation (Rx1day) and maximum accumulated precipitation over five consecutive days (Rx5day), relative to the historical period (1983-2014), based on the CMIP6 multi-model *ensemble*



Note: The colors represent the mean difference in values that are statistically significant, while the labels indicate the range of projections that are significant at the 5% level (Welch's t-test, $p < 0.05$).

Source: Compiled by the authors based on CMIP6 models.

4.2.2. Impacts, risks, and vulnerabilities for sectors and themes of strategic importance to Brazil

The impacts, risks, and vulnerabilities associated with climate change are presented in this section according to the nine National Adaptation Goals (NGs), which guide the implementation of the adaptation agenda in Brazil (Figure 4.68). The NGs provide a framework for organizing the main adaptation challenges identified in the country, taking into account the cross-cutting nature of climate change and the interactions among different sectors, territories, and population groups. Thus, the organization by NGs was adopted as the narrative structure for this section, as it allows evidence on impacts, risks, and vulnerabilities from different sectors and strategic themes to be integrated, while maintaining alignment with national adaptation priorities. The methodological approach underlying this organization is presented in section **4.2.3**.

NG1: Increase the resilience of populations, cities, territories and infrastructure to the climate emergency

Observed impacts

Cities concentrate populations, infrastructure, and services, bringing together a wide range of social, economic, and environmental dynamics within a single space. In Brazil, 87.4% of the population lives in urban areas, with 8.1% living in *favelas* and urban communities (IBGE, 2024a), which highlights both the central role of cities and the persistence of structural inequalities. In addition, it is worth noting that Brazilian cities have different land use patterns, socio-spatial inequalities, and heterogeneous systems and infrastructure, resulting in a highly complex urban environment. Furthermore, differing institutional capacities and arrangements directly influence their organization, planning, and response to socio-environmental pressures. In this context, the impacts of climate change do not manifest uniformly; they are influenced by structural differences and result in distinct patterns among Brazilian municipalities (Brasil, 2025a, 2025p).

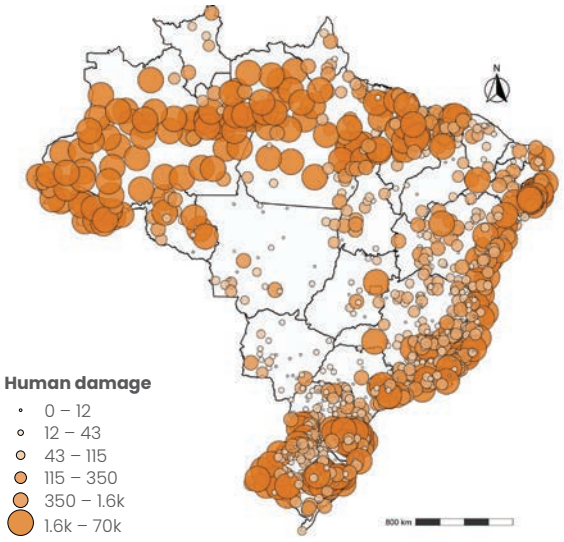
The impacts observed in cities demonstrate how various climate-related hazards (such as changes in rainfall and temperature regimes and the intensification of extreme events), combined with vulnerability and exposure factors, have multiple effects on urban areas. These effects impact infrastructure, essential services, health, and socioeconomic dynamics, underscoring the systemic and interdependent nature of climate impacts (Espíndola and Ribeiro, 2020; Mansur *et al.*, 2018).

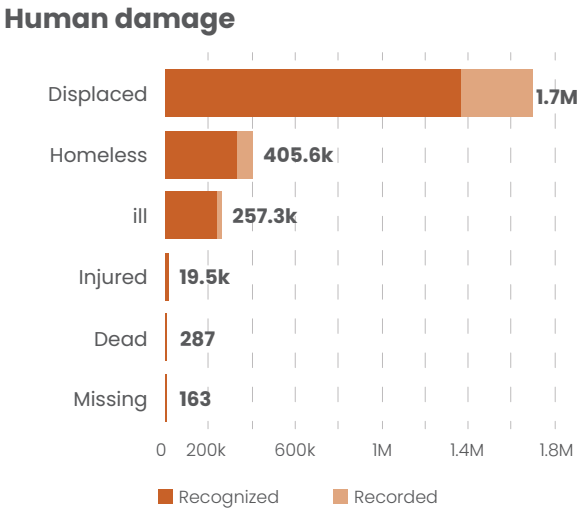
Recent studies indicate that rainfall-related climate disasters have more than tripled in recent decades, particularly those resulting from flooding, fluvial (riverine) flooding, flash flooding, and landslides (Cemaden, 2026). Between 2014 and 2024, there were[15] 5,650 disasters with surface water flooding, flash flooding, and fluvial flooding, resulting in 287 deaths, 2.10 million people displaced and left homeless, in addition to 276,810 people injured or ill and 2.38 million people directly affected (Brasil, 2026a). Among the material damage recorded, damage associated with infrastructure stands out, accounting for 88% of the total. Among public-sector losses, the largest shares are associated with sanitation (46%), followed by education (14%), cleaning and recycling (11%), medical care and emergency services (11%), and water supply (9%) (Figure 4.38) (Brasil, 2026a). In the case of mass movements[16], 1,010 events were recorded over the same period, resulting in 96 deaths, 123.4 thousand people displaced or left homeless, 1,212 people injured or ill, and approximately 124.7 thousand people directly affected. Approximately 87% of material damage was also concentrated in infrastructure. Among public-sector losses, the largest shares are associated with sanitation (45%), public safety (18%), education (8%), and water supply (8%) (Figure 4.39) (Brasil, 2026a).

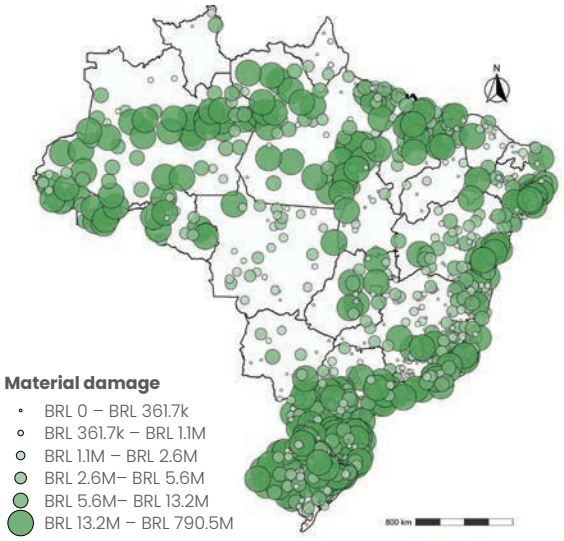
15 Event report recorded by the municipality in the Integrated Disaster Information System (S2ID, Sistema Integrado de Informações sobre Desastres), the Federal Government's official system. Recording of events is not required, and the number of events may vary. Information on human and material damage, and public and private sector losses is self-reported.

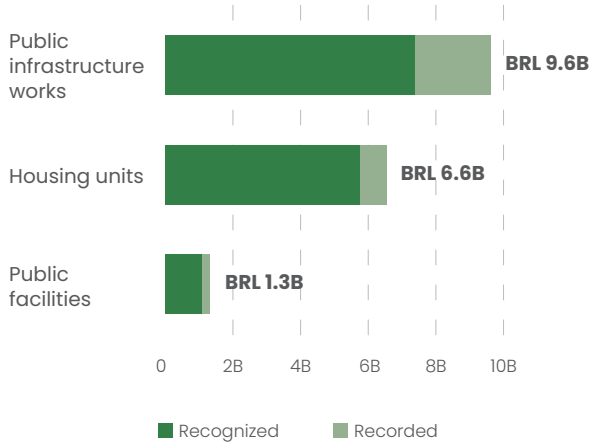
16 Brazil has the Brazilian Classification and Coding System for Disasters (Cobrade, Classificação e Codificação Brasileira de Desastres), which is currently undergoing a review process by the Ministry of Integration and Regional Development. Within this classification, the disaster categories most relevant to extreme rainfall events are geological and hydrological disasters. Geological disasters include mass movements, which, in turn, include landslides. Hydrological disasters include fluvial flooding, flash flooding, and surface water flooding (Cobrade, 2017). This report is consistent with the terminology adopted by the AdaptaBrasil System (MCTI-INPE) and by Cemaden's annual monitoring report, which define geo-hydrological disasters as mass movements, landslides, fluvial flooding, flash flooding, and surface water flooding events.

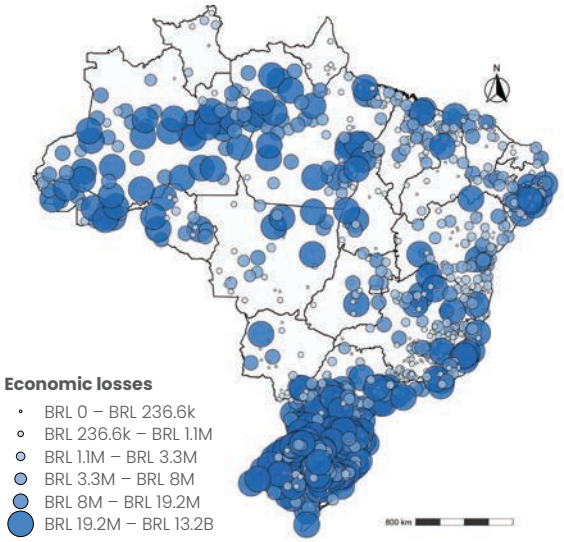
Figure 4.38 Integrated panel of totals for hydrological events

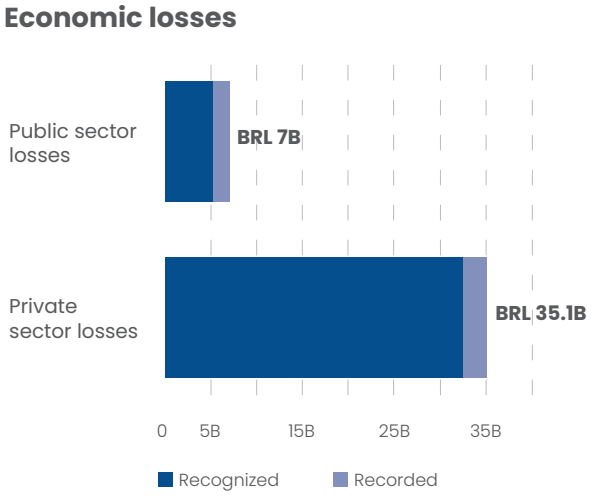








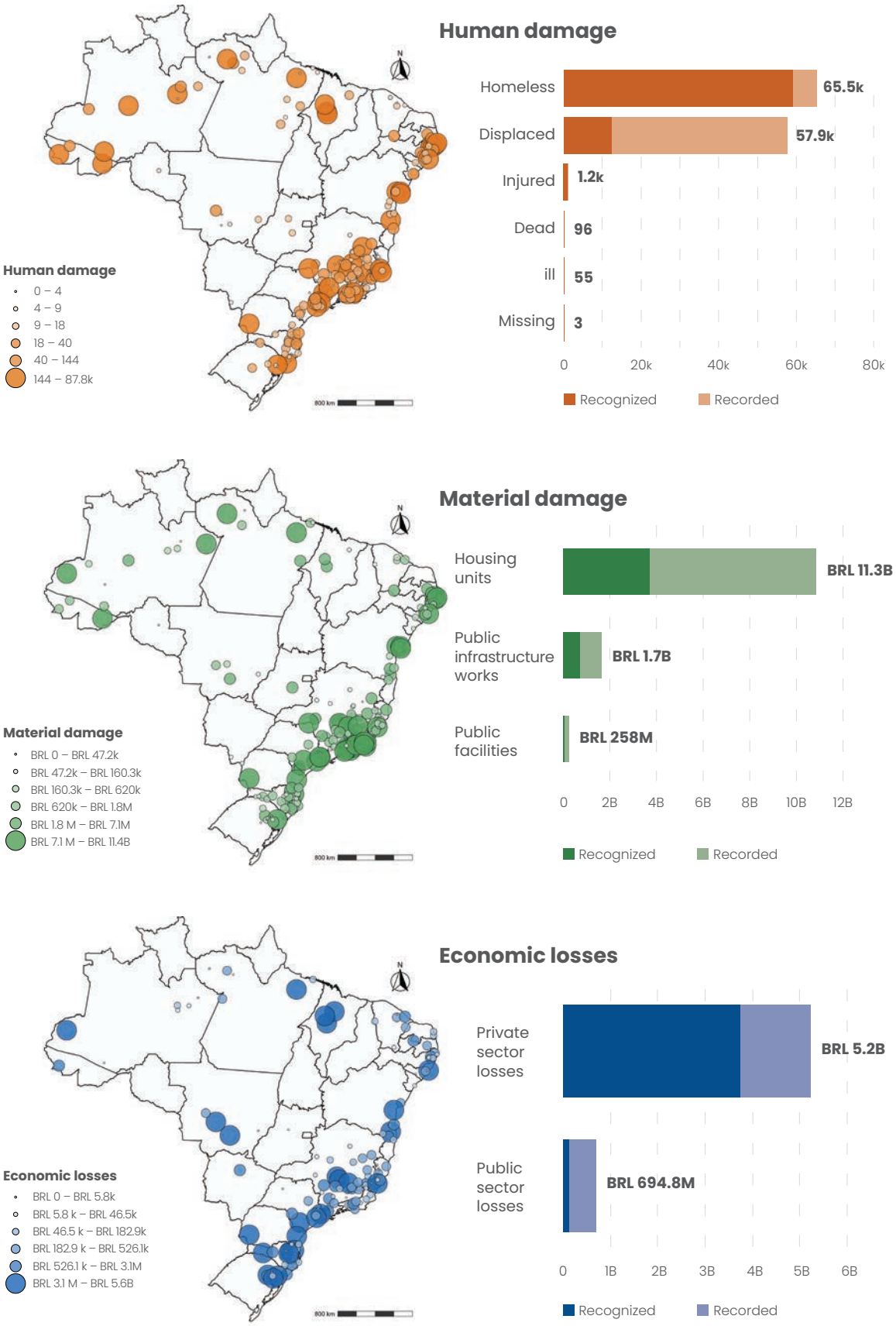




Note: Line 1 – human damage; Line 2 – material damage; Line 3 – public and private sector losses.

Source: Brasil, 2026a.

Figure 4.39 Integrated panel of totals for mass movement events



Note: Line 1 – human damage; Line 2 – material damage; Line 3 – public and private sector losses.

Source: Brasil, 2026a.

These impacts have direct economic consequences for cities, such as disruptions to commercial and service activities, loss of income, and negative effects on the operations of small and medium-sized businesses, especially in the most vulnerable areas. Extreme events disrupt urban supply chains by affecting logistics and transport, making it difficult to distribute food and essential goods. This can drive up prices and exacerbate food insecurity (Brasil, 2025p).

In this context, transport infrastructure has been particularly affected, compromising the country's economic development and territorial integration. Fluvial flooding, landslides, and coastal erosion affect the functionality, safety, and connectivity of transport networks, hindering mobility and access to emergency services. In 2024, for example, Salgado Filho International Airport in Porto Alegre was flooded, causing operations to be suspended for several months. That same year, waterway transportation in the North region was disrupted due to an extreme drought that lowered the water level of the rivers (Brasil, 2025b).

In addition to events related to excessive rainfall, droughts have also become more frequent, prolonged, and widespread, affecting cities through water shortages, rising food prices, disruptions to the hydroelectric system, and migration flows from rural areas (see **Box 4.2**) (Espíndola and Ribeiro, 2020).

The extreme drought that struck the Southeast region beginning in late 2013, considered at the time to be the most severe in the past 55 years, contributed to a sharp drop in water levels in the Cantareira System, an important source of water supply for the São Paulo Metropolitan Region, one of the most populous regions in the country. In 2014 and 2015, the system's usable volume reached negative levels, characterizing what is known as dead storage[17] (Cumplido *et al.*, 2023). This event put approximately 40 million people at risk in the states of São Paulo, Rio de Janeiro, and Minas Gerais (Nobre *et al.*, 2016). Low water levels recurred in 2021 and 2022, keeping the system on alert, with storage levels around 30% (Cumplido *et al.*, 2023). In January 2026, the levels once again reached critical values, ranging from 19% to 20%, the lowest since the 2014/2015 event. This scenario was influenced by both adverse weather conditions and increased water consumption, which was 24% and 30% above average in 2024 and 2025, respectively (Cemaden, 2026) (see **NG3: 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**).

An analysis of the 2014/2015 crisis in the Cantareira System reveals that the impacts of the water shortage were not distributed evenly across the population: lower-income communities, with less access to alternative supply, and populations located in the watersheds that supply water to the São Paulo Metropolitan Region were the most severely affected, highlighting how the management of water crises in metropolitan systems can reproduce and exacerbate preexisting territorial and socioeconomic inequalities, especially in the context of intense weather events (Anazawa, 2018; Fracalanza and Paz, 2018; Souza *et al.*, 2025; Zambiasi, 2025).

Urban populations have also been affected by the increased frequency and intensity of heat waves, with direct effects on health (see **Box 4.6**) and housing conditions. Rising temperatures compromise thermal comfort in homes, increasing the demand for air conditioning and,

17 Dead storage: Refers to the volume of the reservoir intended to store sediment over its service life. It is generally located below the minimum operating levels, where the bottom outlet is typically located (ANA, 2019).

consequently, energy consumption, which can strain urban infrastructure and generate additional costs for households (Vásquez-Arroyo *et al.*, 2021).

These impacts tend to be more severe in *favelas* and urban communities, due both to temperature differences compared with neighboring districts (Juneja *et al.*, 2025) and due to inadequate urban infrastructure, limited access to healthcare services, and poor housing conditions (Neves *et al.*, 2025). Similarly, workers who are more exposed to the elements, such as street vendors, urban maintenance workers, and homeless people are also more severely affected by extreme heat.

Rising temperatures compromise the quality of urban life by affecting the population's thermal comfort during outdoor activities and while using transport systems, which may reduce the usability and attractiveness of these systems, especially for active modes of travel such as walking and cycling (Ribeiro, 2023). In addition to affecting urban mobility, high temperatures can cause pavements, stations, equipment, and systems to overheat, reducing their service life and increasing maintenance costs (Brasil, 2025b; ITDP, 2019; Brasil, 2017; Brasil, 2025a). In this regard, the lack of strategies for tree coverage and shading along routes, sidewalk improvements, shelters at stops, and water availability along routes contributes to worsening the impacts on mobility.

Taken together, these impacts highlight the importance of cities adapting to climate change, as climate change is already compromising the right to the city, simultaneously affecting infrastructure, services, economic activities, and living conditions, with unequal effects across territories and social groups.

Future risks

The Sectoral Plan for Cities identifies the weakening of the right to the city and the decline in urban quality of life for all people, particularly the most vulnerable, as the main climate risk. Associated with this main climate risk are three other related risks, the identification of which facilitates the implementation of strategic actions by specific technical areas:

- increase in housing precariousness and inadequacy;
- decrease in the quality of service and in access to basic sanitation; and
- decrease in the quality of transport services and in access to urban mobility.

The Sectoral Plan for Risk and Disaster Reduction and Management, on the other hand, identifies risks related to the increase in the frequency and intensity of disasters, as well as risks related to the sector's governance structure:

- increase in the frequency and intensity of disasters associated with excessive rainfall;
- increase in the frequency and severity of disasters associated with a lack of or scarcity of rainfall;
- increase in the frequency and severity of disasters associated with changes in temperature, humidity, energy, and air movement; and
- overburdening of the institutional and financial capacity of the National System for Civil Protection and Defense (SINPDEC, Sistema Nacional de Proteção e Defesa Civil) in the context of climate change.

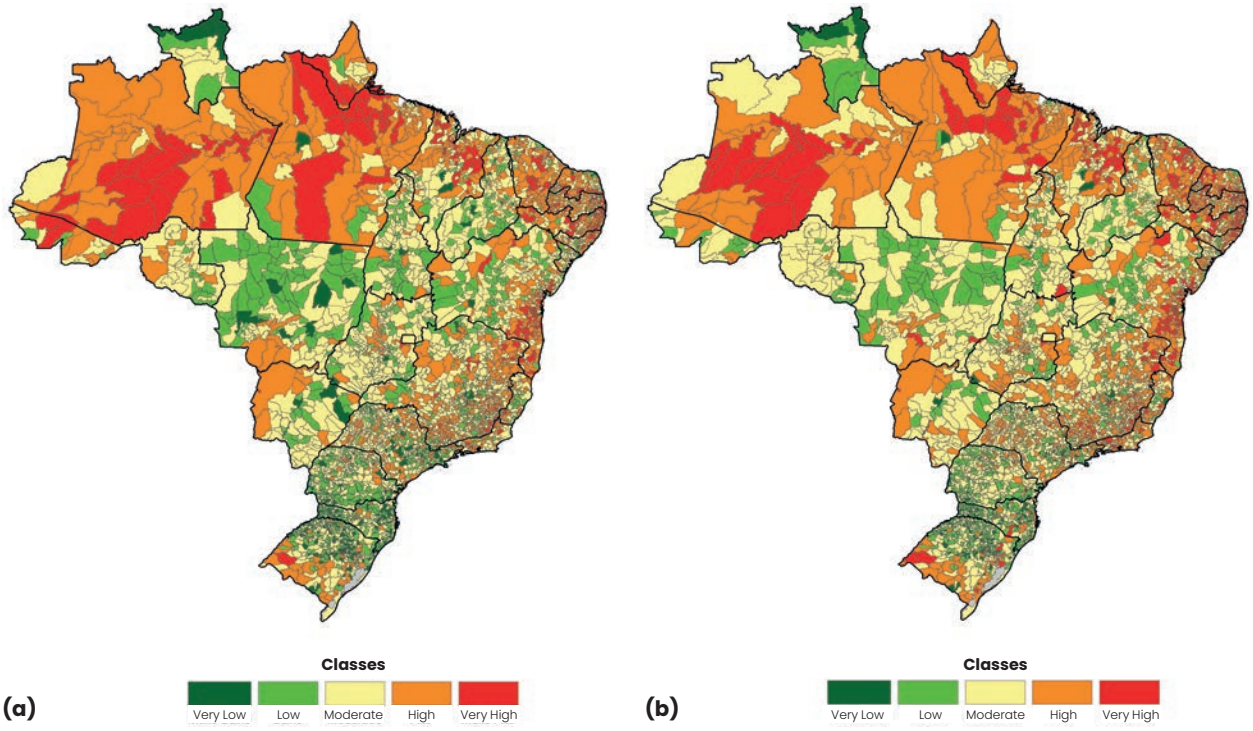
The intensification of extreme events, associated with both excessive and insufficient rainfall, as well as changes in temperature and other climate variables, increases risks to infrastructure,

urban services, and economic dynamics, affecting housing, sanitation, and mobility in an interdependent manner (Brasil, 2025p).

The risks of infrastructure disruption are also listed in the Sectoral Plan for Transport Adaptation, which addresses risks related to civil aviation and road, rail, maritime, and inland waterway transportation. Structural damage caused by extreme weather events (excessive or insufficient precipitation and high temperatures) can lead to operational disruptions, compromising service provision and user safety. As a result, communities may become isolated, and the risk of accidents tends to increase (Brasil, 2025b).

With regard to extreme events, Brazil faces high levels of future climate risk for geohydrological disasters throughout its territory (Figure 4.40). Projections indicate an increase in the number of municipalities classified in the high and very-high risk categories, compared to the current scenario, for fluvial flooding, flash flooding, and surface water flooding, as well as for landslides, with greater intensity in the latter case (Figure 4.41, AdaptaBrasil, 2026a, 2026b).

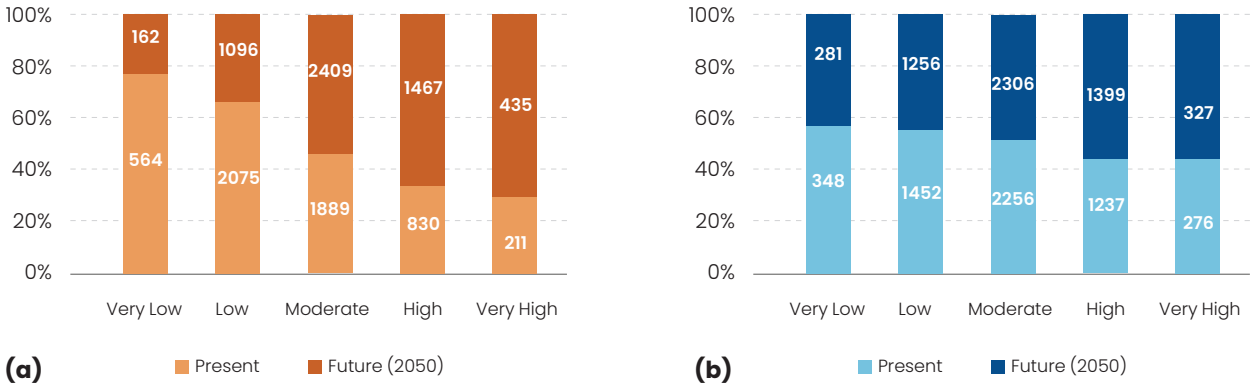
Figure 4.40 (a) Climate risk for fluvial flooding, flash flooding, and surface water flooding events. (b) Climate risk for landslides



Note: A scenario that takes into account geomorphological characteristics, land use, geological features, and climate indices of heavy rainfall (total precipitation over 1 day and over 5 days).

Source: AdaptaBrasil, 2026a, 2026b.

Figure 4.41 (a) Number of municipalities by risk class, in the present and in the future, for landslides. (b) Number of municipalities by risk class, in the present and in the future, for fluvial flooding, flash flooding, and surface water flooding



Source: AdaptaBrasil, 2026a; AdaptaBrasil, 2026b.

The shift in the distribution of risk toward geo-hydrological disasters, which is more pronounced in the case of landslides (AdaptaBrasil, 2026a, 2026b), indicates not only the intensification of climate-related hazards, but also an increase in the potential for impacts on cities, including housing, sanitation services, transport, and mobility. Additionally, the increasing frequency and intensity of disasters, combined with the strain on the institutional and financial capacity of the National System for Civil Protection and Defense (SINPDEC), indicate that these risks involve growing constraints on response, coordination, and management capacity in the context of climate change (Brasil, 2025a).

Finally, climate risks in the urban context are becoming progressively more severe. The challenge lies in controlling horizontal urban growth over natural and agricultural spaces and increasing investment in adaptation in urban areas, with a focus on vulnerable territories. Thus, the growing complexity of climate risk management underscores the need for integrated, preventive, and territorially focused approaches to increase resilience and reduce climate risks and the associated loss and damage.

Vulnerabilities

Climate risks do not stem exclusively from climate events, but rather from the way these events affect territories marked by structural inequalities, with vulnerability being a determining factor (Raju *et al.*, 2022; Lemos, 2025). In the urban context, this vulnerability is deeply shaped by socioeconomic inequality, which manifests itself in patterns of urbanization characterized by informality, socio-spatial fragmentation, unequal access to infrastructure and services, and the marginalization of social groups in decision-making processes (Schipper, 2020; Lemos, 2025). This dynamic, which is widespread in Brazil, a country characterized by high levels of socioeconomic inequality, compromises adaptive capacity and increases exposure to risks (Lemos, 2025).

In the Brazilian context, these vulnerabilities manifest themselves in a scenario in which a large portion of the population and municipalities are already exposed to multiple geo-hydrological

risks: it is estimated that 2,095 municipalities have some level of exposure to landslides, flash flooding, and fluvial flooding (Cemaden, 2026). The greatest vulnerabilities are concentrated in the North, Northeast, and Central-West regions, where socioeconomic conditions are more precarious and access to urban infrastructure services is limited (Brasil, 2023; Saito *et al.*, 2019; Assis Dias *et al.*, 2020).

From a territorial perspective, different patterns can be observed depending on the type of disaster. Hydrological disasters are concentrated mainly in the North, Northeast, and Central-West regions, while landslides occur most frequently in the states of the Southeast, often in connection with informal settlements on hillsides. Droughts and dry spells, on the other hand, are prevalent in the Northeast and in parts of the Southeast and Central-West, highlighting the diversity of risk contexts across the country.

These patterns reflect not only environmental factors but also land use planning dynamics shaped by historical processes of unplanned urbanization, socio-spatial inequality, and inadequate infrastructure, which increase exposure and vulnerability to extreme events (Brasil, 2025c). In this context, more vulnerable populations tend to occupy areas that are more susceptible to environmental hazards, such as hillsides and drainage areas, reinforcing the relationship between socio-spatial inequality and exposure to disasters (Brasil, 2025c; Espíndola and Ribeiro, 2020; Mansur *et al.*, 2018).

In this context, recent urban expansion in Brazil has emerged as a key factor contributing to climate vulnerabilities, as it has occurred at an accelerated pace and, in many cases, without regard for land-use planning and risk management criteria. Between 1985 and 2024, urbanized areas in the country increased 2.5-fold, often encroaching on steep slopes and drainage areas, which are associated with a significantly higher risk of landslides and flooding in recent decades (MapBiomas, 2026). This process contributes to increased exposure to extreme events and to the intensification of risks associated with the use of unsuitable areas, in addition to increasing distances and dependence on motorized transport, increasing travel time and hindering access to essential services, as well as reflecting dynamics of socio-spatial inequality and unequal access to urban land (Espíndola and Ribeiro, 2020; Mansur *et al.*, 2018).

In the urban context, these vulnerabilities are exacerbated by weaknesses in governance, planning, and infrastructure provision (Brasil, 2025a). There is a limited capacity to develop urban planning instruments that prioritize the climate agenda, using as inputs information that supports interventions and urban development aimed at climate resilience. The lack of integration of contingency plans and mapping, such as urban development suitability and risk-area mapping, with instruments such as the Master Plan, the Land Use Planning Law, Land Subdivision Regulations, and Urban Mobility Plans weakens the municipality's capacity to adapt. Poor institutional coordination and insufficient human and financial resources also compromise the capacity to anticipate and respond to disasters (Brasil, 2023) and to help cities adapt.

These limitations are also reflected in the management of waste generated by disasters, a component that is still poorly integrated into urban planning and climate adaptation strategies. Waste generated by disasters, consisting of debris, natural materials, hazardous waste, and other materials resulting from extreme events, can reach large volumes and significantly hinder response and recovery operations. Recent studies show that instruments such as Master Plans, Integrated Solid Waste Management Plans, and Contingency Plans still do not adequately address this issue, with poor integration between solid waste policies and civil defense. Together, these gaps reduce institutional response capacity, increase recovery costs, and underscore the

need for advance planning, interinstitutional coordination, and investment in infrastructure to strengthen urban resilience (UNEP/OCHA, 2011; UNDRR, 2022).

Another key source of vulnerability is deficiencies in urban infrastructure, which directly affect the capacity to respond to extreme events. Problems with urban drainage, sanitation, and mobility contribute to more severe surface water flooding and fluvial flooding, while urban layout and land-use patterns influence the occurrence of heat islands and other climate impacts (Mansur *et al.*, 2018; Parry *et al.*, 2018; Santos *et al.*, 2024). Furthermore, vulnerability to events such as heat waves is associated with inequalities in access to healthcare services and socioeconomic conditions, affecting older people, low-income populations, homeless people, traditional peoples and communities, women, and Black people most severely (Santos *et al.*, 2024; Sousa *et al.*, 2018).

Additionally, the intensification of extreme weather events has increased pressure on the institutional and operational capacity of the National System for Civil Protection and Defense (SINPDEC), highlighting limitations in preparedness, response, and recovery in the face of increasingly frequent and intense disasters (Brasil, 2025c). In urban contexts, more socially vulnerable populations tend to experience greater mobility constraints and have a lower capacity for recovery, reinforcing the intersection of social, environmental, and urban vulnerabilities (Freitas *et al.*, 2019; Carvalho et al., 2022; Parry *et al.*, 2018).

Urban vulnerabilities are also evident in the systems essential to the functioning of cities, such as water, energy, and food. Water scarcity can compromise urban water supply and exacerbate inequalities in access to water, primarily affecting populations in peripheral urban areas (Fracalanza and Paz, 2018; Souza *et al.*, 2025). Similarly, extreme events can impact food production and distribution, as well as energy infrastructure, highlighting the interdependence between urban systems and the increasing risks in the context of climate change (Giatti *et al.*, 2019).

Thus, urban vulnerability in Brazil is a multidimensional and interdependent phenomenon resulting from the interaction between urbanization processes, structural inequalities, infrastructure deficits, and institutional constraints. This context underscores the need for integrated, territory-tailored, and equity-oriented approaches capable of strengthening adaptive capacity and reducing climate risks.

BOX 4.2 HUMAN MOBILITY[18] IN THE CONTEXT OF CLIMATE CHANGE IN BRAZIL

The dimensions of human mobility in the context of climate change are commonly classified into three categories: displacement, migration, and planned relocation (UNFCCC, 2011). Displacement due to disasters refers to the movement of people who are forced or obliged to leave their place of origin or residence, temporarily or permanently, depending on the circumstances of the specific case and whether the damage can be reversed (Viol, 2024), as a result of a disaster or in order to avoid its immediate effects. Migration, in turn, occurs when sudden or progressive changes in the environment associated with climate change, interacting with other social, economic, or political factors, adversely affect the living conditions of a population, leading individuals or groups to leave their habitual place of residence, temporarily or permanently, and move to another location within their country

18 The term "human mobility" refers to the processes of displacement, migration, and planned relocation of populations. It differs from "urban mobility," which concerns people's daily travels and the functioning of transport systems in cities.

of origin or across an international border. Planned relocation, in turn, is an organized process in which people or communities move, or are assisted to move, to areas where they are less exposed to risk, generally with some form of institutional support, particularly for families and individuals in situations of greater vulnerability (UNFCCC, 2024). Finally, immobility, which is also considered relevant in the Brazilian context, refers to people or communities remaining in risk areas, either by choice or because they are unable to move, remaining in voluntary or involuntary situations of vulnerability (IOM, 2023; UNFCCC, 2024). The decision of whether or not to migrate, that is, voluntariness, depends on the degree of vulnerability of the groups concerned and is related to the need, desire, and capacity to actually migrate (Serraglio *et al.*, 2019).

Although human mobility is multifactorial in nature, with diverse and complex motivations, climate conditions have become increasingly important as drivers, acting as stressors that exacerbate pre-existing vulnerabilities, such as high levels of socioeconomic inequality. In Brazil, migration linked to environmental and climate factors has been a reality for decades, driven both by fluvial flooding and landslides in coastal and urban areas and by water scarcity and long dry spells in rural areas (Barbieri and Castiglione, 2025).

The Internal Displacement Monitoring Centre (IDMC) produces annual data and analyses on internally displaced persons and internal displacement in various countries. In the case of Brazil, the IDMC uses data on people displaced or left homeless provided by the National Secretariat for Civil Protection and Defense, which systematically collects data on disaster impacts through the Integrated Disaster Information System (S2iD, Sistema Integrado de Informações sobre Desastres). According to estimates, more than 4.6 million displacements occurred in Brazil between 2013 and 2023 as a result of disasters, with approximately 95% of them associated with fluvial flooding events and storms (Barbieri and Castiglione, 2025).

In 2024, IDMC data indicated a significant increase in internal displacement worldwide, with disaster-related displacement nearly doubling compared to the annual average of the past decade. In the Americas alone, 13.1 million disaster displacements were recorded, with Brazil ranking second, with more than 1.1 million displacements recorded, the highest number in its time series. The largest portion was linked to fluvial flooding events in the state of Rio Grande do Sul, which resulted in more than 775,000 displacements. In the North, droughts in the Amazon were responsible for more than 35,000 internal displacements, and fires in the state of Pará caused 9,400 displacements (IDMC, 2025).

In the Amazon, there is a strong interaction between environmental changes and social and economic factors. The North region is highly sensitive to variations in rainfall regime and has experienced more severe droughts, in addition to having one of the highest rates of internal migration in the country, largely due to increasing urbanization. In 2024, for example, a single municipality located on Marajó Island, in the state of Pará, was hit by a storm that resulted in more than 8,000 reported cases of displaced people. Traditional communities in the region, which are highly dependent on natural resources, are already reporting changes in water temperature, the availability of fish and shellfish, the salinization of freshwater, and rising sea levels. These changes directly affect their productive activities and can be a determining factor in displacement processes (IOM, 2025).

The spread of desertification in the northeastern semiarid region, combined with rising temperatures, reduced rainfall, and soil degradation in the Caatinga biome, has also been impairing rural livelihoods and exacerbating water and food insecurity. This situation impairs family survival strategies in the region and may lead to migration movements, particularly to large regional urban centers (Barbieri *et al.*, 2010). However, displacement driven by slow-onset events, such as droughts, tends to be gradual and less visible, posing challenges for data assessment because the impacts may take time to materialize and may depend on socioeconomic and governance factors, such as access to land and livelihoods (Barbieri and Castiglione, 2025).

In the case of immobility, these situations involve other complicating factors and a range of possible experiences. In some situations, remaining in risk areas is voluntary, motivated by emotional and identity-based ties or by the availability of resources that make it possible to continue living in that area. In other cases, immobility is involuntary, resulting from a lack of financial resources, support networks, or transportation infrastructure, despite a desire to migrate or a need to relocate. This decision also depends on individual and collective perceptions of the risks involved, as well as on an assessment of the available alternatives (Correia, 2024; Barbieri and Castiglione, 2025). Thus, socioeconomic, cultural, territorial, and subjective factors have a decisive influence on these decisions.

Planned relocation, in turn, involves challenges that go beyond physical displacement, including the preservation of identity, ways of life, and ties to the territory. The lack of systematic data makes it difficult to assess the effects of these processes, which are often initiated independently by the communities themselves. Public policies for planned relocation have become increasingly necessary as a tool for adaptation and disaster risk management due to the historical process of urbanization in Brazil, which has exposed part of the population to living in areas of socio-environmental risk (Moreira *et al.*, 2026). In a scenario of rising mean sea level and a high concentration of the population living in coastal areas, planned relocation may become necessary due to increased exposure to surface water flooding and coastal erosion events.

In 2016, the community of Enseada da Baleia, located between the coastlines of São Paulo and Paraná, experienced an extreme erosion event that reduced the strip of land from 20 meters to just two meters, jeopardizing human settlement in the area. In this situation, the community was mobilized, drawing on collaborative academic research and traditional knowledge, to facilitate its relocation to an area where its cultural identity could be preserved. Traditional Caiçara knowledge and community engagement, with female leaders playing a leading role and with the co-production of knowledge, were fundamental in identifying the progressive reduction of the territory and in selecting the most suitable area for relocation, taking into account activities such as agriculture and fisheries, as well as its cultural and symbolic value (Gini *et al.*, 2025). Therefore, the relocation process must take into account the ongoing involvement and participation of communities, particularly in decision-making, site selection, the development and implementation of the plan, and follow-up after relocation (Fiji, 2018).

Within the Brazilian agenda, human mobility associated with climate change has gradually been incorporated into public policies through a climate justice lens, as in the Climate Adaptation Plan and its Sectoral Plans, although it has yet to be operationalized through

specific goals, targets, and indicators (UNHCR, 2026). The Indigenous Peoples Plan highlights the risks of losing territories, homes, and sacred sites, as well as disruptions in access to essential services, such as healthcare, due to mobility constraints, particularly in remote regions. Climate change affects not only infrastructure but also ways of life and cultural practices, with profound impacts on ties to the territory, especially in cases of displacement (Brasil, 2025d). In the Food Security Plan, forced displacement is recognized as a factor that contributes to the risk of increased socioeconomic vulnerability, which in turn affects the food security and traditional livelihoods of the affected communities (Brasil, 2025e). Climate-induced forced displacement is also addressed under the Racial Equality and Combating Racism Plan, with significant impacts on the Black population, families of Roma peoples, traditional communities, and, in particular, women who are heads of low-income households (Brasil, 2025f).

The degradation of essential ecosystems, sacred sites, medicinal plants, and traditional agricultural practices compromises the ability of communities to live with dignity in their territories and accelerates migration processes in situations of vulnerability. As a result, community systems and traditional ways of life are weakened, leading to the erosion of cultural identity and ancestral knowledge (Brasil, 2025f, 2025g). Surveys indicate that 98.2% of Quilombola territories are already subject to various pressures, such as construction projects and activities that contribute to the degradation of the territory, which, combined with climate events, may be a key factor in the increase in displacements (Oviedo et al., 2024). Another group identified as highly vulnerable to increased migration and displacement is that of family farmers. In addition to the impacts already mentioned, this group faces land conflicts and a decline in agrobiodiversity, linked to the decreasing availability of productive land (Brasil, 2025d).

However, significant limitations remain in understanding the impacts of climate change on human mobility, due to the lack of systematic records, mechanisms for continuous monitoring, and integration between databases on migration and climate risks. The availability of data disaggregated by gender, age, color or race, and other characteristics is also limited, making it difficult to identify disproportionate impacts on certain population groups. In Brazil, S2iD collects data on displaced persons, people left homeless, and other affected populations. Nevertheless, this data lacks demographic, intramunicipal, and temporal disaggregation, which limits more detailed analyses of specific population groups and high-risk territories, such as incarcerated populations and people experiencing homelessness in large urban areas. Furthermore, the impacts associated with slow-onset changes remain particularly underdocumented and poorly understood (IOM, 2023). There is therefore a need for further progress in generating data on human mobility associated with climate change and in developing legal frameworks that define institutional responsibilities and safeguard rights, thereby reducing fragmentation and inequalities in responses, enabling more effective action, and ensuring the inclusion of these populations in mechanisms for compensation of loss and damage (UNHCR, 2026).

NG2: Promote sustainable and resilient production and regular access to healthy food of adequate quality and quantity

Observed impacts

Food systems[19] and rural livelihoods in Brazil are affected in different ways by climate change. Among the observed effects are a reduction in planted area and agricultural productivity, a reduction in the availability of and access to land and territory, forced displacements, harvest instability, and a decrease in the diversity of available foods, particularly affecting local and regional markets supplied by family farming (Brasil, 2025h, 2025i). In addition to production, other dimensions of food and nutrition security are also affected, such as the nutritional quality and availability of food, due to various factors, including rising prices (Rockström *et al.*, 2025).

In this context, recent evidence from Rio Grande do Sul illustrates the intensification of these dynamics in the face of increasing extreme weather events. The 2020, 2022, and 2023 grain harvests were marked by losses in both summer crops, due to severe dry spells, and winter crops, which were affected by frost and excessive rainfall. In 2022, grain production fell by 30.3% compared to the previous year, and although there was some recovery in subsequent years, levels remained below recent historical levels. In 2024, the May flooding events exacerbated this situation, especially in areas directly affected, damaging crops that were still being harvested. Successive revisions to production estimates[20] throughout the agricultural cycle highlight the magnitude of these losses, particularly in soybean, maize, and rice crops, for which the cumulative decline between April and the end of 2024 reached 12.5% (BCB - Central Bank of Brazil (Banco Central do Brasil), 2024). The 2024 Brazilian coffee harvest was smaller than initially estimated, mainly due to adverse weather conditions that occurred during the crops' growth. Of particular note is the state of Minas Gerais, which accounts for approximately 52% of national production; there, irregular rainfall and dry spells beginning in April significantly impacted production potential. This scenario highlights the direct influence of weather conditions on agricultural production, resulting in losses and a revision of harvest expectations (CONAB - Brazil's National Supply Company (Companhia Nacional de Abastecimento), 2025).

By compromising agricultural supply, this series of events tends to put upward pressure on food prices, with direct implications for food access and food security. The effects of floods on specific supply chains also highlight the role of logistical factors in supply dynamics. Although direct losses were relatively limited for crops that had already been harvested, such as rice, transportation restrictions reduced supply in the short term, resulting in a temporary rise in prices. The subsequent normalization of supply and more favorable production outlooks contributed to a reversal of this trend, indicating that extreme weather events, even when localized, can affect prices through indirect impacts on food distribution and access (BCB, 2024).

19 Food systems encompass all processes and actors involved in food production and distribution, from cultivation and harvesting to processing, transportation, marketing, consumption, and disposal. These systems are not limited to food production, but also encompass economic, social, cultural, and environmental factors. This means that everything, from what farmers can harvest in the field to the influence of marketing on consumers' food preferences, is part of a larger system that affects food security worldwide (PACTO CONTRA A FOME (PACT AGAINST HUNGER), 2026).

20 Revisions made by the Systematic Survey of Agricultural Production (LSPA, Levantamento Sistemático da Produção Agrícola/IBGE).

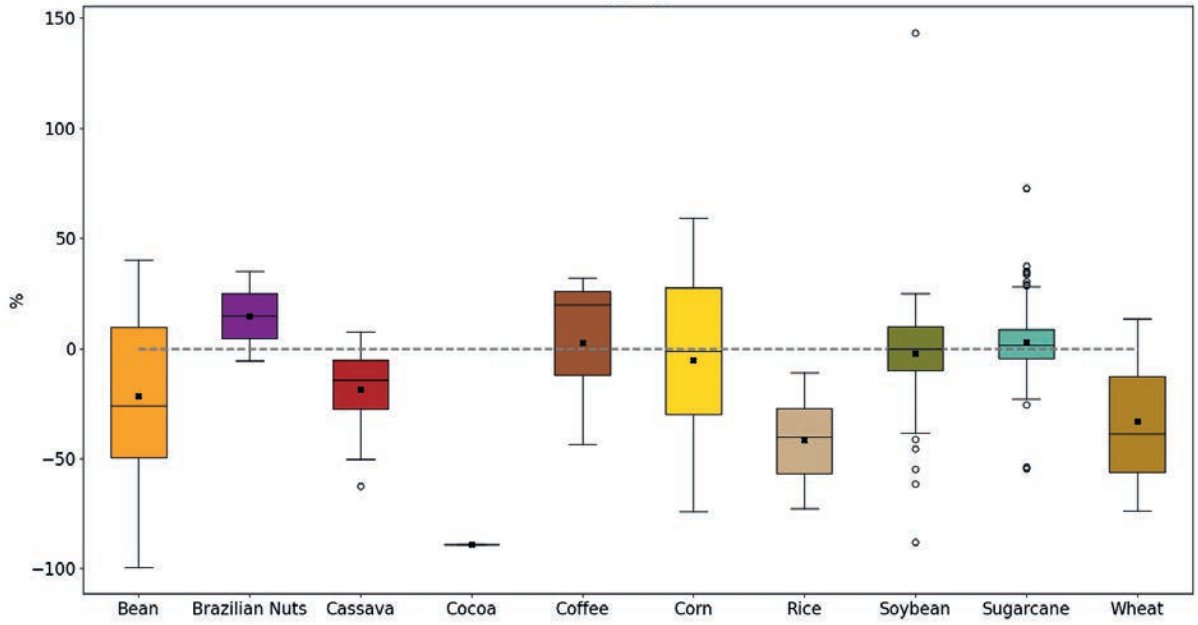
Other documented impacts are associated with processes of environmental degradation that impair production, such as loss of soil fertility, erosion processes, an increase in degraded areas, and desertification. Changes in temperature and precipitation regimes have contributed to changes in the agricultural calendar, an increase in the occurrence of pests and diseases, and a decline in pollinator populations, directly affecting the productivity and sustainability of agricultural systems (Brasil, 2025h; 2025i).

With regard to family farming, which plays a strategic role in food production through sustainable production systems, it contributes directly to the country's food and nutrition security. By supplying local and regional markets and ensuring a diverse food supply, this sector accounts for 60% of the country's Gross Value of Production (GVP) of vegetables (IBGE, 2019) and also has a significant share of temporary crops overall, accounting for 48% of the harvested area of beans, 17% of maize, and 16% of rice, and for 25%, 17%, and 12% of the GVP, respectively (IBGE, 2019). However, despite its importance in food production, this sector faces historical and structural constraints in terms of access to land, occupying only 23% of the area designated for agricultural activities in the country. Thus, the dimension of climate justice is relevant to understanding the impacts on family farming, and it is essential to consider the complex intersections of gender, generation, race/ethnicity, socioeconomic status, and geographic origin.

Recent empirical evidence documents the impacts of climate change on food security in Brazil. Fiorini *et al.* (2024), in a systematic review of 1,844 articles, summarized 53 studies on the observed climate effects on Brazilian agriculture. The results indicate the predominance of negative impacts on agricultural and livestock productivity. Although the magnitude and direction of these impacts vary across regions, crops, and climate conditions, the review shows that climate change is already having a significant impact on food production in the country (Fiorini *et al.*, 2024).

Evidence was found of negative effects on the productivity of beans, cassava, cocoa, coffee, maize, oranges, rice, tomatoes, sugarcane, soybeans, and wheat, as well as on livestock and poultry production systems (Fiorini *et al.*, 2024). However, there is a predominant focus on the analysis of commodity production systems, particularly soybeans, wheat, sugarcane, and coffee (Figure 4.42). On the other hand, there are significant gaps in our understanding of the effects on family farming and staple foods in the national diet, such as beans and cassava, despite their importance to food security. Furthermore, the number of studies related to livestock is also considerably lower than that of studies on agricultural crops, with some types of livestock being overlooked in the literature (such as goats, swine, and poultry) (Fiorini *et al.*, 2024).

Figure 4.42 Analysis of the impact of climate change on crops in Brazil



Source: FIORINI *et al.* (2024).

Another important gap identified concerns the collection of observed evidence on changes in Agricultural Climate Risk Zoning (ZARC, Zoneamento Agrícola de Risco Climático) patterns resulting from changes in climate patterns. Given the importance of ZARC as a tool for minimizing risks to agricultural production in Brazil and its link to the provision of insurance and loans in the sector, any changes to these patterns could have a major impact on public policies that use this zoning as a reference (Fiorini *et al.*, 2024).

Future risks

Three sectoral plans associated with the Climate Adaptation Plan are directly related to the National Goal on agriculture and food security, and identify the following priority risks:

Sectoral Plan for Family Farming (Brasil, 2025h):

- A decline in production and productivity in family farming;
- A reduction in the availability of and access to land for family farming;
- An increase in migration and forced displacement of farming families; and
- Damage to and loss of infrastructure, logistics, and technological capacity.

Sectoral Plan for Food and Nutrition Security (Brasil, 2025e):

- Decreased food availability;
- Increased socioeconomic vulnerability;
- Rising food prices;
- An increase in the number of people facing food and nutrition insecurity;
- Impaired access to healthy foods; and
- A decrease in the availability of water for consumption and food production.

Sectoral Plan for Agriculture and Livestock (Brasil, 2025i):

- A decline in production and productivity;
- Disruption of supply chains;
- An increase or outbreak of diseases and pests;
- Degradation of agricultural soils;
- Loss of quality and nutritional value of agricultural products;
- Loss of genetic resources (e.g., landrace seeds); and
- Water shortage for irrigation and for human consumption and livestock watering.

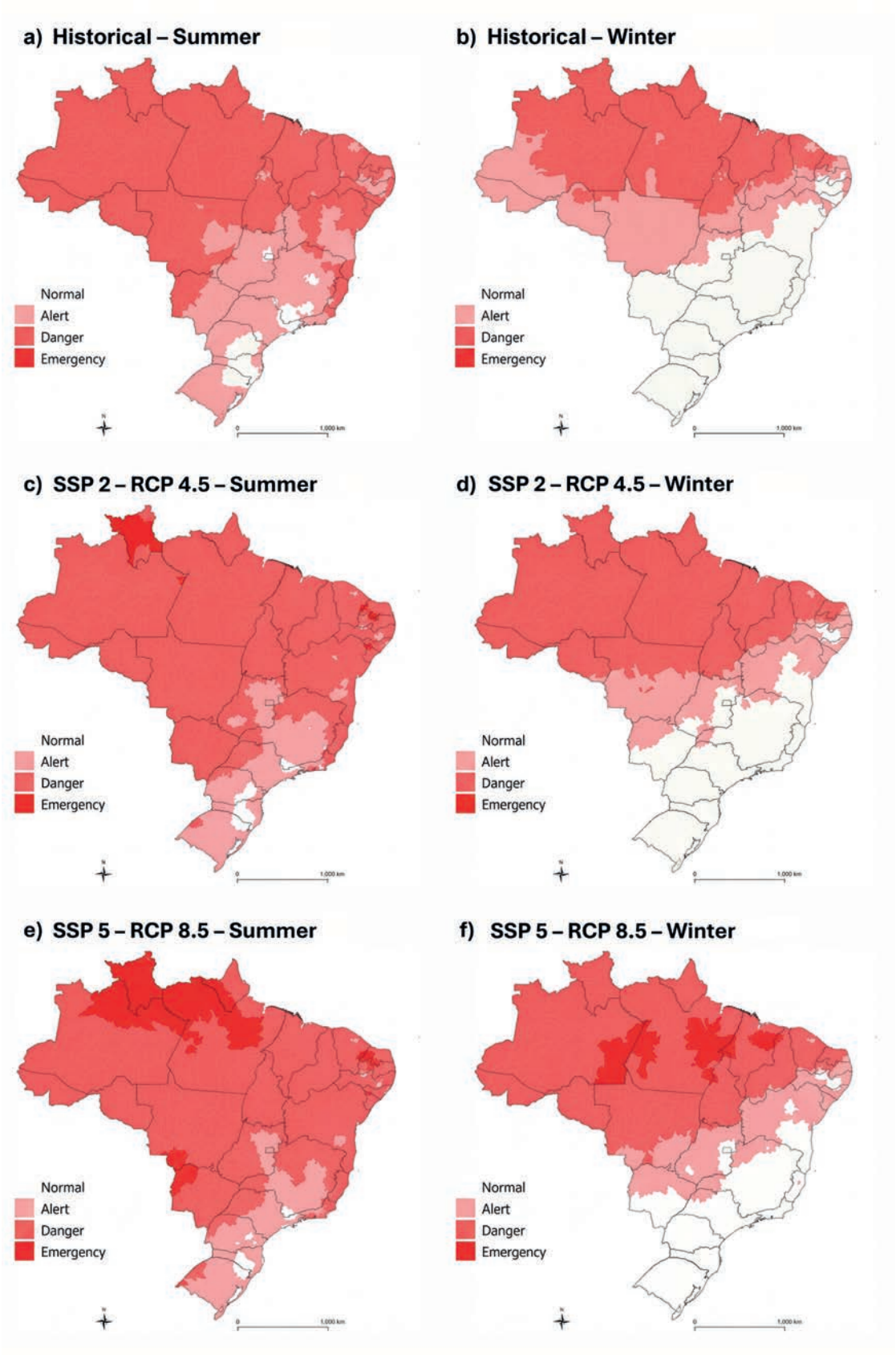
Other plans address various aspects related to food security. The Thematic Plan for Indigenous Peoples identifies the risk of loss of food production, associated with food insecurity; the Thematic Plan for Traditional Peoples and Communities also identifies the risk of loss of food production, associated with food insecurity; and the Plan for Racial Equality and Combating Racism highlights increasing levels of food and nutrition insecurity, as well as morbidity and deaths related to food insecurity (BRASIL, 2025d; BRASIL, 2025g; BRASIL, 2025f). Thus, the plans address food security from different dimensions, including food production, food and nutrition insecurity, and its impacts on health.

An integrated analysis of the plans shows that the risks associated with food security and agricultural production are highly interdependent and operate in a systemic manner (Brasil, 2025e, 2025h, 2025i). The future climate risks identified for food security in Brazil stem primarily from trends toward rising mean surface temperatures, with the resulting intensification of heat stress, changes in precipitation regimes, and an increase in the frequency of extreme events. Recent evidence based on climate scenarios and sectoral modeling indicates that such risks could compromise agricultural and livestock productivity, increase supply volatility, and affect strategic supply chains, with potential impacts on food prices and access to food (Garcia et al., 2025b; Silva et al., 2025).

Recent analyses based on CMIP6 climate projections (SSP2-4.5 and SSP5-8.5 scenarios) indicate a significant expansion of areas subject to critical heat stress for agriculture by 2060 (Figure 4.43). The application of the Temperature-Humidity Index (THI)[21] at the municipal level shows: (i) an expansion of the zones classified as "danger" and "emergency" for crops and cattle herds; (ii) a reduction in thermal comfort windows, including in winter under high-emissions scenarios; and (iii) a further intensification of risks in the North, Northeast, and parts of the Central-West regions (Figure 4.43). This scenario implies a potential decline in productivity, increased management costs, and the risk that conventional livestock systems may become unfeasible in certain areas.

21 The Temperature-Humidity Index (THI) is an indicator used to assess the level of heat stress in living beings, especially in livestock (such as cattle, swine, and poultry), by combining the effects of air temperature and relative humidity.

Figure 4.43 Animal heat stress in Brazil under different future scenarios



Source: Silva *et al.*, 2025.

In the case of soybean, a key crop for animal feed, exports, and bioenergy, a study[22] indicates that productivity responds nonlinearly to climate conditions. Critical thresholds of approximately 26.9ºC for mean temperature and 1,194 mm for accumulated precipitation during the growing season were identified. Up to these levels, increases in temperature and rainfall tend to benefit production; above them, the effect becomes negative, reducing yields. Given the projected increases in temperature and changes in precipitation regimes, part of Brazil's territory may exceed these thresholds in the coming decades, increasing the risk of productivity losses. Given that Brazil accounts for approximately 40% of global soybean production, these impacts have significant implications for food security and for the national economy (Garcia *et al.,* 2025b).

Other crops of national importance may also experience changes in productivity. Estimates based on RCP 8.5 indicate annual productivity losses ranging from 1% to 16% for beans, 1% to 17% for rice, and 13% to 61% for maize, depending on the biome. These impacts show a high degree of regional heterogeneity, reflecting climate and structural differences across the country. The South, Southeast, and Central-West regions tend to experience the largest losses (Souza and Haddad, 2021).

These risks are exacerbated by associated environmental and socioeconomic processes, such as soil degradation, the loss of agrobiodiversity and agricultural genetic resources, the emergence of pests and outbreaks of diseases, and water shortages for irrigation and livestock watering. These factors may render supply chains unviable and increase production costs, affecting both family farming and larger-scale production systems, particularly the social sectors that are most vulnerable and exposed to climate risks (Brasil, 2025e, 2025h, 2025i).

Climate risks related to food security have important synergies with other dimensions of the socioecological system. A decline in agricultural productivity can trigger cascading effects on food systems, reducing food availability and increasing prices, while limited access to land, water, and adaptive technologies constrains producers' capacity to respond. Thus, the risks associated with food systems, particularly the production of healthy foods, and the socioeconomic vulnerabilities of populations reinforce one another, increasing the complexity of adaptation challenges in both urban and rural contexts (Brasil, 2025e, 2025h, 2025i).

In this context, risks related to the availability of and access to healthy, regular, and adequate food, a human right guaranteed by the Constitution, directly reflect the interactions described above, highlighting how productive, environmental, and socioeconomic dynamics interact in shaping climate risk. However, an analysis of future scenarios indicates a trend toward an increase in these risks, both in terms of food availability and access to food, due to the worsening of climate-related hazards and their impacts on production, distribution, and prices. Thus, projections of these scenarios reinforce the need for adaptation strategies that take into account not only current conditions, but also expected changes in climate patterns and their effects on food systems.

Climate risk analysis should incorporate vulnerability, defined as the susceptibility of systems and populations to adverse impacts, as well as their capacity to respond and adapt. Thus, vulnerability plays a central role through adaptive capacity and sensitivity, influencing the

22 An econometric model using panel data at the municipal level (2000-2022) was employed, combining IBGE data on soybean production with climate data on temperature, precipitation, and air humidity. The climate variables were obtained from the ERA5 reanalysis, with adjustments to achieve a resolution compatible with the municipal level in Brazil (Garcia et al., 2025b).

reduction of the impacts on food security, especially in contexts marked by limitations in income, access to resources, and infrastructure.

Vulnerabilities

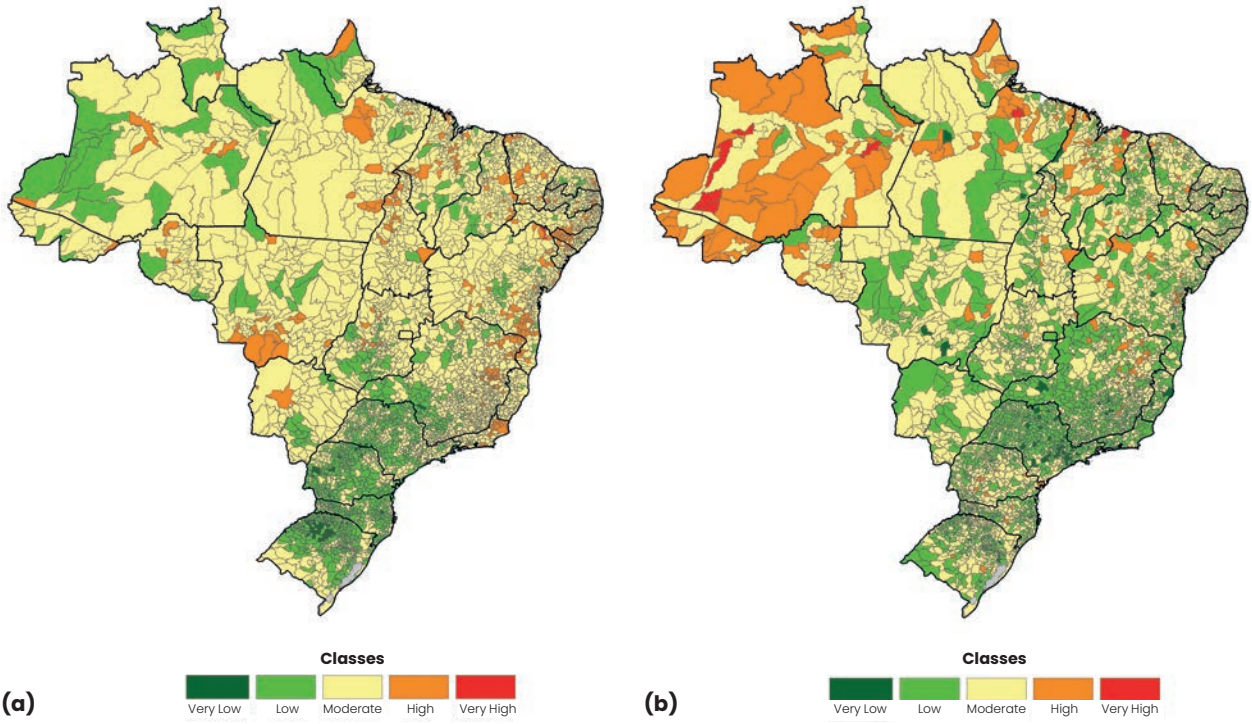
Climate impacts and risks tend to affect certain social groups and territories more severely, highlighting important dimensions of climate justice. Among the most vulnerable groups are family farmers, agrarian reform settlers, Indigenous Peoples, Quilombola communities, Roma and *terreiro* peoples, and other potentially affected groups of traditional communities, as well as low-income rural populations and small-scale producers. Women farmers, rural youth, children, and other historically marginalized groups are also more exposed to the effects of climate change due to structural inequalities related to access to productive resources, land, credit, infrastructure, and public policies (see **Box 4.3**) (Brasil, 2025e, 2025h, 2025i).

Several structural factors contribute to increasing the vulnerability of these groups, such as their dependence on production systems that are sensitive to climate variability, limited access to land and water, the limited availability of technical assistance and adaptive technologies, as well as the occurrence of land and territorial conflicts (AdaptaBrasil, 2026c, 2026d; Brasil, 2025i). The prevalence of rainfed agricultural systems[23] in various regions of the country also increases exposure to the impacts of droughts and irregular rainfall (Brasil, 2025h) (see **NG3: 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**).

From a territorial perspective, climate risks are distributed throughout the country, but are most severe in regions characterized by greater socio-environmental vulnerability. The Brazilian semiarid region is particularly noteworthy, as prolonged droughts, desertification, and water insecurity increase the challenges to food production and the maintenance of rural livelihoods. Regions with a strong presence of family farming, such as the North and Northeast, also require priority attention, as do traditional territories, areas with poor infrastructure, and regions affected by socio-environmental conflicts (Brasil, 2025e, 2025h, 2025i, 2025p). Regional inequalities reinforce this situation: in 2023, hunger affected 7.7% of households in the North, compared with 2% of households in the South, highlighting important territorial differences in vulnerability to food insecurity (Santos-Degner *et al.*, 2025). The North, Northeast, and Central-West regions have the highest levels of medium- to high-level vulnerability regarding food availability and access in the context of drought-related climate risk; among the factors contributing to this vulnerability are those associated with production, technical assistance, and socioeconomic conditions (Figure 4.44, AdaptaBrasil, 2026c, 2026d).

23 Rainfed agriculture: Crops are planted during the rainy season. It becomes a high-risk form of agriculture because crop success depends on the distribution of precipitation (rainfall), as dry spells during critical stages of crop development, such as flowering or pod filling, can reduce final yields (Embrapa, 2026).

Figure 4.44 (a) Vulnerability regarding food availability. (b) Vulnerability regarding food access and consumption



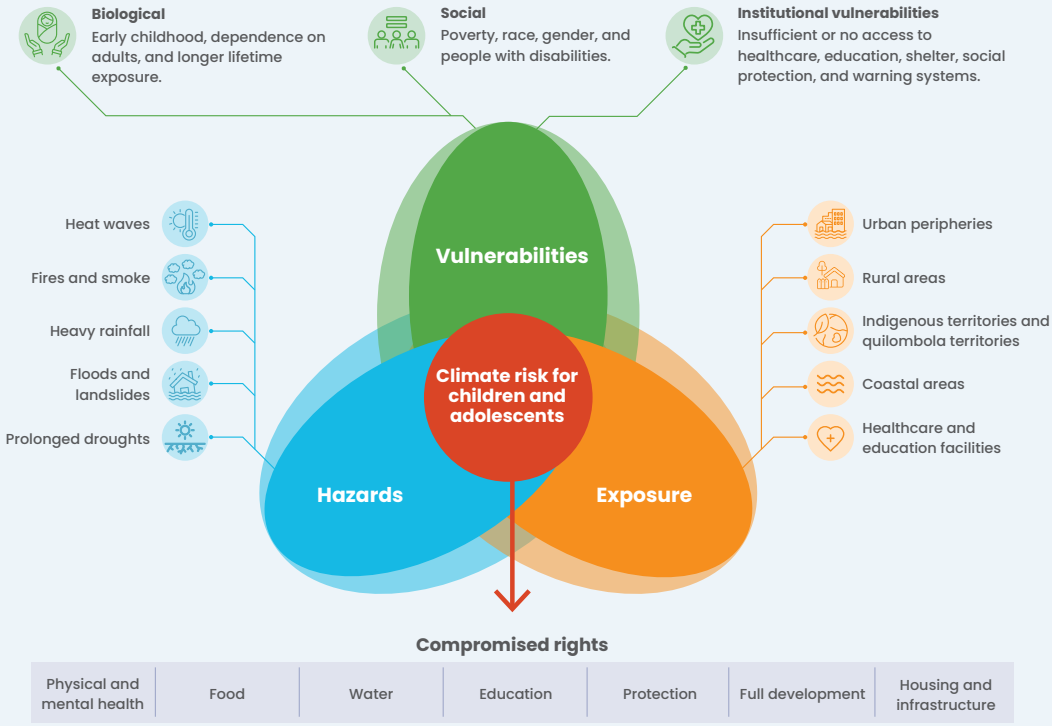
Source: AdaptaBrasil, 2026c, 2026d.

Finally, climate change can exacerbate existing vulnerabilities, with direct implications for food production, prices, and access, especially among the most exposed populations (Severo *et al.*, 2025).

BOX 4.3 CLIMATE CHANGE IMPACTS, RISKS, AND VULNERABILITIES FOR CHILDREN AND ADOLESCENTS IN BRAZIL

Climate change increasingly impairs the right of children and adolescents to a clean, healthy, and sustainable environment and, in turn, the exercise of the rights to health, food, water, education, protection, and development (Figure 4.45). In Brazil, the impacts of climate change on children and adolescents vary significantly across territories, reflecting the interaction between different environmental contexts, socioeconomic inequalities, and unequal access to essential services (UNICEF, 2022; IPCC, 2022; Médicos pelo Clima, 2025). **It is estimated that more than 40 million Brazilian children and adolescents, approximately 60% of this population, are exposed to more than one climate or environmental risk**, including heat waves, water scarcity, fluvial floods, and air pollution, highlighting the magnitude of the adaptation challenges faced by the country (UNICEF, 2022). This high level of exposure reflects not only the diversity of climate-related hazards across Brazil, but also the specific characteristics of child development and the inequalities that shape the vulnerability and adaptive capacity of children and adolescents.

Figure 4.45 Climate risk for children and adolescents



Source: Compiled by the authors, adapted from Bustamante, 2025; IPCC, 2022; Santos-Degner *et al.*, 2025; FMCSV - Maria Cecilia Souto Vidigal Foundation (Fundação Maria Cecilia Souto Vidigal), 2025; Médicos pelo Clima (Doctors for Climate), 2025; UNICEF, 2022.

Due to the unique characteristics of their physical, physiological, and cognitive development, their greater dependence on adults and on essential services, and their prolonged exposure to climate change throughout their lives, children and adolescents constitute one of the priority population groups for adaptation policies (Figure 4.45). As climate change intensifies, these risks tend to increase and increasingly compromise the health, food security, education, protection, and development of this population.

The impacts of climate change on children and adolescents manifest themselves in various ways, **compromising access to water, food, healthcare, education, and social protection**. Changes in the hydrological regime, forest degradation, fires, and prolonged droughts exacerbate water and food insecurity, increase respiratory illnesses related to smoke from fires, and hinder access to essential services. These impacts are observed, for example, in the Amazon, where they disproportionately affect Indigenous and riverine children, and other traditional populations; and in the Semi-Arid region, where prolonged droughts and desertification processes compromise food systems, agricultural production, and the nutritional status of children and adolescents (Bustamante, 2025; Santos-Degner *et al.*, 2025; Médicos pelo Clima, 2025). Between 2017 and 2021, an estimated 2,600 cases of internal displacement of children associated with droughts occurred in Brazil (UNICEF, 2023).

In other contexts, the impacts stem from the **disruption of urban systems and public infrastructure**. The fluvial flooding events that occurred in the South region in 2024 highlighted how extreme events can cause population displacements, disrupt school activities, jeopardize health and social services, and result in the loss of homes. It is estimated that 1,178,435 students were affected by school disruptions in 2024 alone due to extreme weather events, particularly by fluvial flooding events (UNICEF, 2025). In major urban centers, the combination of heat islands, soil sealing, a lack of green spaces, precarious settlements, and air pollution intensifies the impacts on the well-being, learning, and physical and mental health of children and adolescents (Bustamante, 2025; Carvalho, 2025; Médicos pelo Clima, 2025).

In the Brazilian context, these risks are even higher due to socioeconomic, racial, territorial, and gender inequalities, which increase exposure and vulnerability and limit the adaptive capacity of children and adolescents (Bustamante, 2025; Santos-Degner *et al.*, 2025; IPCC, 2022; UNICEF, 2022). Poverty and unequal access to adequate food and safe drinking water (see **NG3: 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**), sanitation, housing, education, health services, and social protection reduce the capacity of children, adolescents, and their families to cope with, respond to, and recover from the impacts of climate change (IPCC, 2022; UNICEF, 2022). Food and water insecurity, important mediators of the impacts of climate change on child health, are more prevalent among households headed by women, Black people, Indigenous Peoples, and Quilombola communities (Santos-Degner *et al.*, 2025).

The risks also vary depending on the stage of development and other social markers. Early childhood is a period of heightened biological and developmental sensitivity, during which exposure to extreme heat, air pollution, food insecurity, water contamination, and extreme events can have lasting effects on growth, cognitive development, learning, and mental health (Instituto Alana (Alana Institute), 2024; Bustamante, 2025; Fundação Maria Cecilia Souto Vidigal, 2025). Children with disabilities face greater barriers to evacuation, continuity of care, and access to health and social services during disasters. Girls tend to experience differentiated impacts related to overburdening by increased caregiving responsibilities, interruption of their education, and heightened risks of violence in emergency contexts. Indigenous children and children from traditional peoples and communities, such as the Quilombolas, are even more severely affected by environmental degradation, changes in ecosystems, and greater dependence on natural resources for food security, water supply, and maintenance of their ways of life (Bustamante, 2025; UNICEF, 2022).

School infrastructure is an important component of adaptive capacity in the face of climate change. **Only 35% of Brazilian daycare centers and preschools have green spaces, reducing opportunities for adaptation to extreme heat** (Maria Cecilia Souto Vidigal Foundation (Fundação Maria Cecilia Souto Vidigal, 2025)). In Brazilian state capitals, 37.4% of early childhood and primary schools have no green spaces on their premises, a figure that rises to 43.5% among early childhood education schools. This shortage is even more common in schools located in *favelas* and urban communities (52.4%) and in those with a higher proportion of Black students; 51.3% of schools in high-risk areas

have more Black students, while 4.7% have more white students, highlighting how racial and territorial inequalities are also reflected in school infrastructure and in the capacity to adapt to climate change (Instituto Alana, 2024). In addition, **approximately 370,000 children enrolled in early childhood education and elementary school attend schools located in areas prone to fluvial flooding, flash floods, and landslides** in **Brazilian state capitals** (Alana Institute (Instituto Alana, 2024)). These conditions reduce the adaptive capacity of communities and local systems, increasing their susceptibility to the impacts of climate change. As a result, the same climate event can have very different impacts across population groups and territories, deepening pre-existing inequalities and compromising multiple children's rights (Bustamante, 2025; Santos-Degner *et al.*, 2025; UNICEF, 2022).

These findings reinforce the importance of incorporating the specific characteristics of childhood and adolescence into adaptation policies and actions by reducing environmental exposure, strengthening essential services, inclusive early warning and social protection systems, and ensuring the meaningful participation of children and adolescents in decisions that affect them.

NG3: 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

Observed impacts

Sectoral consumptive water use in Brazil is primarily allocated to irrigated agriculture (50.3%), urban water supply (22.3%), and manufacturing industry (9.9%), which together account for approximately 83% of the total volume of freshwater withdrawn, followed by livestock water supply, thermoelectric power generation, and mining (ANA, 2025a). The volumetric distribution of these uses, however, should not be confused with their order of priority: The National Water Resources Policy stipulates that, in situations of water scarcity, human supply and livestock watering take precedence over other consumptive uses, a principle that confers upon access to safe drinking water the status of a fundamental right in water resources governance and that should guide the analysis of the information presented below.

Water security is defined as the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socioeconomic development; for ensuring protection against water-borne pollution and water-related disasters; and for preserving ecosystems in a climate of peace and political stability (UN-WATER, 2013). Water security has come under increasing pressure from a range of observed impacts that combine reduced water availability, increasing rainfall variability, rising temperatures, and changes in water stocks. Evidence indicates trends toward drier conditions across extensive areas of the country, interspersed with extreme precipitation events (Brasil, 2025k; ANA, 2024b).

Regionally, these trends vary, with decreases in low flows in the southern Amazon and Central-West regions and increases in high flows in the Northeast and Southeast, influenced by the effects of climate change and land use (Chagas *et al.*, 2022). Furthermore, extreme weather events have increasingly occurred in a combined and simultaneous way across Brazil, exacerbating impacts on water resources (Gesualdo *et al.*, 2024). Compound events and uncertainties associated with the hydrological regime represent an increasing challenge for adaptation and integrated water resources management in Brazil.

As detailed in section **4.2.1.2. Current climate change trends,** the past few decades have been marked by alternating periods of severe droughts and extreme rainfall, with water crises being the predominant events. Prolonged and successive droughts occurred in various regions of the country between 2013 and 2020, affecting water supplies in major urban centers, as well as activities such as agriculture, livestock farming, fisheries, tourism, and transport. Between 2020 and 2024, there were critical events, most notably the 2021 drought in the Southeast and Central-West, which severely affected energy supply and generation, as detailed in **NG6: Ensure energy security in a sustainable and accessible manner**. In the South, the 2022 drought caused significant economic losses in agriculture. In the Amazon and Pantanal, the most critical period was between 2023 and 2024, when Rio Negro (Negro River) in Manaus reached its lowest water level on record, also increasing the risk of fires, isolating communities, and affecting local fauna, as will also be discussed under the main risks and vulnerabilities of NG4: Protect, conserve, restore and strengthen ecosystems and biodiversity, while ensuring the provision of ecosystem services (ANA, 2025a; Brasil, 2025k).

Monitoring of changes in surface water extent using satellite observations found a 1.1% decrease in the surface area of permanent water bodies, a 1.6% decrease in the minimum reservoir area, and a decrease of more than 7% in minimum river flows from 2017 to 2021 relative to the 2000-2019 baseline (ANA, 2025a). Studies indicate that, beginning in 1980, there has been a significant trend toward the intensification of droughts in the river basins of central Brazil, particularly in the Cerrado, Caatinga, and Pantanal biomes, with increased evapotranspiration and decreased precipitation (Tomasella *et al.*, 2023, 2025a; Silva et al., 2023).

Between 2021 and 2023, approximately 26.7 million people were affected by more than 4,000 drought events recorded in the country. These events were concentrated mostly in the Northeast, where 49.3% of the population was affected (Brasil, 2025k). An assessment conducted by Rede PENSSAN - Brazilian Research Network on Food and Nutrition Sovereignty and Security (Rede Brasileira de Pesquisa em Soberania e Segurança Alimentar e Nutricional)[24], as outlined in the Food and Nutrition Security Adaptation Plan, indicates that approximately 12% of the Brazilian population faces poor access to water, and that food insecurity is strongly associated with this constraint (Brasil, 2025e).

The effects of this scenario also extend to public health and education. Water scarcity, combined with deficiencies in sanitation services, contributes to an increased incidence of waterborne diseases and has important indirect impacts, such as school absenteeism among children and reduced educational performance (see **Box 4.3**). The lack of or inadequacy of water supply,

24 Rede PENSSAN is a national association that brings together researchers, academic institutions, and professionals dedicated to the production and dissemination of knowledge on food and nutrition sovereignty and security, contributing to the monitoring of hunger and food insecurity in Brazil and to the improvement of public policies in this area. Available at: <https://redepenssan.org.br/>. Accessed on: Aug 17, 2026.

sanitation, and hygiene infrastructure compromises continuous access to education. It is estimated that, each year, more than 300,000 children are hospitalized for illnesses associated with a lack of basic sanitation, with repercussions that extend into adulthood, according to a study by Instituto Trata Brasil (Trata Brasil Institute) (2024), based on data from the Ministry of Health and the IBGE.

The effects of water scarcity also affect women differently (see **Box 4.4**), particularly due to structural gender inequalities and the division of labor, which makes them primarily responsible for household water supply and management, especially in critical regions such as the Brazilian semiarid region (Brasil, 2025e). During droughts, irregular water supply and the need to seek alternative water sources increase workloads, heighten exposure to risks, including violence, and adversely affect health and well-being. These conditions have a more severe impact on households headed by women, who often also bear the financial burden of accessing water, highlighting the gender dimension of the water crisis (Moraes, 2025).

This evidence demonstrates that the water crisis in the country goes beyond a physical imbalance between water supply and demand. It is an unevenly distributed phenomenon whose impacts fall more heavily on populations in situations of greater vulnerability, especially in scattered rural areas, urban peripheries, and watersheds where competition for water for different uses is more intense (Brasil, 2025e, 2025k).

Future risks

As it is a cross-cutting issue, risks associated with water security were identified in several sectoral and thematic adaptation plans and are also addressed under other themes in this section. The Thematic Plan for Water Resources (Brasil, 2025k) identifies as priorities the risks related to reduced surface water and groundwater flows, associated with droughts, as well as increases in flows resulting from extreme events, such as floods. The Agriculture and Livestock Plan (Brasil, 2025i) highlights the risk of water scarcity for irrigation and for human consumption and livestock watering, resulting from reduced rainfall across a large portion of the country and the consequent decline in river and stream flows, particularly in rural areas. This is noteworthy, given that irrigation is the primary consumptive use of water resources in the country, accounting for more than 50% of demand (ANA, 2025a).

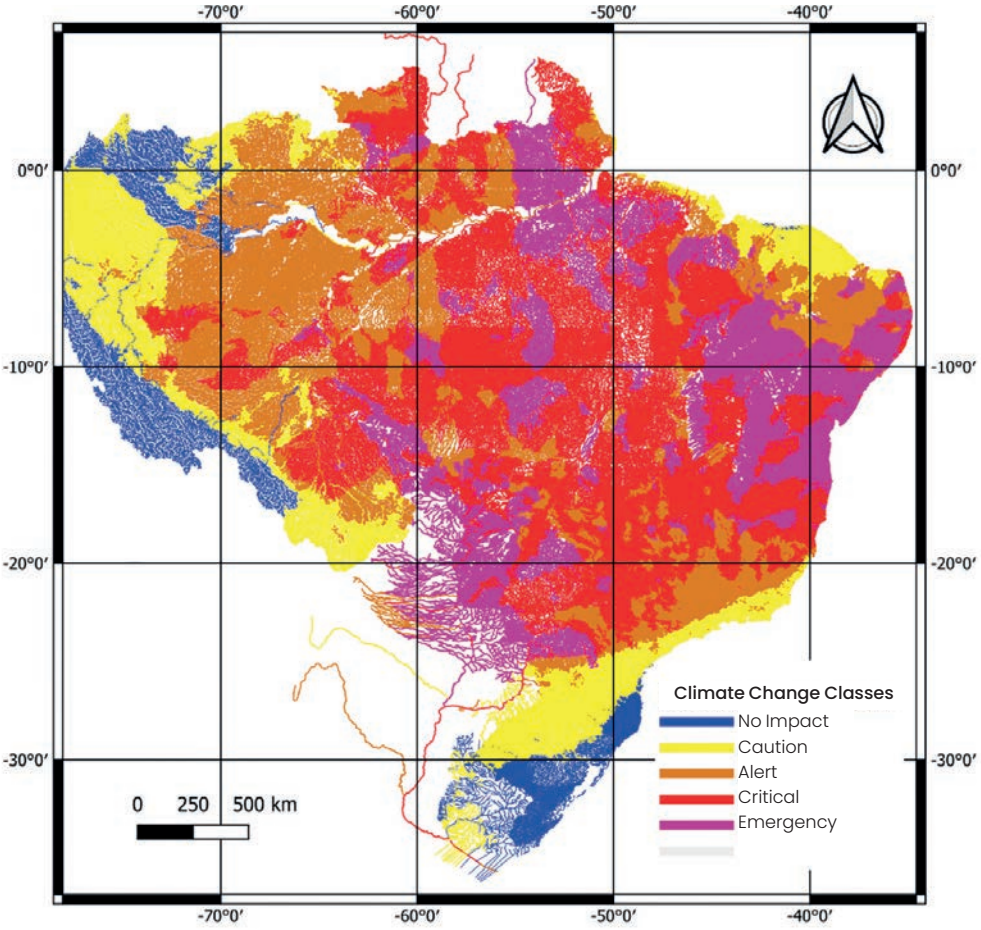
Several Plans identified risks related to reduced water availability for human supply and food production, both in urban and peripheral contexts, with an emphasis on reduced access to basic sanitation (Brasil, 2025a), and among specific population groups, such as traditional peoples and communities (Brasil, 2025g), Indigenous Peoples (Brasil, 2025d), and Quilombola communities, communities of African origin, and Roma peoples (Brasil, 2025f). These risks highlight concerns about increasing food and nutrition insecurity resulting from water scarcity. The Food Security Plan (Brasil, 2025e) also identifies access to water as one of the main risks and vulnerabilities from the perspective of realizing the Human Right to Adequate Food. The Health Plan (Brasil, 2025j), in turn, highlights the impacts of inadequate access to water, sanitation, and hygiene, as well as increasing droughts. This phenomenon is also highlighted by the Transport Sector (Brasil, 2025b), which links dry spells to the risk of disruption of navigation, including on waterways, suspension of port operations, and damage to waterway infrastructure.

The study entitled *"Impact of Climate Change on Water Resources in Brazil"* (ANA, 2024b) assessed the potential effects of climate change based on multiple representative scenarios,

considering three time horizons (2015-2040, 2041-2070, and 2071-2100) and using the smallest territorial scale available, based on the Ottocoded Hydrographic Base (BHO, Base Hidrográfica Ottocodificada). The results indicate a downward trend in precipitation and, consequently, in streamflows in 10 of the country's 12 hydrographic regions, with the exception of the Uruguay and South Atlantic regions. Evapotranspiration, in turn, is projected to increase throughout the country, particularly in the Amazon, Paraguay, and São Francisco river basins. The study also highlights increasing future uncertainty regarding precipitation and streamflow patterns, adding a significant challenge to water resources management (Brasil, 2025k).

Based on the modeling results, a classification system was developed based on risk levels for water availability, influenced primarily by water scarcity, with the aim of guiding the development of adaptation strategies focused on this issue. The cartogram below shows this risk classification across the country (Figure 4.46), ranging from situations in which climate scenarios indicate no significant changes relative to the current pattern (no-impact class) to scenarios with a high potential for impacts that require intensive action (critical class) or immediate responses to imminent water scarcity (emergency class).

Figure 4.46 Classification of the potential impact of climate change on water availability



Source: Brasil, 2025k.

Critical and emergency risk classifications are predominant throughout the country. The hydrographic regions of the São Francisco, Paraná, Tocantins-Araguaia, Paraguay, and Xingu rivers contain a large number of sections classified as vulnerable. The study also cross-referenced the results of the future scenarios with the water intake points registered with the National Water and Basic Sanitation Agency (ANA) for the irrigated agriculture, power generation, public water supply, and industrial sectors. Among these, irrigated agriculture stands out as the most vulnerable sector, with more than 54% of its water intake points falling into the "critical" and "emergency" classes, followed by the urban water supply, industrial, and hydroelectric power generation sectors (Brasil, 2025k). This situation is likely to worsen given the projected increase in water demand of up to 15% by 2040, compared to the demand estimated based on current mean climate conditions (ANA, 2025a). In the case of the Pantanal, projections of reduced precipitation and rising temperatures would lead to a decrease in the frequency and magnitude of flood pulses, with direct implications for regional water security and the multiple uses of water in the Paraguay and Paraná river basins (Petry *et al.*, 2025).

Vulnerabilities

Given the cross-cutting nature of water-related issues, vulnerabilities and adaptive capacities vary significantly across the country. Among the main factors contributing to climate vulnerability identified in the Water Resources Adaptation Plan (Brasil, 2025k), the following are highlighted:

- **Demographic and economic pressures**: Demand for water has grown substantially in the country, driven by factors such as population growth, expanding urbanization and increased access to basic sanitation, a reduction in average household size, rising incomes, and increased agricultural and industrial activities, in addition to the effects of rising temperatures (Carmo *et al.*, 2014; Veiga *et al.*, 2023). In 2024, the urban water supply, irrigated agriculture, and manufacturing industry sectors together accounted for about 83% of total water withdrawals, with the agriculture sector accounting for approximately 58% of the total. Between 2006 and 2024, water withdrawal in the country increased by 24% (ANA, 2025a);
- **Inefficient water management**: Water management still faces challenges stemming from inadequate infrastructure and practices that could be improved, resulting in significant losses and waste. The agriculture sector, given the large volumes of water it uses and its presence across various regions of the country, offers important opportunities for improving water-use efficiency. In urban areas, a survey based on 2023 data indicates that 40.3% of the treated water produced in the country is lost before reaching the end consumer, totaling approximately 5.8 billion m³ annually, a volume that is sufficient to supply about 50 million people per year (Instituto Trata Brasil (Trata Brasil Institute) and Go Associados, 2025). Currently, only 44.7% of the national territory is covered by state or interstate watershed committees, which are fundamental instruments of participatory water management (ANA, 2025a). The limited budgetary resources allocated to the sector also hinder the effective implementation of integrated water resources management (ANA, 2025a; Brasil, 2025k);
- **Environmental degradation**: Deforestation, watershed degradation, and the expansion of urbanized areas (Prates *et al.*, 2012) reduce the soil's capacity to retain water and reduce water's capacity to infiltrate the soil, affecting river flows and aquifer recharge. According to models developed for the Thematic Plan for Water Resources Adaptation, the deficit in

Permanent Water Preservation Areas (APPs, Áreas de Preservação Permanente)[25] in Brazilian biomes is estimated at approximately 9 million hectares;

- **Over-exploitation of aquifers**: In many cases, excessive groundwater extraction occurs at rates that exceed natural recharge capacity. Added to this are limitations in data and monitoring systems, which make it difficult to understand the effects of climate change on aquifers, the management of which involves constitutionally shared responsibilities between the Federal government and the states, with ANA playing a coordinating role in interstate and transboundary aquifer systems, and with private users representing the primary sources of pressure on recharge;
- **Inequality in access**: Climate change tends to exacerbate existing inequalities. It is estimated that about 10 million people in Brazil still lack access to safely managed drinking water services. The highest concentrations of households without access to piped water are in the North, Northeast, and Southeast regions. Racial inequality is consistently evident, with non-white populations having less access in every region of the country. The lack of access to drinking water is a critical indicator of racial and socioeconomic inequality in Brazil, a component that is also mentioned in **Box 4.7** and **NG2: Promote sustainable and resilient production and regular access to healthy food of adequate quality and quantity** (ANA, 2025b);
- **Inequality in supply**: The country exhibits contrasting regional realities, with significant asymmetry in the spatial distribution of water resources relative to demand. The Amazon region accounts for approximately 80% of the country's water availability, but less than 7% of its water demand, while more populous regions with intensive agricultural activity, such as the Paraná River Basin, account for approximately 19% of water withdrawals, but have only 6.8% of the country's water availability. Given Brazil's continental dimensions, water balance and water resources management must take these regional and local specificities into account, since supplying water across large areas of different river basins is not feasible (ANA, 2025a);
- **Impaired water quality**: Low coverage of sewage collection and treatment services, combined with diffuse pollution and increased sediment loads, impairs water quality and limits its uses. Inequalities in access to safely managed sanitation services persist, with coverage reaching 62.9% of the white population, compared with only 51.2% of the non-white population (ANA, 2025b). In 2023, only 57.6% of domestic wastewater was treated safely, and 73.6% of the monitored water bodies had good water quality (ANA, 2025a);
- **Escalation of conflicts over water use**: The most vulnerable regions tend to experience an escalation of conflicts associated with the multiple uses of an increasingly scarce resource. In addition, Brazil is home to six major international river basins and shares eleven transboundary aquifer systems, which pose additional challenges for establishing operational agreements, cooperation mechanisms, and joint management arrangements (ANA, 2025a).

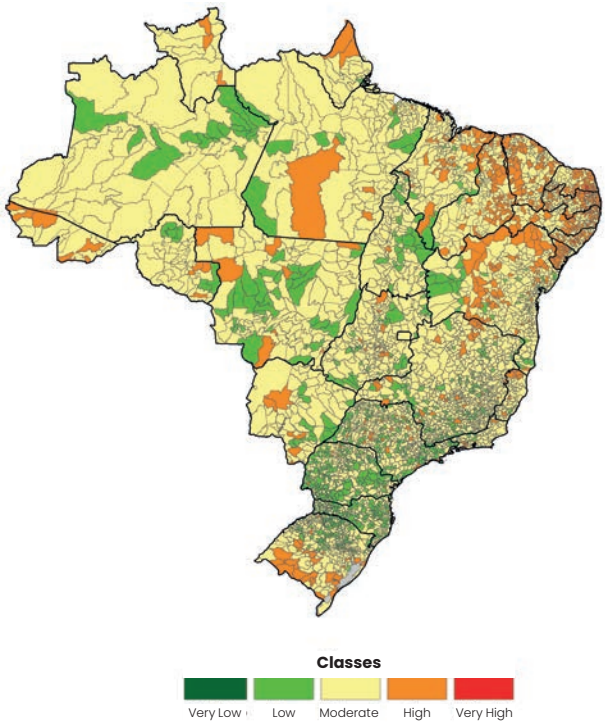
These vulnerability factors are included in the vulnerability index that makes up the water stress risk index, developed by AdaptaBrasil MCTI (Figure 4.47). Indicators such as water quality and production efficiency tend to reduce vulnerability when present, highlighting the strategic role of sanitation and of the operational management of water systems. These factors indicate that hydrological resilience depends as much on climate conditions as it does on the integrity

25 Permanent Water Preservation Areas (APPs) are protected areas, whether or not covered by native vegetation, located around natural bodies of water, such as riverbanks, lakes, springs, and waterholes, as well as on slopes and in wetlands associated with the hydrological regime. Under the terms of Law No. 12,651/2012, these areas serve the environmental purpose of preserving water resources, ensuring the stability of ecosystems, protecting biodiversity, ensuring gene flow among fauna and flora, and preventing degradation processes such as erosion and siltation.

of infrastructure, soil conservation, and vegetation (AdaptaBrasil, 2026e; Brasil, 2025k). Poorer populations, those living in risk areas or without access to adequate infrastructure, and those who depend directly on ecosystem services for their livelihoods are more severely affected by droughts, floods, and water supply disruptions (Brasil, 2025e; 2025k).

According to AdaptaBrasil MCTI (2026e), a large portion of the country (more than 80%) has very low, low, or moderate adaptive capacity to water stress. Only 17.3% of municipalities fall into the high or very high capacity categories, reflecting, for example, higher household income, better water storage conditions, and greater diversification of water supply sources. In contrast, the socioeconomic constraints faced by vulnerable social groups and the need to strengthen policies and programs for water management and access, such as the installation of cisterns and other water-access technologies, remain key factors to ensure access to quality water, particularly for human consumption and food production, especially in the North and Northeast regions, as well as in scattered rural areas. This disparity in adaptive capacities means that, even in the face of similar hazards, the severity of impacts and the speed of recovery tend to vary significantly across regions and social groups (AdaptaBrasil, 2026e; Brasil, 2025e).

Figure 4.47 Vulnerability of Brazilian municipalities based on the water stress risk index



Source: AdaptaBrasil, 2026e.

BOX 4.4 GENDER AND CLIMATE: MAIN RISKS AND VULNERABILITIES

Climate change disproportionately affects women and girls, particularly Black, Indigenous, Roma, rural, and peasant women and girls; women family farmers; women and girls from peripheral urban areas; those belonging to traditional peoples and communities (such as Quilombola communities); women experiencing homelessness; and LBTI women (Lesbian, Bisexual, *Travesti*, Transgender, and Intersex women) (Brasil, 2026b). This overview was presented throughout this section, with data highlighting socioeconomic gender disparities in section **4.1.1, National circumstances relevant to adaptation actions** and, in a cross-cutting way, in discussions on vulnerability related to the themes addressed under impacts, risks, and vulnerabilities.

Recognizing the need for a specific assessment and for the development of guidelines, goals, and action plans that promote consideration of structural inequalities in addressing climate change, the Cross-Cutting Strategy on Women and Climate was developed under the Climate Plan, coordinated by the Ministry of Women (Brasil, 2026b).

The Cross-Cutting Strategy identifies, among the main risks associated with the relationship between gender and climate, the **reduction in economic autonomy and the increase in the burden of care**. Brazilian women play a central role in providing for their families, being responsible for approximately half of all households, and spend, on average, more hours per week on unpaid domestic work than men. The intensification of extreme weather events increases this burden by increasing demands related to caregiving, water management, food security, and recovery from damage, particularly in situations of vulnerability. This reduces the time available for education, entry into the labor market, and social participation, making it more difficult to build pathways toward economic autonomy.

The education of girls and women is also significantly hindered. Extreme events have disrupted classes and hindered access to basic services in schools, with more severe impacts on students living in poverty and in vulnerable territories. Climate change exacerbates problems such as period poverty, increasing barriers to remaining in school and widening gender inequalities.

Another critical aspect is the i**ncrease in gender-based violence in the context of climate change.** Extreme events and disasters are associated with an increase in domestic, sexual, and institutional violence, which can persist for long periods after the events. Situations involving displacement, loss of income, and the weakening of safety nets increase risks, as evidenced by recent disaster situations in Brazil, where cases of gender-based violence were reported in temporary shelters used following the fluvial flooding disaster in Rio Grande do Sul (Stochero *et al.*, 2024).

Food and water insecurity and land loss constitute another key area of risk that affects women more severely. In Brazil, a significant portion of women still lack adequate access to treated water and sanitation, which jeopardizes their health and social participation. Food insecurity has a strong gender dimension. In 2024, approximately 60% of households facing food insecurity were headed by women (IBGE, 2025f). In rural areas, inequalities in access to land, credit, and technical assistance exacerbate the vulnerability of women farmers, despite their vital role in food production.

The impacts also extend to **access to essential public services and damage to infrastructure**. Extreme events affect transport, sanitation, energy, and health systems, with more severe impacts on women, who rely more heavily on these services and make multiple trips related to paid work and caregiving responsibilities. In this context, adaptive social protection policies, such as cash transfers, care services, and safe shelter, are essential for reducing vulnerabilities and strengthening resilience.

In this context, women are also more severely affected by the impacts of climate change on **physical and mental health**. Heat waves, air pollution, vector-borne diseases, and disruptions to healthcare services particularly affect women in vulnerable situations, including pregnant women and caregivers. There is evidence of direct impacts, such as the link between high temperatures and preterm births and low birth weight (Brasil, 2026c), as well as difficulties in treatment follow-up during extreme weather events. In addition, significant effects on mental health, such as anxiety, chronic stress, and depression, are already being observed, associated with insecurity, loss, forced displacement, and an increased burden of responsibilities (Skonieski *et al.*, 2026).

Finally, the **underrepresentation of women and the risk of reduced participation by women in decision-making and rights advocacy forums** should be highlighted, as this limits the incorporation of their perspectives into public policies. Low levels of political participation, combined with gender-based political violence and the risks faced by women who are environmental advocates, especially Indigenous women and those from traditional communities, constitute a major obstacle to incorporating a gender perspective and developing more inclusive and effective responses to climate change. In 2023, women made up only 17.9% of Brazil's parliament (IBGE, 2024d). Brazil ranks second in the world in the number of deaths of environmental and human rights activists, with 26 cases in 2025, predominantly motivated by land conflicts (Global Witness, 2026).

Despite the lack of data on climate impacts disaggregated by gender, which limits more precise assessments and the formulation of more effective public policies, the available evidence points to inequalities in the impacts of climate change. The intersectionalities of gender, color or race, class, and other markers should also be considered relevant factors that exacerbate vulnerabilities, highlighting that the impacts are not felt by the entire population in the same way. At the same time, women, in all their diversity, play a central role in developing sustainable solutions, sustaining care networks, promoting social cohesion, and leading innovative adaptation practices, such as agroecology and other strategies for living with climate conditions (Brasil, 2026b).

NG4: Protect, conserve, restore and strengthen ecosystems and biodiversity, while ensuring the provision of ecosystem services

Observed impacts

Brazil is the most biodiverse country on the planet. It is estimated that the six Brazilian biomes, the Amazon, Caatinga, Cerrado, Atlantic Forest, Pantanal, and Pampa, currently harbor about 10 to 15% of the world's total species, in addition to the rich marine biodiversity found in Brazil's marine territory (Brasil, 2026f). Rising temperatures, changes in rainfall regime, and the intensification of extreme weather events resulting from climate change are already having an impact on these ecosystems and threatening Brazil's biodiversity (Brasil, 2025l).

The observed impacts on biodiversity and ecosystem services in Brazil point to an accelerated process of degradation resulting from a combination of anthropogenic pressures and climate change. Habitat loss and fragmentation have already substantially reduced the capacity of ecosystems to perform essential functions, such as climate regulation, pollination, water quality maintenance, and soil stability (Brasil, 2025l). Recent studies point to a trend toward increasing aridity in different regions of the country, including the expansion of semiarid areas and the unprecedented emergence of areas classified as arid, as well as growing signs of vegetation stress across all Brazilian biomes (Tomasella *et al.*, 2025b).

The ecological and climate resilience of Brazilian biomes and the coastal-marine system, defined as the capacity of ecosystems to return to a state similar to that prior to a disturbance after experiencing disturbances, thereby restoring their ecological functions, interactions, and structures (Flores *et al.*, 2024), is already declining under current climate conditions. Impacts are already evident in the Amazon, where reductions in precipitation are associated with a decline in forest cover, the risk of tree mortality, loss of biomass, and an increase in the occurrence of fires (Pinho *et al.*, 2020). The coastal-marine system has been experiencing impacts such as rising temperatures and increased marine heat waves, acidification, deoxygenation, sea-level rise, and an intensification of extreme events (IPCC, 2019), with observed impacts that will be detailed under **NG9: Strengthen the vital role of the ocean and coastal zone in tackling climate change**.

In addition to longer dry seasons, the Amazon region has been experiencing rising temperatures. In some areas, long-term monitoring shows that forest degradation has increased, with dense, humid forests that are rich in tree diversity experiencing species mortality and being replaced by species associated with droughts. It is estimated that 38% of the biome's area has been affected by extreme droughts, fires, logging, and edge effects (Flores *et al.*, 2024). In 2023, a historic drought in the Amazon Basin, with above-average temperatures, led to increased evapotranspiration and, consequently, a reduction in available soil moisture. River water levels have reached their lowest point in 120 years, with the surface area of Lake Tefé shrinking by 75% over the course of a month. There was also an increase in the lake's water temperature, which exceeded 40°C even at greater depths, causing the death of fish and more than 200 river dolphins (Clarke *et al.*, 2024; Fleischmann *et al.*, 2025).

A study conducted by INPE observed an average increase of up to 3°C in surface temperature during the dry season and a 12% reduction in evapotranspiration in heavily deforested regions of the Amazon compared with areas that retain more than 80% forest cover. On average, there

were 11 fewer days of rain per year in regions with lower forest cover, indicating that deforestation affects not only the total volume of precipitation but also its distribution over time (Silveira *et al.*, 2025). Recent studies also point to a reduction in precipitation in the southern Amazon associated with historical deforestation, reinforcing the impacts of forest loss on the regional climate (Cui *et al.*, 2026).

In biomes such as the Atlantic Forest, ecological connectivity is severely compromised, affecting species dispersal and the ecological flows necessary for the provision of ecosystem services (Pinho *et al.*, 2020). Species found in mountainous areas, for example, are moving to higher elevations because of climate change. According to Bergamin *et al.* (2024), of the 627 tree species studied at 96 different sites in the Atlantic Forest, 27% showed a tendency to move to higher elevations. The mean temperature in the study region increased by 0.25ºC per decade over the past 50 years.

Another biome severely affected by the loss of native vegetation is the Pampa, driven primarily by the expansion of soybean cultivation and forestry (MAPBIOMAS, 2024). This process compromises important ecosystem services, such as water regulation, carbon storage, and support for traditional extensive livestock farming, in addition to affecting one of the most biodiverse grassland systems in the country, characterized by low levels of legal environmental protection (Overbeck *et al.*, 2015; Ribeiro *et al.*, 2021).

The Cerrado's fauna has also been severely affected by climate change, mainly due to changes in rainfall patterns and the increased frequency of extreme events. Future projections indicate that these impacts on the biome's biodiversity are likely to intensify, with estimates suggesting that approximately 70% of amphibian species could lose part of their geographic range under future climate scenarios (Alves-Ferreira, 2022).

In the Caatinga, the aridification processes observed in recent decades have led to a decline in primary productivity and have directly affected the provision of food and water for human populations and wildlife. Recent studies have identified, for the first time, the presence of an area classified as arid within the biome, in addition to the expansion of semi-arid and dry subhumid areas, highlighting the intensification of the region's aridification process (Tomasella *et al.*, 2025b).

In the Pantanal, the world's largest floodplain, droughts and fires have intensified. A drying trend has been observed in the biome in recent decades, associated with decreases in precipitation, river flows, and the extent of flooded areas. The system is highly sensitive to climate variations, with modeling indicating a contraction in the flooded wetland area of approximately 30% between 1985 and 2021 (Caballero *et al.*, 2025). In 2024, extreme droughts, with rainfall below 60% of the average and record-high temperatures exceeding 40ºC, led to unprecedented levels of wildfires in the Pantanal, destroying an area three times larger than usual (Kelley *et al.*, 2025).

Overall, the observed impacts point to a decline in ecosystem resilience, with biological and socio-environmental effects that are already detectable and increasing. Although the extent of the impact varies across biomes, the predominant trend at the national level is one of increasing negative effects on species and their habitats (Malecha *et al.*, 2025). The convergence of environmental degradation, climate pressures, and monitoring gaps creates a scenario of increasing risks to ecosystems and their services.

Future risks

The Thematic Plan for Biodiversity Adaptation (Brasil, 2025l) identified seven priority risks:

1. Increased risk of extinction of species, populations, and genetic and functional diversity;
2. Increased loss of ecosystems and ecosystem services, and reduced resilience of biomes;
3. A reduction in stocks of sociobiodiversity-derived resources and their economic value;
4. A decline and loss of pollinators and seed dispersers;
5. Increased invasion by and proliferation of invasive alien species;
6. Desertification, arenization, that is, the expansion of sandy patches as a result of soil erosion, surface water processes and vegetation loss (SUERTEGARAY, 2012), accelerated soil degradation, and loss of soil biodiversity; and
7. Increase in fires in natural and managed areas.

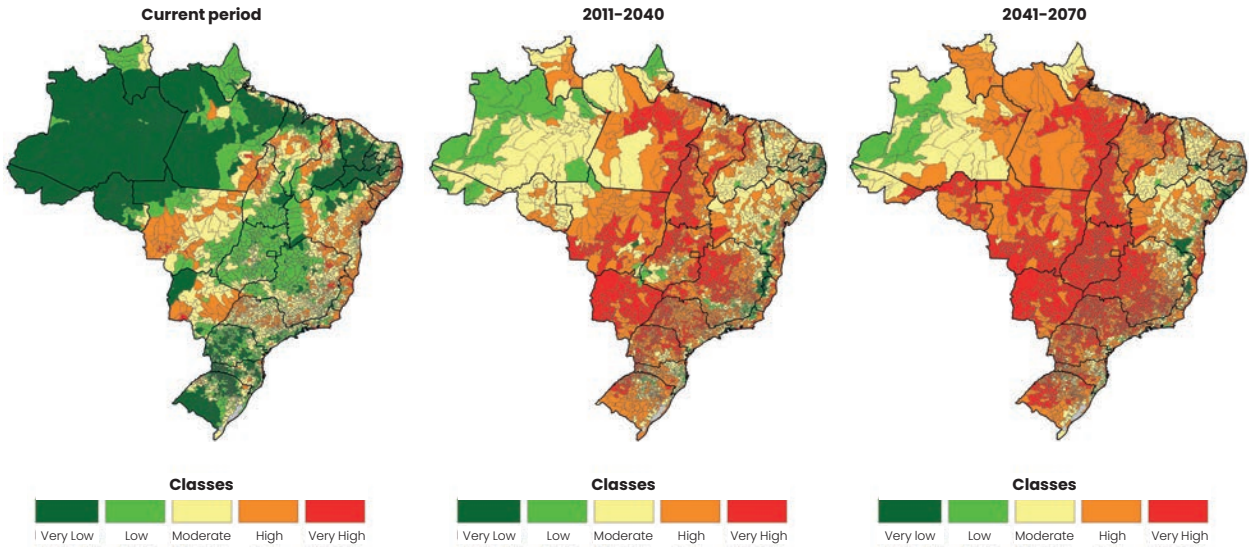
Consolidated projections for Brazil indicate an increase in risks to ecosystems and ecosystem services through the end of the century, with a loss of resilience, especially in the Amazon and in already fragmented ecosystems of the Atlantic Forest (Pinho *et al.*, 2020; Brasil, 2025l). The risks stem from the interaction between climate factors and changes in land use, particularly the increased likelihood and severity of fires in Brazilian biomes, reduced water availability in the Cerrado, and intensified aridification processes in the Caatinga, affecting primary productivity, soil fertility, and the provision of pollination and water regulation services (Brasil, 2025l). In the Pantanal, projections indicate that rising temperatures and decreased rainfall may further intensify the loss of wetlands and the impacts on the biome's biodiversity (Caballero *et al.*, 2025).

Brazilian biomes have varying levels of climate resilience, a concept that refers to an ecosystem's capacity to maintain its original structure and functions following disturbances, and a reduction in this resilience poses a threat to ecological integrity (Pinho *et al.*, 2020). The *Biome Integrity Risk Index*, developed by the AdaptaBrasil MCTI platform, combines vulnerability, exposure, and climate hazard indices, using indicators derived from information from the Fourth National Communication and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)[26], as well as information from other sources, such as the IPCC, the Brazilian Platform on Biodiversity and Ecosystem Services (BPBES, Plataforma Brasileira de Biodiversidade e Serviços Ecossistêmicos), and the Ministry of the Environment and Climate Change (MMA) (AdaptaBrasil, 2026f). The climate resilience of biomes was estimated using climate niche modeling[27] (Pinho *et al.*, 2020) regarding the likely response of the biomes' vegetation to temperature and precipitation conditions different from those of the historical period (1960-1990), considering the RCP 8.5 scenario and the 2011-2040 and 2041-2070 periods. In the current period, more than 53% of Brazilian municipalities are classified as having a medium or high risk. In the 1.5°C warming scenario, these categories include more than 63% of municipalities, while in the 2°C scenario, this figure rises to 72%, an increase of 19% over the period (Figure 4.48).

26 The IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) is an independent intergovernmental platform that brings together governments, scientists, and other experts to assess the state of biodiversity and ecosystem services, providing scientific input for the formulation of public policies aimed at the conservation and sustainable use of nature. Available at: <https://www.ipbes.net/>. Accessed on: Aug 17, 2026.

27 It was assumed that each vegetation type is adapted to a specific range of current temperature and precipitation conditions (Pinho et al., 2020).

Figure 4.48 Biome Integrity Impact Risk Index for Brazil for the current period and for the 2011-2040 and 2041-2070 periods under the RCP 8.5 scenario

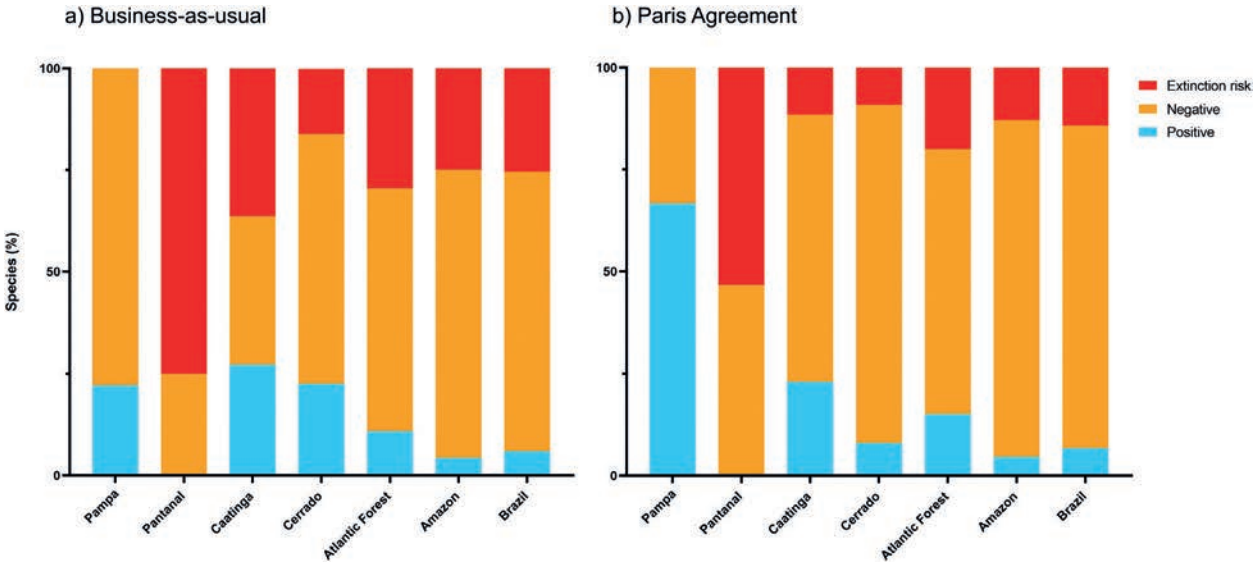


Source: AdaptaBrasil, 2026f.

A publication compiling 20,582 risk projections derived from 131 scientific studies found that, under a business-as-usual scenario (BAU ≥ 2ºC), that is, a more severe climate change scenario that assumes no implementation of emissions reduction policies, the mean annual magnitude of impacts on Brazilian biodiversity is greater than that observed under a scenario compatible with the Paris Agreement (< 2ºC) (Malecha *et al.*, 2025). Adherence to the Paris Agreement could reduce mean impacts by approximately 20% and halve the proportion of species at risk of extinction (loss of >80% of their geographic range). The differences between the impacts projected for the two scenarios are statistically significant for the Amazon and Atlantic Forest, the biomes with the largest database, reinforcing that increased GHG emissions have a direct impact on ecological risk and on the maintenance of ecosystem services that sustain water and food security and human health (Malecha *et al.*, 2025).

In a scenario with a higher level of warming, more than 90% of animal and plant species in terrestrial and freshwater ecosystems will suffer negative impacts resulting from climate change, and approximately 25% of these species will be threatened with extinction (Figure 4.49). Invasive species are expected to suffer much less negative impact than native and endemic species (Malecha *et al.*, 2025). Current and future trends point to a feedback loop of risks associated with the loss of key species. Such loss leads to a reduction in the availability of natural resources, such as fertile soil, water, timber, firewood, and fisheries (Brasil, 2025l).

Figure 4.49 Percentage of risk projections (difference between future and present biodiversity parameters) for species at risk of extinction and those positively and negatively impacted in future projections, considering the scope of the Paris Agreement and the BAU scenario



Source: Malecha *et al.*, 2025.

There are several studies on the Atlantic Forest that demonstrate a high risk of biodiversity loss among terrestrial vertebrates due to climate change (Malecha *et al.*, 2025; Manes *et al.*, 2022). Added to this is the biome's low connectivity, which limits species movement, restricts adaptive responses, and increases the risk of functional collapse in communities, even under moderate temperature increases. These factors create a cumulative risk scenario, with potential losses of phylogenetic and functional diversity, reduced ecological redundancy, and increased vulnerability to biological invasions (Malecha *et al.*, 2025; Pinho *et al.*, 2020).

In the Amazon, the combination of intensifying temperature increases and decreasing precipitation trends, together with declining forest cover, creates conditions for an accelerated loss of resilience and the impairment of climate regulation services on a continental scale (Malecha *et al.*, 2025).

In the Cerrado, rising temperatures and prolonged droughts increase the occurrence of wildfires, with projections indicating an increase in the proportion of days with critical fire danger (from 20% to 32% by the end of the century) (Brasil, 2021). In an assessment of 103 bird species in the biome in relation to climate scenarios projected for 2050, 67% were found to be sensitive to the changes, 71% showed low adaptive capacity, 39% would be directly exposed to the impacts, and 25% were classified as highly vulnerable (Borges, 2019).

Furthermore, projections indicate that the Caatinga is likely to see an increase in areas of desertification, with the biome expanding into the country's coastal regions, the South, and the Central-West. The biome, which has a high degree of endemism, could see 90% of its plant species lose suitable habitat by 2060 (Moura *et al.*, 2023). This situation is exacerbated by the high level of vulnerability already faced by the biome's species, given that more than 232 of the fauna species are classified as critically endangered, endangered, or vulnerable (ICMBio – Chico Mendes Biodiversity Conservation Institute (Instituto Chico Mendes de Conservação da Biodiversidade), 2026).

In the Pantanal, although the number of studies is still limited, available projections indicate that the biome will be the most negatively affected, with high rates of impact on freshwater fish. The Pantanal is one of the world's largest wetlands and has been severely affected by more severe droughts and more frequent fire events, which tend to alter hydrological regimes (Malecha *et al.*, 2025).

The more moderate projected impacts for the Pampa are consistent with the climate risk projected for the region, which is likely to experience the lowest temperature increases in Brazil (Malecha *et al.*, 2025). However, it should be considered that this biome is highly vulnerable due to anthropogenic pressure on its grassland ecosystems.

Biome-scale modeling shows that, as annual precipitation declines to between 1,000 mm and 1,800 mm, Amazon resilience decreases sharply, making the biome more vulnerable to collapse under severe events. This decrease in precipitation stresses vegetation, leading to higher tree mortality, reduced biomass, and an increase in the incidence of fires, which compromises climate regulation services and carbon balance on regional and global scales. The intensification of the Amazon biome's degradation jeopardizes the so-called "flying rivers" — masses of water vapor transported by the atmosphere, originating from the forest's evapotranspiration —, which feed the rainfall regime in other regions of Brazil and South America. In this context, the deterioration of this ecosystem service increases systemic risks to the country's water, food, and energy security, reinforcing the interdependence between the risks and vulnerabilities of **NG4: Protect, conserve, restore and strengthen ecosystems and biodiversity, while ensuring the provision of ecosystem services** and the themes of water and energy security addressed in **NG3: 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**. These impacts, combined with trends in warming and hydrological variability, suggest that tipping points (see **Box 4.5**) may be reached within time-horizons consistent with international targets, if anthropogenic pressures persist (Pinho *et al.*, 2020; Brasil, 2025l; Rodrigues, 2025).

Vulnerabilities

In 2026, 1,264 animal species are officially recognized by ICMBio as being classified in threatened categories (ICMBio, 2026). In addition to climate change, biodiversity has been severely impacted by changes in land use and land cover resulting from anthropogenic activity (Brasil, 2025l). Habitat loss and fragmentation caused by deforestation and the conversion of native vegetation into pasture or cropland, for example, are among the main factors contributing to the threat of species extinction (Díaz *et al.*, 2019; Harfoot *et al.*, 2021; Pardini *et al.*, 2018). This factor reduces carrying capacity, that is, the maximum number of individuals of a species or community that a given environment can sustain over time without causing its degradation, and landscape permeability, which refers to the capacity of a landscape (the set of ecosystems and natural and human-made elements that comprise it) to allow the movement and dispersal of organisms, energy, and materials (Opdam and Wascher, 2004). Therefore, these pressures reduce the capacity of species to move across the landscape in search of suitable climate conditions and alter population dynamics and the richness of natural communities, creating vulnerabilities that contribute to a feedback loop that exacerbates the impacts of climate change (Brasil, 2025l).

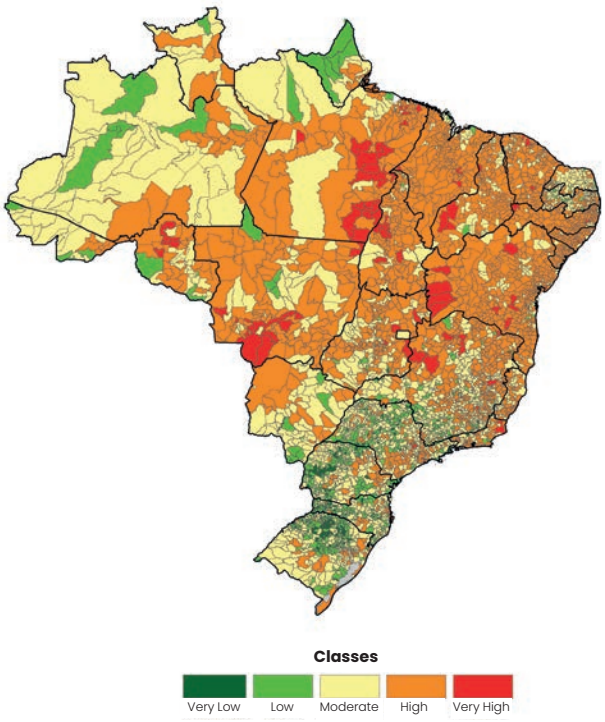
In the Amazon, approximately 30% of the areas that have been deforested are in a state of secondary forest. The region, considering its entire extent in South America, is home to more than 40 million people, including 2.2 million Indigenous people, who depend heavily on the forest for their ways of life and survival, and contains more than 15,000 tree species, 99% of which are rare (Flores et al., 2024). In the Atlantic Forest, where approximately 28% of the remaining forest cover is highly fragmented (Rezende *et al.*, 2018), ecosystem resilience is compromised by low landscape connectivity, hindering species movement through low-permeability matrices in response to climate change (Malecha *et al.*, 2025).

In the Caatinga and Cerrado, vulnerability is associated with a greater propensity for water shortages, the intensification of high temperatures, and recurrent fires, with impacts on hydrological services and the productivity of agrifood systems. The Cerrado plays a strategic role in national water security. The projected reduction in water availability and the expansion of conditions conducive to fires may affect aquifer recharge and the stability of springs that sustain major river basins (Pinho *et al.*, 2020), including the Paraná River Basin, which supplies water to the Itaipu Hydroelectric Power Plant. In this regard, the degradation of their phytophysiognomies and the reduction in water availability reinforce the interdependence between biodiversity, water security, and energy security (Salmona *et al.*, 2023). Furthermore, in the Pantanal, a factor that aggravates the situation of biodiversity is river fragmentation, particularly by dams. Approximately 4% of the current geographic range and up to 45% of the future geographic range of migratory fish could be disrupted by dams in the upper Paraná River Basin (Peluso *et al.*, 2022).

The impact of climate change on biodiversity has direct consequences on people's lives, jeopardizing food and water security, as well as the health of the Brazilian population, especially the most vulnerable. Indigenous Peoples and traditional peoples and communities (Quilombola, riverine, and extractivist communities, among others), and family farmers are among the most vulnerable groups, given their direct dependence on ecosystem services (see **Box 4.7**) for their livelihoods, cultural identity, food and water security, as well as their exposure to extreme events (Brasil, 2025l). It is important to note that the presence of Indigenous and traditional populations is a positive factor for adaptive capacity, as they play a strategic role in maintaining resilient ecosystems through sustainable practices and diverse traditional knowledge (Flores *et al.*, 2024).

On the AdaptaBrasil MCTI platform, the main factors that increase sensitivity in the Biome Integrity Risk Index include the lack of sustainable agricultural practices, degraded pastures, and the presence of hydropower plants. With regard to adaptive capacity, the lack of technical guidance, a management committee, and a management plan for protected areas influences the calculation of the Index, which uses biodiversity conservation instruments as indicators. According to the platform, approximately 80% of the municipalities (Figure 4.50) were classified as having medium to high vulnerability (AdaptaBrasil, 2026g).

Figure 4.50 Climate vulnerability index of the integrity of Brazilian biomes



Source: AdaptaBrasil, 2026g.

Other vulnerability factors common across biomes include illegal hunting; lack of enforcement; insufficient monitoring of sensitive species and species listed as threatened with extinction; wildlife trafficking; limited capacity of species to adapt and physiologically regulate in response to changes in habitat and climate patterns; species subject to use pressures; air, soil, and water pollution; and the absence or insufficiency of ecological restoration and integrated landscape management policies (Brasil, 2025l).

Finally, knowledge gaps represent a strategic vulnerability. There is a strong taxonomic bias toward plants and vertebrates (>90% of the database), as well as an underrepresentation of identified species from coastal-marine environments, invertebrates, and fish. This gap limits the ability to assess the scale of compound risks and prioritize interventions based on scientific evidence. The shortage of studies involving coastal and marine ecosystems highlights a critical knowledge gap, especially considering that marine ecosystem services sustain fisheries, coastal protection, and climate regulation. These gaps can be addressed through the production of periodic syntheses, harmonized time series, and the integration of biodiversity, climate, and land-use data, as well as by strengthening monitoring networks and assessments of the effectiveness of ecological corridors and restoration measures (Malecha *et al.*, 2025). A summary of the main observed impacts, risks, and vulnerabilities related to the coastal zone and the ocean is presented in **NG9: Strengthen the vital role of the ocean and coastal zone in tackling climate change.**

BOX 4.5 AMAZON TIPPING POINTS

Brazil's First BTR highlighted several **tipping points** — critical thresholds capable of triggering abrupt and potentially irreversible changes, driven by positive feedback loops — that have already been identified by science and have direct effects on the national territory. Understanding of these thresholds and their interconnections has been advancing in recent years, and science indicates that rising global temperature may trigger tipping points in systems that are critical and fundamental to humanity, leading to their destabilization and potentially irreversible impacts (Boulton *et al.*, 2025). Recent research has advanced our understanding of one of the most critical of these points: the collapse of the Amazon ecosystem's integrity. The Amazon rainforest system, which plays a central role in the global climate system, has been affected by both climate change and anthropogenic pressures, bringing it progressively closer to these thresholds. Although uncertainties remain regarding the exact definition of these critical thresholds, there is a scientific consensus that cumulative changes can lead to the forest's transformation into a less diverse and less productive state, reversing its role from a carbon sink to a net source of carbon emissions (Rodrigues, 2025; Brando *et al.*, 2025; Nobre *et al.*, 2009).

Among the main factors associated with this risk are deforestation and forest degradation, driven by the conversion of forest areas to agricultural production, the rise of real estate speculation, and the increased frequency and intensity of wildfires. Evidence indicates that approximately 38% of the Amazon's remaining forests are already subject to some degree of degradation due to the interaction between wildfires, deforestation, and extreme droughts (Lapola *et al.*, 2023). This degradation impairs the regulation of the hydrological cycle and can reduce evapotranspiration during the dry season by up to 34 percent, with direct implications for regional climate stability (Flores *et al.*, 2024).

Estimates indicate that high levels of deforestation, in the range of 20% to 40% of the original forest cover, could cause significant changes in regional precipitation regimes. More recent evidence, however, indicates that these thresholds are not uniform; they vary spatially and depend on the interaction between deforestation, global warming, forest degradation, and changes in fire regimes. These interactions can reduce the system's resilience and increase the likelihood of critical transitions in different parts of the Amazon (Rodrigues, 2025; Brando *et al.*, 2025; Nobre *et al.*, 2009).

Global climate change, characterized by rising mean temperatures and a prolonged dry season at the local level, also acts as an important driver of critical ecosystem transitions by increasing evapotranspiration rates and reducing soil moisture. As detailed in section **4.2.1.2, Current climate change trends** of this report, the Amazon biome has already shown a consistent pattern of warming over the past few decades. Climate models indicate that some critical regions of the Amazon could experience temperature increases of up to 4ºC during the dry season by the middle of the 21st century, particularly under high-emissions and land-use change scenarios (Oliveira *et al.*, 2021; IPCC, 2021). The stability of the Amazon rainforest depends on high levels of precipitation. Evidence indicates that below approximately 1,000 mm of annual precipitation, the ecosystem becomes unstable and forest persistence becomes unviable, while values between 1,000 mm and 1,800 mm would significantly increase the risk of a transition to more open vegetation states, particularly under the combined effects of climate and anthropogenic disturbances (Nobre *et al.*, 2016). For floodplain ecosystems, the critical threshold is estimated at 1,500

mm of annual precipitation. Currently, the Amazon basin has an average of approximately 2,300 mm of precipitation per year, although there are significant variations across the territory (Rodrigues, 2025; Flores *et al.*, 2024).

This situation is exacerbated by the increase in the frequency and intensity of extreme events, including both droughts and fluvial floods (Rodrigues, 2025; Nobre *et al.*, 2009). The meteorological drought that occurred in the Amazon Basin between 2023 and 2024, for example, was the most severe on record and was attributed primarily to climate change, which made this type of event ten times more likely to occur (Clarke *et al.*, 2024). In addition, the Amazonian rainfall regime is strongly influenced by the interaction between the ocean and the atmosphere, particularly by variations in the temperature of the Atlantic Ocean. The warming of these waters directly affects the distribution of precipitation and, consequently, the stability of the forest. Changes in major ocean currents, such as the Atlantic Meridional Overturning Circulation (AMOC), may also pose an additional risk to the integrity of the Amazonian system (Rodrigues, 2025; Flores *et al.*, 2024).

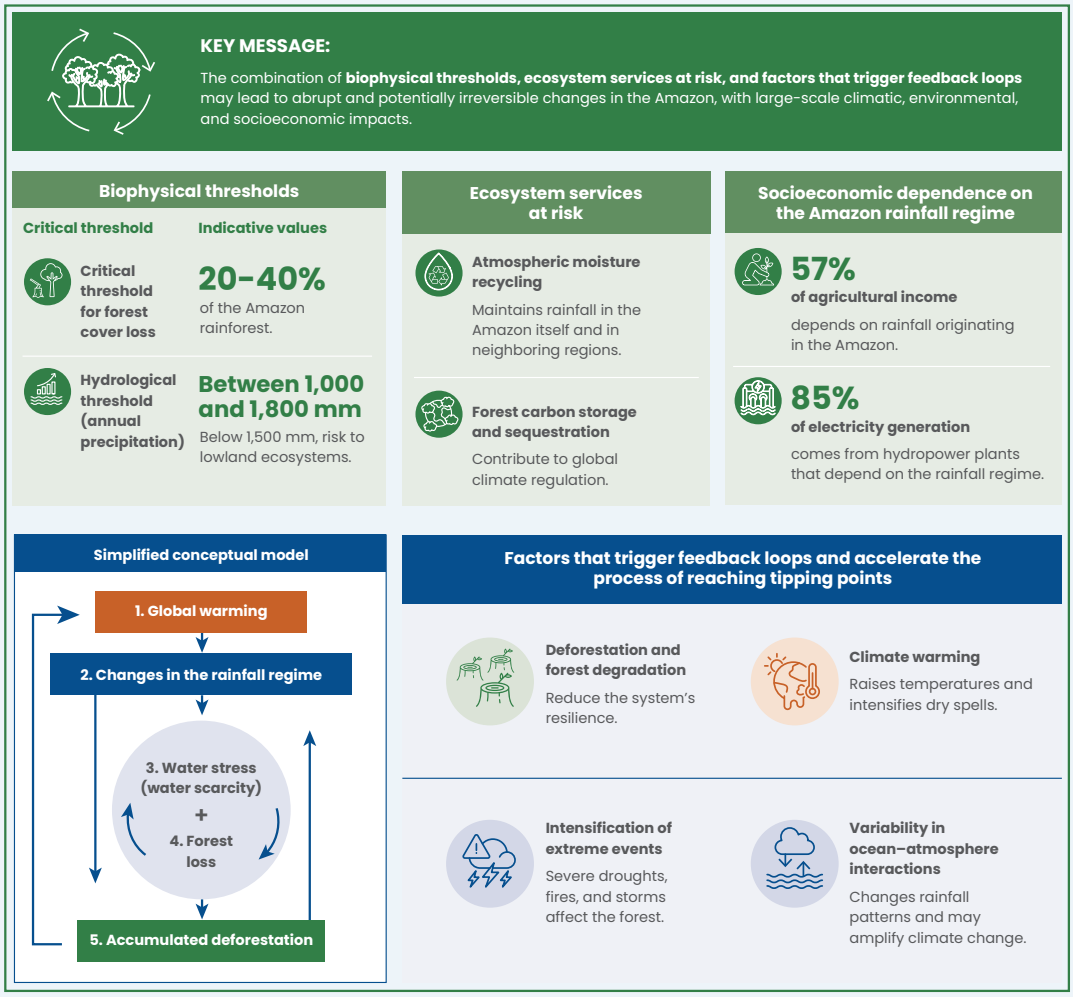
The combination of these factors can result in the loss of vegetation responsible for evapotranspiration, reducing atmospheric humidity and rainfall, which, in turn, increases the risk of forest fires and tree mortality. Forest degradation also leads to the release of large carbon stocks, contributing to the intensification of climate change. At the same time, the loss of species diversity reduces the resilience of ecosystems, making them even more vulnerable to future disturbances. These processes, therefore, operate in an interconnected and mutually reinforcing way, through a feedback loop (Rodrigues, 2025; Flores *et al.*, 2024; Brando *et al.*, 2025).

Evidence indicates that parts of the Amazon rainforest are already showing signs of destabilization, and projections suggest worsening scenarios. By around 2050, between 10% and 47% of the Amazon could be exposed to disturbances capable of triggering abrupt transitions, although significant uncertainties remain due to the complexity of the system. Once the tipping points are crossed, the region may experience permanently drier conditions, with progressively more arid ecosystems (Flores *et al.*, 2024).

The potential consequences are wide-ranging and varied, spanning from the loss of biodiversity and large-scale species extinction to a reduction in the availability of water for human consumption, energy generation, and agricultural production — not only in the Amazon, but throughout the entire country, with effects that also extend to neighboring countries (Rodrigues, 2025; Brando *et al.*, 2025). This is because the forest plays an important role in moisture recycling, returning a significant portion of the precipitation it receives to the atmosphere through evapotranspiration and creating flows of water vapor — the so-called flying rivers that contribute to rainfall formation in areas far from the Amazon biome (Nobre *et al.*, 2009). Estimates indicate that, in Brazil, approximately 57% of agricultural income and 85% of the major hydroelectric power plants depend on the rainfall dynamics associated with the functioning of the Amazon system (Mattos *et al.*, 2024; Pinto *et al.*, 2024).

For local populations, impacts include increased health risks due to fires, heat waves, and vector-borne diseases. The impacts are multidimensional, affecting the integrity of the territories, food and water security, and the ways of life of Indigenous Peoples and Traditional Peoples and Communities (see **Box 4.7**). In addition, traditional practices may be compromised, leading to the loss of a significant portion of intangible cultural heritage and the erosion of the cultural and spiritual values of local communities and Indigenous Peoples (Rodrigues, 2025; Brando *et al.*, 2025).

Figure 4.51 Amazon Tipping Points – Thresholds, mechanisms, and factors that accelerate the transition



Source: Compiled by the authors based on Flores et al., 2024.

Given this context, reducing the risk of reaching these tipping points requires accelerating coordinated actions on multiple scales aimed at mitigation through a broad reduction in greenhouse gas emissions, with a focus on combating deforestation, controlling the incidence of wildfires, and enhancing removal by sinks, notably by promoting large-scale restoration of degraded ecosystems (Rodrigues, 2025; Flores *et al.*, 2024; Brando *et al.*, 2025).

NG5: Promote, protect and recover the health and well-being of populations, while respecting the ways of life of traditional peoples and communities

Observed impacts

The impacts of climate change on the health of the Brazilian population manifest themselves through multiple factors, involving both direct and indirect effects associated with extreme weather events and gradual changes in the climate. Because they result from the interaction between environmental, social, and institutional factors, measuring them is complex due to the nonlinear nature of the relationships between exposure, climate vulnerability, and health outcomes (Brasil, 2025j).

Among the impacts already identified, those related to human health and the Brazilian National Health System (SUS) stand out (WHO, 2021; Brasil, 2025j). Impacts on the health of the population can result both from changes in the patterns of morbidity and mortality caused by climate-sensitive diseases — such as arboviral diseases and malaria — and from injuries, health conditions, and deaths associated with extreme weather events, such as droughts, fluvial floods, wildfires, and landslides, with particular emphasis on the effects of heat waves (see **Box 4.6**), which have become more frequent and intense in recent decades (AdaptaBrasil, 2026h, 2026i, 2026j, 2026k; Santos *et al.*, 2024; Brasil, 2026c; Pinho *et al.*, 2025b).

Geographic expansion and shifts in vector distributions, disease emergence and re-emergence (the return of a disease that had previously been controlled or was in decline), changes in seasonality, and increased risk of zoonotic diseases have already been observed (Ellwanger *et al.*, 2020; Barcellos *et al.*, 2022, 2024). Recent evidence indicates that persistent thermal anomalies have contributed to the spread of dengue in Brazil, including to higher-altitude areas that previously acted as barriers to the disease's transmission (Barcellos *et al.*, 2024). There is also evidence that populations living in areas with changes in precipitation patterns, air humidity, and temperature, combined with inadequate sanitation conditions, may be more exposed to vector-borne diseases (AdaptaBrasil, 2026h, 2026i; Brasil, 2025j).

Extreme events associated with the hydrological cycle have also had an impact on public health. Prolonged droughts, which contribute to the occurrence of fires, may be linked to an increase in hospitalizations due to respiratory diseases in the Amazon region, particularly among children up to 5 years old and older people[28] (Machado-Silva *et al.*, 2020). Extreme weather events have been linked to an increase in the incidence of leptospirosis and gastroenteritis, particularly in small and medium-sized municipalities, highlighting the relationship between extreme weather events, inadequate sanitation, and social vulnerability (Gracie *et al.*, 2021; Sousa *et al.*, 2018).

On the other hand, there are significant impacts on the capacity to provide healthcare services, resulting from increased demand for healthcare, whether due to changes in the epidemiological profile of climate-sensitive diseases or in the context of extreme events and disasters. These

28 A study conducted in Porto Velho (state of Rondônia), the third most populous city in the Brazilian Amazon, identified an increase of up to 27% in hospitalizations caused by respiratory diseases (except asthma) during drought years between 2000 and 2016. Among children aged 5 years or younger and older people, hospitalization rates were, respectively, 11 and 22 times higher than in the general population (Machado-Silva *et al.*, 2020).

events can compromise or disrupt the provision of healthcare services and trigger public health emergencies, increasing pressure on the Brazilian National Health System (SUS) and leading to higher public spending on epidemiological surveillance, vector control, and healthcare (Brasil, 2026c, 2025j; WHO, 2021; Romanello *et al.*, 2023; Hacon, 2019).

In remote regions, particularly in the Amazon and Indigenous territories, severe droughts and floods can compromise river navigability and other forms of transportation, restricting access to diagnostic tests, procedures, and medium- and high-complexity healthcare, which often require travel to referral centers. This limited access to specialized services exacerbates health inequalities and increases the vulnerability of these populations to the impacts of climate change (Fellows *et al.*, 2021).

Future risks

Climate change tends to increase the frequency, magnitude, and complexity of health risks, including deaths, an increase in diseases, disruptions in the provision of healthcare services, and even public health emergencies of national or international concern.

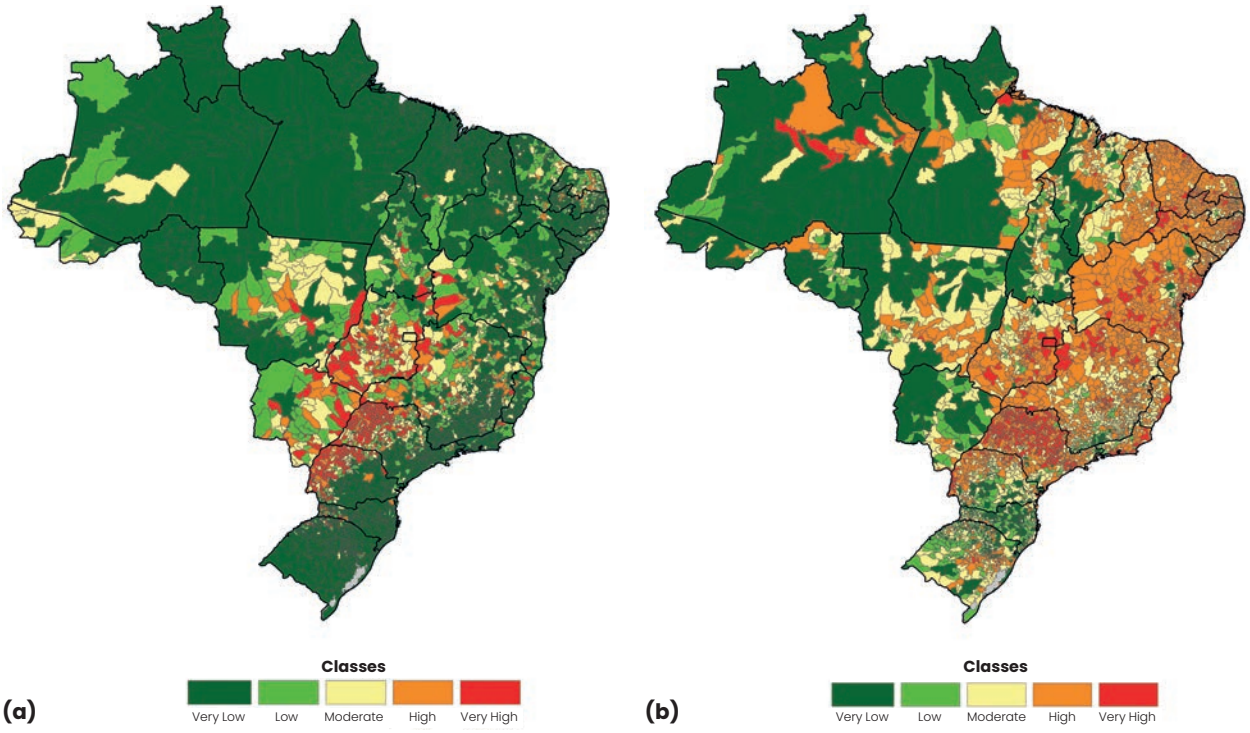
According to AdaptaSUS[29], the main climate-related health risks are linked to an increase in the incidence of diseases (morbidity) and deaths (mortality), as well as to a rise in demand for healthcare services (Brasil, 2025j). These risks primarily relate to:

- Changes in the profile of vector-borne and zoonotic diseases (Figure 4.52);
- Food and nutrition insecurity;
- Inadequate access to water, sanitation, and hygiene; and
- Health risks associated with extreme temperatures (heat and cold) and precipitation (associated geohydrological disasters, droughts, and water scarcity), and air pollution.

Health risks were also highlighted in other sectoral and thematic plans, such as those on Racial Equality and Combating Racism (Brasil, 2025f), Indigenous Peoples (Brasil, 2025d), Traditional Peoples and Communities (Brasil, 2025g), Transport (Brasil, 2025b), and Industry and Mining (Brasil, 2025n). These plans point, respectively, to: (i) increased food and nutrition insecurity, with a rise in associated morbidity and mortality; (ii) an increase in the incidence of respiratory diseases; (iii) an increase in the incidence and geographic distribution of diseases and other health conditions, including accidents involving venomous animals, vector-borne diseases, and diseases associated with water scarcity and poor sanitation; (iv) risks to workers' health and safety; and (v) adverse impacts on the well-being and health of passengers, customers, and workers.

29 AdaptaSUS is the sectoral Health strategy, presented in the Climate Adaptation Plan – Health Sectoral Plan.

Figure 4.52 (a) Incidence of arboviral diseases per 100,000 inhabitants, between 2017 and 2022; (b) Risk of arboviral diseases for RCP 8.5, for the year 2050



Source: AdaptaBrasil, 2026h.

The incidence of arboviral diseases[30] (dengue, Zika, and chikungunya), calculated by AdaptaBrasil and shown in Figure 4.52 for Brazilian municipalities, is used as an indirect variable for population sensitivity, given that municipalities with higher rates tend to have a greater risk of transmission. It has been observed that this incidence in recent years can be intensified by climate variations, such as minimum and maximum temperatures, precipitation, temperature range, number of heat waves, and relative humidity, resulting in an increase in projected risk under the RCP 8.5 scenario for 2050 (AdaptaBrasil, 2026h).

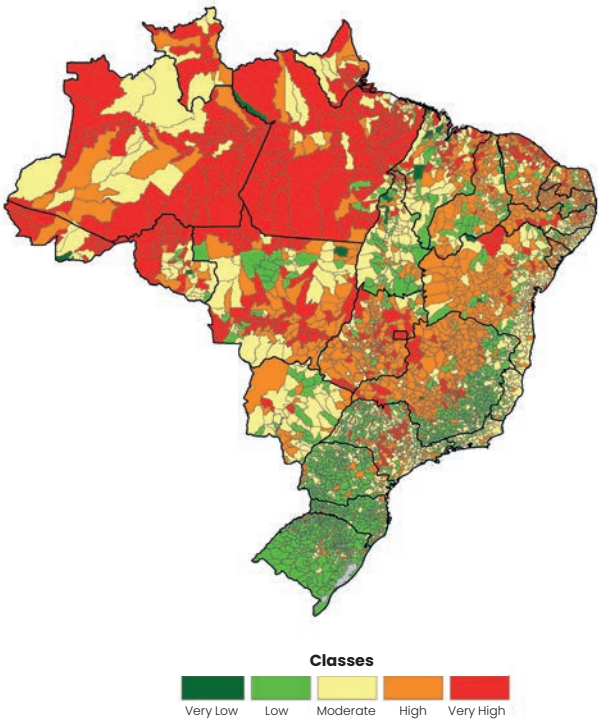
Climate events have been associated with increased incidence and severity of noncommunicable chronic diseases, such as respiratory and cardiovascular diseases, cancer, diabetes mellitus, and mental disorders. In the field of mental health, extreme events, forced displacement, material and non-material losses, and disruptions to territories associated with

30 The indicator is the result of the sum of the number of probable cases of dengue, Zika, and chikungunya for each year between 2017 and 2022, which is, then, divided by the estimated population of the municipality for the corresponding year and multiplied by 100,000, which results in the annual incidence rate of these arboviral diseases per 100,000 inhabitants in the municipality for each year between 2017 and 2022. These annual rate data are used to estimate the mean incidence rate of arboviral diseases per 100,000 inhabitants in the municipality over the entire 2017-2022 period. This mean rate is, then, multiplied by a weight assigned by experts based on the importance of this indicator for the occurrence of dengue, Zika, and chikungunya in the Brazilian biomes. Municipalities with higher mean incidence rates of arboviral diseases are considered to have greater sensitivity. Data on the number of probable cases of dengue, Zika, and chikungunya at the municipal level were made available by the Ministry of Health through the Notifiable Diseases Information System (SINAN, Sistema de Informação de Agravos de Notificação) in 2024. The exception is municipalities in the state of Espírito Santo, which, since 2020, have reported cases through the State Health Department's e-SUS system, rather than through SINAN. Notifications for these municipalities for the last three years of the period analyzed were, therefore, obtained from this system (AdaptaBrasil, 2026h).

climate change contribute to increased rates of anxiety, depression, and post-traumatic stress disorder, representing a growing yet still underestimated dimension of health risks in the context of climate change (Pearson *et al.*, 2021; Romanello *et al.*, 2023; WHO, 2021).

In the field of climate-sensitive infectious diseases, changes are observed in the incidence and prevalence patterns of infectious diseases, especially vector-borne diseases and zoonoses, in which animals act as reservoirs[31], as a result of changes in ecosystems and biological cycles influenced by climate conditions. Impacts on waterborne and foodborne diseases have also been observed, as well as damage to health associated with disasters (Brasil, 2025p; Ellwanger *et al.*, 2020; Valdivino *et al.*, 2021; Barcellos *et al.*, 2022; ANGELO *et al.*, 2017). Projections from AdaptaBrasil MCTI[32] indicate a trend toward the spatial expansion of climate risk associated with arboviral diseases, malaria, American cutaneous leishmaniosis, and visceral leishmaniosis across the country by 2050 (Figure 4.52 and Figure 4.53) (AdaptaBrasil, 2026h, 2026i, 2026j, 2026k).

Figure 4.53 Risk of malaria according to RCP 8.5, for the year 2050



Source: AdaptaBrasil, 2026i.

31 A reservoir is any site, plant, animal, or human in which an etiological agent lives and multiplies and from which it can reach other hosts. Some authors consider the ideal living reservoir (animal or human) to be one that harbors the etiological agent without being adversely affected by its presence (SBP - Brazilian Society of Parasitology (Sociedade Brasileira de Parasitologia), 2026).

32 AdaptaBrasil MCTI is the Brazilian government's climate risk assessment platform, which uses the IPCC risk framework as its methodological basis. AdaptaBrasil MCTI was developed through cooperation between the National Institute for Space Research (INPE) and the National Education and Research Network (RNP, Rede Nacional de Ensino e Pesquisa), with funding from the Ministry of Science, Technology and Innovation (MCTI).

Food and nutrition insecurity tends to worsen as a result of extreme events, changes in rainfall regime, rising mean temperatures, and impacts on agricultural production, affecting in particular populations living in poverty, as well as Indigenous Peoples and traditional communities whose ways of life depend directly on local ecosystems (see **Box 4.7**). Reduced availability of and access to adequate food can lead to malnutrition, worsening of chronic diseases, and increased susceptibility to infections (ALPINO *et al.*, 2022; Brasil, 2025j, 2025p).

Modeling studies indicate a significant increase in mortality caused by heat-related respiratory and cardiovascular diseases, especially among older people, with estimated additional rates ranging from 95 to 149 deaths per 100,000 inhabitants in the 2030-2050 and 2079-2099 time horizons, varying according to the climate scenario and population profile (Diniz *et al.*, 2020).

In addition to the social and health impacts, including those on SUS, there is also the risk of significant budgetary impacts for Brazilian governments associated with increased public spending on epidemiological surveillance, vector control, and healthcare (Brasil, 2025j; Hacon *et al.*, 2019).

Vulnerabilities

Although climate change affects the entire population, its impacts are felt most acutely by vulnerable groups due to biological, physiological, social, economic, territorial, and environmental factors, which often intersect. Among the groups most affected are older people, children, women, Black populations, Indigenous Peoples, traditional peoples and communities, people living in precarious housing and working in poor working conditions, and people with disabilities (Hacon *et al.*, 2019). In the Brazilian context, marked by profound socio-environmental inequalities, environmental damage and damage to health disproportionately affect the same groups that have historically been subjugated by racially hierarchical power dynamics (Grosfoguel, 2007; Quijano, 2005) and by the racialization of poverty (Brasil, 2025f).

Social vulnerability is closely associated with socio-environmental conditions, such as access to sufficient income for subsistence, basic sanitation, adequate housing, and the effective guarantee of territorial rights and other fundamental Indigenous rights, conditions that are particularly challenging in peripheral countries such as Brazil. This is compounded by low adaptive capacity, characterized by the limited capacity of institutional actors to develop effective health surveillance and healthcare strategies, which weakens the system and compromises the guarantee of the right to health (Brasil, 2025p).

In addition to vulnerability itself, in the field of health, exposure reflects the unequal distribution of populations and services in territorial contexts subject to climate-related hazards, such as densely populated urban areas with heat islands, territories susceptible to recurrent fluvial flooding and landslides, or regions with ecological conditions conducive to the spread of disease vectors (Brasil, 2025j, 2025p; Ozturk *et al.*, 2022; WHO, 2021).

With regard to Brazil's macro-regions, the North and Northeast exhibit high levels of health vulnerability to climate change, particularly in the Legal Amazon, areas of unplanned urban expansion, and municipalities with low coverage of primary healthcare services. In these regions, the combination of high climate exposure, changes in land use and land cover, and lower adaptive capacity increases the risk of infectious diseases and heat-related health conditions (Brasil, 2025j, 2025p; Ellwanger *et al.*, 2020). Metropolitan areas in the Southeast are also considered critical territories due to their high population density and the intensification of urban heat islands (Diniz *et al.*, 2020).

The climate risk of malaria, for example, is concentrated in municipalities in the North, Central-West, and Northeast regions (Figure 4.53), and is influenced by climate factors, such as rising temperatures, precipitation, and humidity, as well as socio-environmental determinants, including changes in land use, artisanal and small-scale mining, and population mobility (ANGELO *et al.,* 2017). The higher risk of arboviral diseases in the Northeast, on the other hand, is associated with an increase in the number of heat waves and in annual maximum temperatures; whereas in the Southeast, in addition to the number of heat waves, the high risk of arboviral diseases is related to higher population density (Figure 4.52).

With regard to heat waves, women, non-white people, and individuals with lower levels of education face higher risks, reinforcing the interaction between climate factors, social inequalities, and environmental racism, particularly in metropolitan areas (Brasil, 2026c; Santos *et al.*, 2024; Silveira *et al.*, 2019). The limited availability of public services, as reflected in the unequal capacity of SUS to respond and in low levels of intersectoral integration, increases health risks and contributes to the perpetuation of climate injustice, since the impacts fall disproportionately on populations that already face restrictions in access to sanitation, adequate housing, and healthcare services (Sousa *et al.*, 2018; Brasil, 2016b).

BOX 4.6 EXTREME HEAT EVENTS AND HEALTH IN BRAZIL

Between 2000 and 2019, heat waves were associated with a significant impact on mortality in Brazil, with **an estimated 119,643 attributable deaths**, corresponding to 0.6% of total deaths during that period (Brasil, 2026c). The effects were observed throughout the country, demonstrating that the risk is widespread, although it varies depending on the climate and population characteristics.

The impact is greatest among older people (aged 65 and older), a group in which 97,167 attributable deaths were estimated, which is equivalent to 0.81% of all deaths in this age group, indicating greater physiological and epidemiological vulnerability to extreme heat. A gender dimension is also observed, with a greater impact among women: **the percentage increase in mortality risk associated with heat waves ranged from 6% to 16% among women**, exceeding that observed among men (4% to 9%, depending on the climate zone) (Brasil, 2026c). In addition, there is also an educational dimension, with **an increased risk reaching 19% among people with no schooling**, ranging from 7% to 10% in the climate zones of the Central-West and North regions and 19% in the South, while the effects were lower among individuals with higher levels of education (Brasil, 2026c).

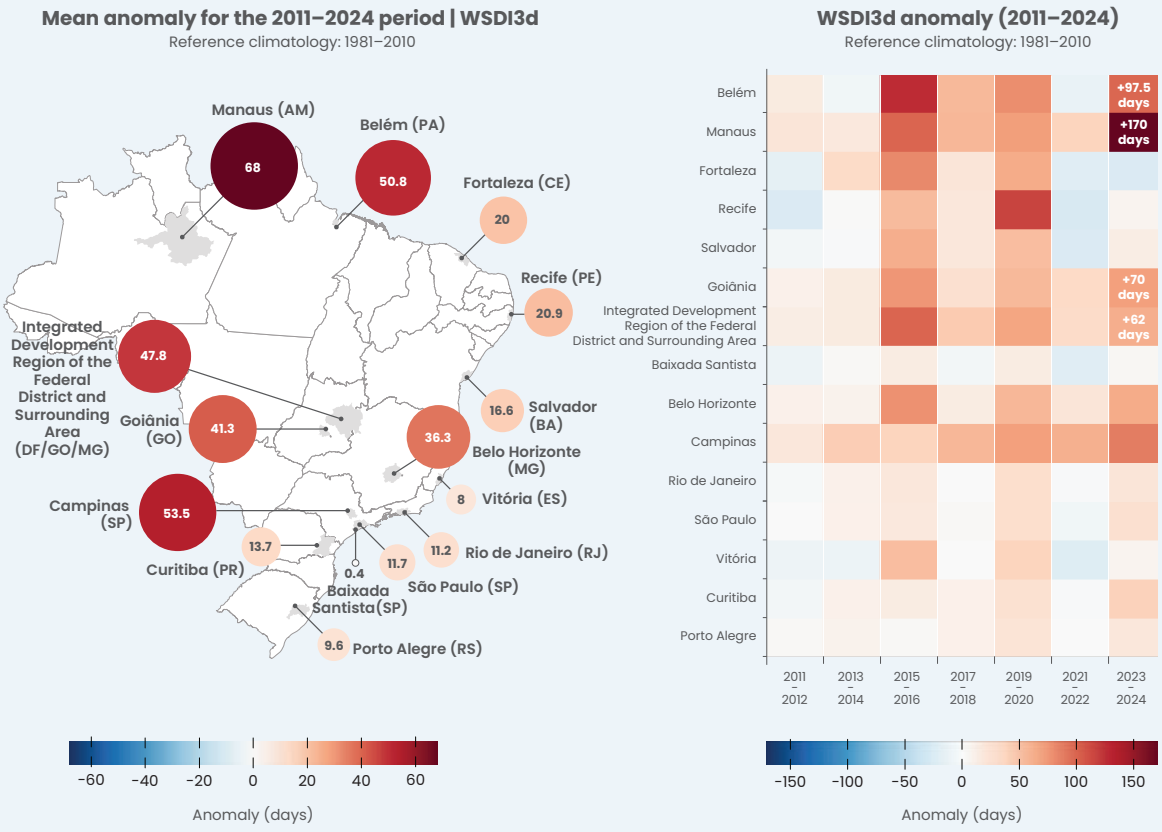
As for causes of death between 2000 and 2019, an estimated 33,858 deaths caused by **cardiovascular diseases** (0.53%) and 24,225 caused by **respiratory diseases** (1%) were attributable to heat waves. Although cardiovascular diseases account for the largest absolute number of attributable deaths, respiratory diseases have a higher attributable fraction, indicating greater proportional sensitivity to extreme heat (Brasil, 2026c).

Taken together, the results show **that heat waves already have preventable and socially unequal impacts on mortality in the country**, affecting older people, women, and

populations in situations of greater socioeconomic vulnerability most severely. Given the trend toward the intensification of heat events, these findings reinforce the need to expand health surveillance, develop contingency plans, and promote protection strategies targeted at priority groups.

Focusing specifically on metropolitan areas (Figure 4.54), the analysis by color or race indicates a pattern that is different from that observed for the country as a whole. In these areas, the risk of mortality related to heat waves among the Black population is similar to, or, in some cases, higher than, that of the white population. It is worth noting that, in metropolitan areas within the Semi-Arid climate zone, the increased risk of mortality related to heat waves among the Black population reached 30 percent, the highest rate recorded in the country. This finding points to the presence of socio-spatial inequalities (Brasil, 2026c), associated with urban segregation, housing conditions, and unequal access to urban infrastructure and healthcare services (Brasil, 2026c; Santos *et al.*, 2024).

Figure 4.54 3-Day WSDI in Brazilian metropolitan areas with a population of over 2 million inhabitants (1981-2024)



Source: Compiled by the authors based on ERA5[33] reanalysis data.

33 Adopted definition of heat wave duration: annual count of days occurring in periods of at least 3 consecutive days when Tmax > 90th percentile.

Recent evidence shows that, in Brazilian cities, the difference in surface temperature between high-income neighborhoods and areas with precarious housing can exceed **10°C to 15°C on days of extreme heat**, reflecting the concentration of heat islands in territories with less vegetation cover and higher building density (Juneja *et al.*, 2025). This pattern reinforces territorial inequality in heat exposure and underscores the centrality of climate justice in analyzing the health impacts of heat waves, particularly in large urban centers (Juneja *et al.*, 2025; Santos *et al.*, 2024).

NG6: Ensure energy security in a sustainable and accessible manner

Observed impacts

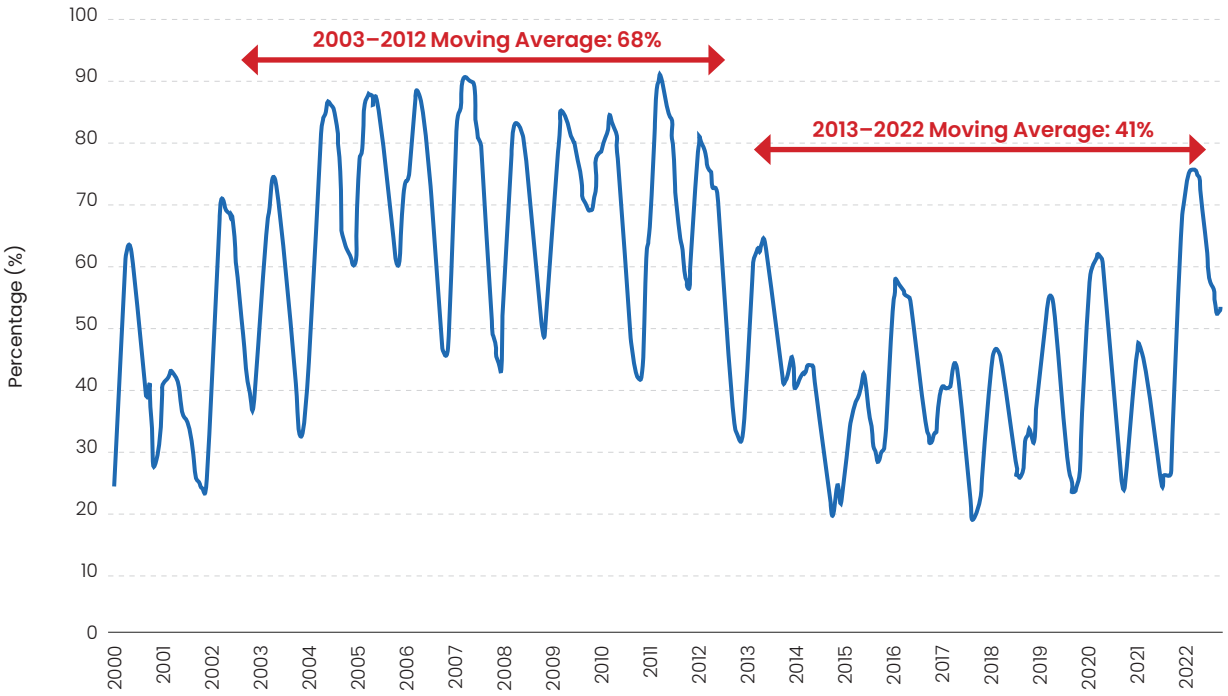
Climate change has had impacts on Brazil's energy matrix, posing major challenges to the maintenance and expansion of the Brazilian Interconnected System (SIN, Sistema Interligado Nacional). The scientific literature primarily reports on the impacts on hydropower generation, given its direct dependence on the hydrological regime, and on electricity demand, particularly due to increased indoor cooling during extreme heat events. In addition, there is growing evidence of effects on the production of bioenergy crops and increasing reports of extreme events affecting transmission and distribution infrastructure, with repercussions for the continuity and quality of energy services.

With regard to hydropower, the observed impacts are associated with changes in precipitation and temperature patterns, which alter evapotranspiration and water storage. The lack of rain and extreme drought events reduce the inflow to run-of-river power plants and reservoirs. Consequently, the Natural Inflow Energy (ENA, Energia Natural Afluente)[34] and the system's generation capacity are affected (Vásquez-Arroyo *et al.*, 2021). Between 2011 and 2021, the cumulative precipitation deficit in the Parnaíba (in the states of Piauí and Maranhão) and Grande (in the states of Minas Gerais and São Paulo) river basins, as well as along the main channel of the Paraná River, reached levels exceeding mean annual rainfall. Comparing the periods 2003-2012 and 2013-2022, the moving average of stored energy (EAR, Energia Armazenada)[35] decreased from 68% to 41%, demonstrating a significant decline over recent decades (Figure 4.55) (Brasil, 2025o).

34 Inflow energy to a system of hydropower facilities, calculated based on the energy that can be generated from the natural inflows to these facilities, at levels corresponding to 65% of their operational usable storage volumes (ONS, 2026b).

35 Energy available in a system of reservoirs, calculated based on the energy that can be generated from the volume of water stored in the reservoirs at their respective operating levels (ONS, 2026b).

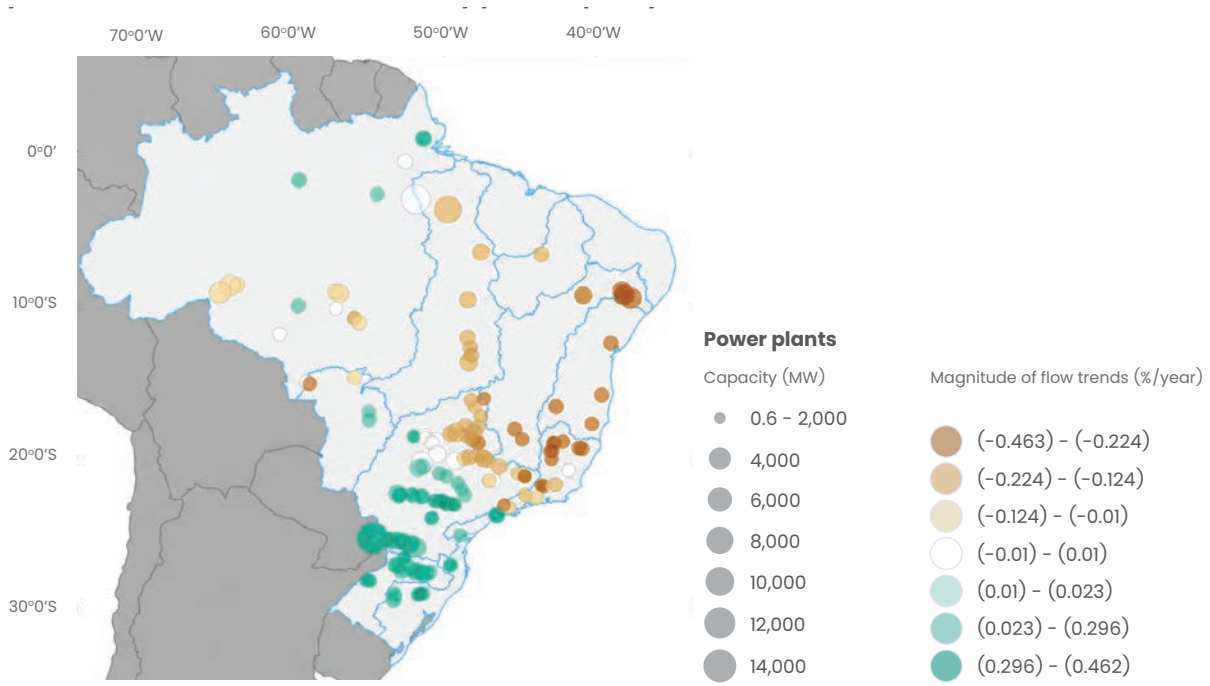
Figure 4.55 Stored energy from the Brazilian Interconnected System (SIN)



Source: MME – Ministry of Mines and Energy (Ministério de Minas e Energia), 2023; Brasil, 2025o.

A study conducted by Fichtner (2023) identified trends of substantial reductions in flow in strategic river basins such as the São Francisco and Tocantins-Araguaia basins (Figure 4.56). Although positive trends were also observed, especially in the South, the results indicate that these gains are not sufficient to offset the declines seen in the other regions. This worsening of water shortage reduces the predictability and reliability of hydropower supply and, by increasing the need to rely on backup sources, such as thermal power plants, may decrease the relative share of renewables in the energy matrix and put pressure on costs and emissions in the short and medium terms.

Figure 4.56 Magnitude of trends in mean monthly flows at hydropower plants in the Brazilian Interconnected System (SIN), from 1931 to 2021, by plant capacity



Source: Compiled by the authors (Cenergia).

On the demand side, the main observed impact is the increase in electricity consumption associated with rising temperatures and greater use of air conditioning for indoor cooling, with direct implications for peak loads and increased stress on SIN operations, particularly in urban grids. Garcia (2025a) combined temperature and relative humidity data from meteorological stations (INMET, 2022) with load data from the SIN (ONS, 2022) and found significant impacts of heat waves on energy demand, particularly in the Southeast/Central-West and South subsystems. In February 2025, Brazil experienced an extreme heat event that led to high electricity demand, breaking the record for instantaneous load demand at the time, which exceeded 106,000 MW (ONS, 2025).

The electricity transmission and distribution system, which supports approximately 96% of the country's total capacity, enables the interconnection of several energy submarkets, allowing electricity to be dispatched across nearly the entire national territory through the Brazilian Interconnected System (SIN). The SIN offers an advantage in terms of adaptive capacity, as it is capable of maintaining the country's energy supply even in the event of regional impacts. However, power transmission and distribution in this system are highly vulnerable to extreme weather events, such as heavy rainfall, strong winds, and landslides (Brasil, 2025o).

In 2024 and 2025, several adverse climate events were observed, such as heavy rainfall exceeding expected levels in the Southeast, a higher incidence of lightning strikes, and cyclones that caused disruptions to electricity supply, mainly in the South (Brasil, 2025o). In June 2020, a cyclone disrupted electricity supply to 1.5 million consumer units (Vásquez-Arroyo *et al.*, 2021), and in 2024, more than 560,000 users were left without electricity supply following the heavy rainfall and floods in the state of Rio Grande do Sul (Suárez *et al.*, 2024). Other impacts due to changes in climate factors have been observed, such as reductions in transmission efficiency

and capacity, increased electrical losses due to high temperatures, and particle deposition during prolonged dry spells, causing the degradation of materials and increasing the risk of short circuits (Brasil, 2025o; Brito *et al.*, 2022; Cruz *et al.*, 2025).

Other infrastructure belonging to the SIN has also been affected, such as dams. The heavy rainfall in Rio Grande do Sul in 2024 caused the partial failure of structures, slope collapses, and other impacts that disrupted the power and communication systems of Usina Hidrelétrica 14 de Julho (14 de Julho Hydropower Plant), the fourth-largest hydropower plant in Rio Grande do Sul by installed capacity, which remained out of operation for 50 days (Brasil, 2025o; Suárez *et al.*, 2024). Impacts were reported at 25 hydropower plants, representing more than 13% of the state's installed hydropower capacity. It is estimated that the financial impacts of the floods in Rio Grande do Sul on the electricity sector exceeded BRL 1.8 billion (Suárez *et al.*, 2024).

Finally, evidence suggests that climate change is already affecting the production of bioenergy crops in Brazil, primarily through rising temperatures, changes in precipitation, and extreme droughts, with significant regional variation (Fiorini *et al.*, 2024). In Brazil, the main biofuels are ethanol and biodiesel (Vásquez-Arroyo *et al.*, 2021). Major sugarcane crop losses have occurred over the past 15 years (12.2% in the 2011/2012 harvest; 11.6% in the 2021/2022 harvest; and 11% in the 2014/2015 harvest) due to prolonged droughts, reducing the availability of sugarcane, one of the main feedstocks for biofuel and bioelectricity production, for the production of sugar and ethanol (Brasil, 2025o; Vásquez-Arroyo *et al.*, 2021).

Among the studies on the impacts on biofuel production (sugarcane, soybeans, and maize) reviewed by Fiorini *et al.* (2024), 67% reported negative impacts, while 15% found mixed effects, 11% neutral effects, and 7% positive effects. Results vary depending on local conditions and the territorial dimension under analysis. For sugarcane, there is empirical evidence that increases in temperature lead to a decrease in production, while increases in precipitation tend to boost productivity, although some studies indicate less pronounced effects under conditions of extreme drought. For soybeans, studies indicate yield losses due to rising temperatures of up to 6% for every degree Celsius of temperature increase, as well as greater sensitivity during drought years and under conditions of higher vapor pressure deficit, in addition to varying responses associated with the ENSO phenomenon across regions. As for maize, the observed impacts appear to be primarily linked to droughts and water and atmospheric stress, with evidence of losses in significant areas of the Cerrado.

Future risks

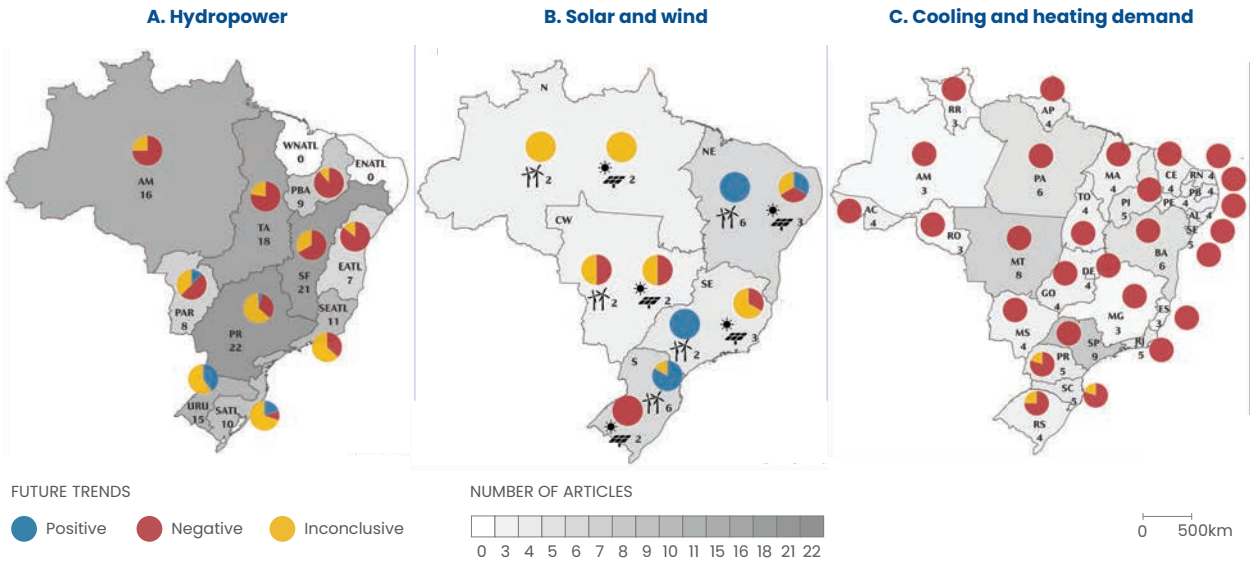
The Energy Sectoral Adaptation Plan identifies the following risks as priorities:

1. A decrease in the supply of hydropower;
2. Effects of flood events on hydropower plant reservoirs and river basins;
3. A decrease in the supply of biofuels;
4. A decrease in the supply of electricity and fuel to isolated communities and systems;
5. Sudden and/or significant changes in electricity demand;
6. Increased frequency and duration of supply disruptions – transmission;
7. Increased frequency and duration of supply disruptions – distribution;
8. Severe damage to electricity infrastructure and equipment;
9. Severe damage to fuel production equipment; and
10. Reduced electricity supply from wind, solar, and thermal power sources.

Additionally, the Thematic Adaptation Plan for Indigenous Peoples considers the risk of disruption or impairment of access to resources such as electricity and communications, with a focus on energy supply in isolated communities (Brasil, 2025d).

In the coming decades, Brazil's energy matrix is likely to face an environment of increasing risk as climate variability and the frequency and severity of extreme events intensify. Scientific studies that analyze future impacts on the Brazilian energy system generally use climate models to simulate how these variables will evolve over time and then integrate these results into sectoral models — such as hydrological, energy, and demand models — in order to estimate the effects on the different components of the energy system (Cruz *et al.*, 2025). In this context, the systematic review conducted by Cruz *et al.* (2025) compiled evidence from 65 studies and provided an overview of the potential impacts of climate change on the Brazilian energy system. The summary indicates that future risks to energy security are significant but heterogeneous, differing depending on the component analyzed and the territorial dimension considered (Figure 4.57).

Figure 4.57 Future trends in the potential impacts of climate change on energy security in Brazil



Source: Cruz *et al.*, 2025

On the supply side, the main risk is associated with the hydropower component of the energy system, given its direct dependence on water availability. Changes in precipitation and temperature affect river flows and evapotranspiration, reducing the water available for generation and, consequently, hydropower output. This risk is systemic because hydropower still accounts for 55% of the domestic electricity supply (EPE, 2025), so that hydrological deficits can raise operating costs and increase the use of backup power sources. The evidence indicates a median 6% reduction in water availability and a median 4% decline in hydropower generation, signaling increased stress on the main pillar of electricity supply. Furthermore, vulnerability varies by region, with greater exposure in the river basins of the North and Northeast, particularly the São Francisco, Tocantins-Araguaia, and Amazon basins (Cruz *et al.*, 2025).

In the case of wind and solar power, although these sources reduce dependence on hydropower, they are also climate-sensitive. Solar power generation can be affected by cloud cover and water vapor, as well as by rising temperatures, which reduce the efficiency of photovoltaic panels. Regarding wind power, changes in the distribution and persistence of wind speed affect the performance and predictability of power generation. Studies indicate a nationwide increase in wind power potential of between 6% and 15% by the end of the century. As for photovoltaic power generation, the positive effects of increased solar radiation are offset by warmer temperatures in future climate change scenarios (Poyer *et al.*, 2026). This reinforces the need for regional planning and climate robustness criteria for the siting and integration of these energy sources, especially because wind and solar power already account for approximately 20% of national electricity generation, increasing the importance of managing variability and of the infrastructure needed to integrate these sources into the SIN (Cruz *et al.*, 2025).

With regard to transmission and distribution, extreme events and heat stress increase the vulnerability of transmission lines, substations, and grids to damage, losses, and disruptions. These structures are expected to be increasingly affected by significant changes in extreme wind conditions and an increase in lightning strikes during the summer and spring, particularly in the South region of the country (Brasil, 2025o). Another hazard identified by the Energy Sectoral Plan was wildfires, an important factor in the degradation of the quality of public electricity transmission services. Studies indicate that an average temperature increase of 1ºC has the potential to increase the number of transmission line outages caused by wildfires by 10% (Costa *et al.*, 2023).

On the demand side, risks tend to intensify with warming and the increasing frequency of heat waves, increasing the need for cooling to maintain thermal comfort through both more intensive use of existing equipment and expansion of the stock of air-conditioning units, particularly in tropical regions. Projections indicate a net increase in energy consumption when indoor cooling and heating are considered together, with a median increase of 8%, reflecting the predominance of cooling in Brazil's energy demand. This trend increases the risk of peak loads, puts pressure on urban grids, and requires greater operational flexibility, with more critical impacts in densely populated areas where cooling is rapidly expanding, such as metropolitan areas and urban corridors (Cruz *et al.*, 2025).

Finally, there are significant risks associated with bioenergy and biofuels, as biomass supply depends on edaphoclimatic conditions[36] that affect agricultural productivity and the availability of suitable land, with the potential for instability in feedstock supply and in the associated energy generation. A study by the National Center for Research on Energy and Materials (CNPEM, Centro Nacional de Pesquisa em Energia e Materiais) projects that climate change could cause a 20% decline in sugarcane production in Brazil's Central-South region over the next 10 years (Petrielli, 2024).

The combination of these factors increases operational risks and investment needs, with potential effects on costs and tariffs, service continuity and quality, and supply reliability (Cruz *et al.*, 2025).

36 A set of factors related to the soil ("edaphic") and the climate ("climatic") that influence the development of plants, ecosystems, or agricultural activities.

Vulnerabilities

As noted previously, the national energy system, by its very configuration, is highly dependent on climate conditions. Nearly 50% of total primary energy supply and 88% of electricity come from renewable sources (EPE, 2025), making Brazil more vulnerable to shocks and trends associated with climate change. Furthermore, since large-scale projects require long implementation timelines, the capacity for rapid response is limited, making it essential to incorporate adaptation as a permanent pillar of the sector's planning and operations (Cruz *et al.*, 2025).

In the case of electricity generation, vulnerability is influenced by the predominance of hydropower, with cascading hydropower plants and the use of reservoirs for regulation; the growing share of wind and solar power; the contribution of sugarcane-associated generation; and the regional interdependence enabled by SIN. As for the risk of a decline in hydropower supply, all subsystems are located in critical areas, particularly the semi-arid region and the basins of the São Francisco, Grande, Paraná, Paranaíba, Madeira, and Xingu rivers. Other factors influence the vulnerability of electricity supply, such as deforestation and vegetation degradation in reservoir recharge areas and the failure to update operating parameters, which rely on time series (Brasil, 2025o).

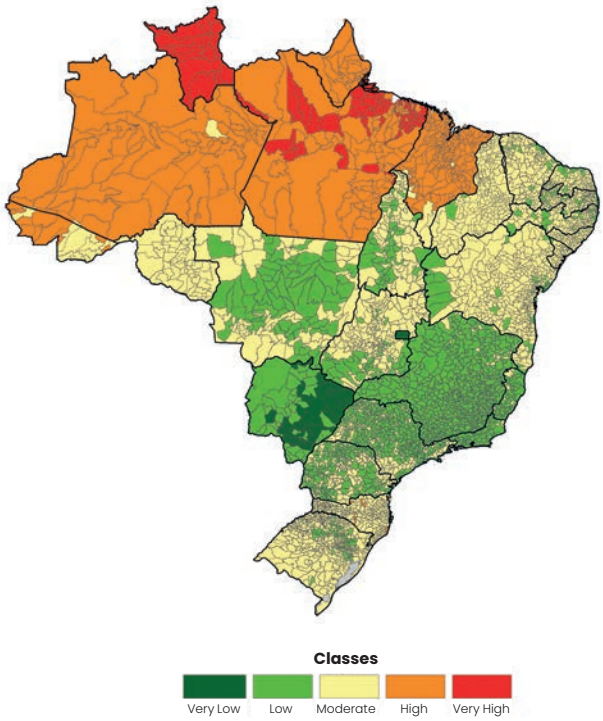
In general, existing energy infrastructure, such as dams, wind turbines, and transmission and distribution networks, was designed using historical parameters that do not account for the worsening and unpredictability of climate conditions. On rivers where hydropower plants are planned or already exist, the 10,000-year flood is commonly adopted as the design flow for sizing spillways. However, discharges exceeding this parameter have been recorded with increasing frequency and need to be duly incorporated into the data series used for design calculation (Cruz *et al.*, 2025; Brasil, 2025o).

In the case of biofuels, there is a trend toward a growing demand, as provided for in the decarbonization targets of the National Biofuels Policy (RenovaBio) and Law No. 14,933/2024 (Brasil, 2024b), which promotes the so-called "Fuels for the Future," including the promotion of green diesel produced from renewable biomass feedstocks; an increase in the mandatory blend of anhydrous fuel ethanol to 27%, with the possibility of increasing it to 35%; and an increase in the biodiesel blend in diesel, reaching 20% by 2030. The evidence base for this component, therefore, needs to be further developed to support planning, incorporating climate criteria into zoning and water management in order to reduce uncertainty regarding risks and adaptation responses under climate stress scenarios (Cruz *et al.*, 2025).

Furthermore, population growth, socioeconomic development, the increased use of air-conditioning equipment, and the electrification of the economy are contributing to a trend of rising demand for electricity. Between 2023 and 2024, electricity consumption in Brazil grew by 5.5%, and in the transport sector, electricity use was 2.5 times higher (EPE, 2025). There are growth projections for energy-intensive sectors that will drive an increase in energy demand, such as: the extraction of minerals used for storing energy and manufacturing equipment for renewable energy generation; the rapid expansion of *data centers*, driven by advances in artificial intelligence; and the potential increase in demand for hydrogen. These growing activities increase variability and place additional strain on the system (Brasil, 2025o).

Vulnerability with regard to access is particularly pronounced in Brazil's North region, reflecting the high level of energy poverty[37] in the Amazon, as shown by the AdaptaBrasil MCTI Platform (Figure 4.58). The index includes data on physical access to energy sources, ownership of household appliances, and the ability to pay for energy use, as well as high rates of discontinuity in the supply of electricity and high electricity consumption relative to GDP (AdaptaBrasil, 2026l).

Figure 4.58 Vulnerability Index for access to electricity



Source: AdaptaBrasil, 2026l.

The consequences of the climate risks identified affect the entire population but are more severe for populations in situations of greater vulnerability, who face higher energy costs, supply interruptions, and shortages. The Thematic Plan for Indigenous Peoples (Brasil, 2025d), for example, includes as vulnerability factors the lack of maintenance of energy and communications infrastructure, dependence on precarious and less resilient infrastructure, the existence of remote areas with limited access to maintenance, and a lack of investment in infrastructure. People living in remote areas, therefore, tend to be more affected.

37 The indicator was obtained from the article entitled "The multidimensionality of energy poverty in Brazil: A Historical Analysis" by Bezerra *et al.* (2022). It encompasses three dimensions: (i) physical access to energy sources, measured, for example, by connection to the Brazilian Interconnected System (SIN); (ii) appliance ownership, such as television sets, refrigerators, freezers, and internet access; and (iii) affordability, or the ability to pay for energy use, measured by the share of energy expenditure in total household expenditure. In the article, the *Multidimensional Energy Poverty Index* (MEPI) was calculated by state, distinguishing between urban and rural populations. In AdaptaBrasil MCTI, in order to arrive at a single value for each state, the index was weighted by the urban and rural populations. The MEPI was obtained from the article cited above, and the rural and urban populations were obtained from the 2017-2018 Household Budget Survey (POF, Pesquisa de Orçamentos Familiares) conducted by the Brazilian Institute of Geography and Statistics (IBGE).

NG7: Promote socioeconomic development and reduce inequalities

Observed impacts

Brazil has high levels of social inequality, with significant differences in vulnerability across its territory (IPEA - Institute of Applied Economic Research (Instituto de Pesquisa Econômica Aplicada), 2018). In this context, climate change acts as a factor that exacerbates these inequalities by simultaneously impacting productivity, economic stability, and access to resources, with different distributional effects across social groups and territories, posing challenges to climate-resilient development[38] and to the promotion of climate justice (Birkmann *et al.*, 2022; Brasil, 2025v; Schipper *et al.*, 2022).

In Brazil, the effects of climate change are manifested in reduced productivity and increased economic instability, particularly in strategic sectors such as water resources, energy, agriculture, and logistics, leading to higher unemployment, which in turn affects economic growth and social well-being (Brasil, 2025b, 2025v). Changes in temperature and precipitation regimes exacerbate environmental degradation and the pressure on natural resources, particularly the decline in water availability in biomes such as the Caatinga, the Cerrado, and the Atlantic Forest. In addition, there has been a notable increase in extreme events, such as droughts and fluvial floods, which have disproportionate impacts on racialized territories, particularly in the Amazon, Atlantic Forest, and Caatinga biomes (Brasil, 2025v; Cemaden, 2026). These processes directly affect food production, water availability, and electricity generation, highlighting the interdependence between natural and economic systems, and tend to result in reduced productivity, increased costs, and disruptions in supply chains, especially in contexts of low diversification and limited access to resources (see **Box 4.7**).

These climate changes intersect with structural dimensions, such as poverty, socioeconomic inequalities, socio-spatial segregation in cities, access to basic services (such as healthcare and education), and marginalization based on gender and ethnicity (such as Indigenous Peoples, traditional communities, and the Black population) (Brasil, 2025v).

In the agriculture sector, droughts lead to changes in crop selection, increased demand for irrigation, and production losses, which drive up costs, put pressure on prices, and jeopardize food security, including that of family farms (Cemaden, 2026; Brasil, 2025i). This dynamic is corroborated by the results of a study that estimates human and economic losses due to climate-related disasters associated with droughts and extreme rainfall events[39] that occurred between 2000 and 2023, based on municipal reports and meteorological data. In the case of droughts, economic losses are concentrated in the private sector (approximately BRL 720 billion), notably in agricultural activities (BRL 689 billion), in addition to significant impacts on cultivated areas. These events are most frequently reported by smaller municipalities with lower GDP *per capita*, particularly in the Northeast, South, and Southeast regions (CICEF - Celso Furtado

38 An inclusive process that integrates climate change adaptation and greenhouse gas mitigation measures with sustainable development, guided by climate justice and respect for planetary boundaries (adapted from Schipper *et al.*, 2022).

39 The study linked data on damage and losses reported in the Digital Atlas of Disasters in Brazil with the following meteorological indicators: daily and monthly meteorological variables, with gridded values at a 0.25° × 0.25° resolution for precipitation, temperature, and rainfall intensity (CICEF, 2025).

International Center for Development Policy (Centro Internacional Celso Furtado de Políticas para o Desenvolvimento)/ICS - Climate and Society Institute (Instituto Clima e Sociedade), 2025).

In turn, disasters associated with extreme rainfall resulted in significant material damage (BRL 265 billion) and private-sector losses (BRL 229 billion), and were more frequent in municipalities with larger populations, higher GDP, and higher GDP *per capita*. In this context, the floods that occurred in the state of Rio Grande do Sul in 2024 highlight the magnitude and intersectoral nature of the impacts of extreme events, which simultaneously affect infrastructure, economic activities, and living conditions. Estimates from the Inter-American Development Bank, the Economic Commission for Latin America and the Caribbean, and the World Bank[40] indicated a total impact of approximately BRL 88.9 billion, the response to which required coordination among the federal, state, and municipal governments (Suárez *et al.*, 2024). The effects — measured in terms of damage, losses, and additional costs — were felt across the social, infrastructure, productive, and environmental sectors, with the greatest impact on the productive sectors. Trade suffered the most damage, while agriculture recorded the greatest losses and the social sector incurred the highest additional costs[41] (see section **4.7, Information related to averting, minimizing and addressing loss and damage associated with climate change impacts**).

These results show that the economic impacts of extreme events are significant and unevenly distributed, with impacts concentrated in productive sectors and municipalities with lower response capacity.

Another sector directly affected by climate change, with significant implications for the country's economy, is transport and logistics. The occurrence of extreme weather events, such as heavy rainfall, fluvial flooding, and landslides, compromises the integrity and functionality of infrastructure, including roads, railways, ports, and airports, resulting in disruptions to logistics chains and the movement of people and goods. These impacts constitute physical risks that affect the reliability and efficiency of transport systems, increase operating costs, and hinder the movement of goods from production areas to markets. As a consequence, transportation costs increase, raising the prices of goods and services, resulting in inflation and reduced economic competitiveness, with indirect effects on supply chains. In addition, such disruptions can compromise access to markets, inputs, and essential services, particularly in more isolated or vulnerable regions and populations, highlighting the interdependence among logistics infrastructure, economic development, and social well-being (Brasil, 2025b).

40 The DaLA (*Damage and Loss Assessment*) methodology was applied to estimate the impacts of the disaster in the state of Rio Grande do Sul, based on the quantification of damage, losses, and additional costs, without including detailed structural analyses. The assessment was led by the Inter-American Development Bank (IDB) and the World Bank, with technical coordination by the ECLAC and support from other UN agencies. The estimates were based on official data from state and federal governments, as well as interviews with municipal representatives, the private sector, and civil society organizations, with institutional support from the Rio Grande do Sul Department of Finance and the National Secretariat for Civil Protection and Defense.

41 The above-mentioned study adopted the following concepts: (i) Impacts: refer to results in macroeconomic variables such as GDP, public finances, the balance of payments, and the wage bill; (ii) Damage: Represents the monetary value of damage to the assets of each sector affected by the incident, including buildings, machinery, vehicles, furniture, roads, ports, inventories of finished and semi-finished goods, among others; (iii) Losses: correspond to goods that cease to be produced and services that cease to be provided from the time of the disaster until full recovery; and (iv) Additional costs: refer to the additional expenditures required for the production of goods and services or to support the emergency needs of the population due to the disaster, reflecting the response of the public and private sectors and potentially including additional expenditures or the reallocation of expenditures.

Future risks

Climate risks associated with socioeconomic development and the reduction of inequalities are cross-cutting and manifest themselves differently across sectors; they have been identified in various sectoral and thematic adaptation plans, reflecting impacts on productive activities, living conditions and social inequalities.

With regard to economic development, the Agriculture and Livestock Plan highlights risks related to declines in production and productivity and the disruption of supply chains (Brasil, 2025i), while the Family Farming Plan identifies changes in infrastructure, logistics, and technological capacity, as well as declines in production and productivity (Brasil, 2025h). In the context of Food and Nutrition Security, rising food prices stand out as one of the main risks identified (Brasil, 2025e). In the Industry and Mining plan, risks are associated with constraints on the supply of essential inputs, such as water, energy, and feedstocks, resulting from disruptions in supply chains (Brasil, 2025n). The Biodiversity Plan highlights the risk of a reduction in the stocks of socio-biodiversity resources and in their economic value, with direct implications for productive performance and the generation of income and employment (Brasil, 2025l).

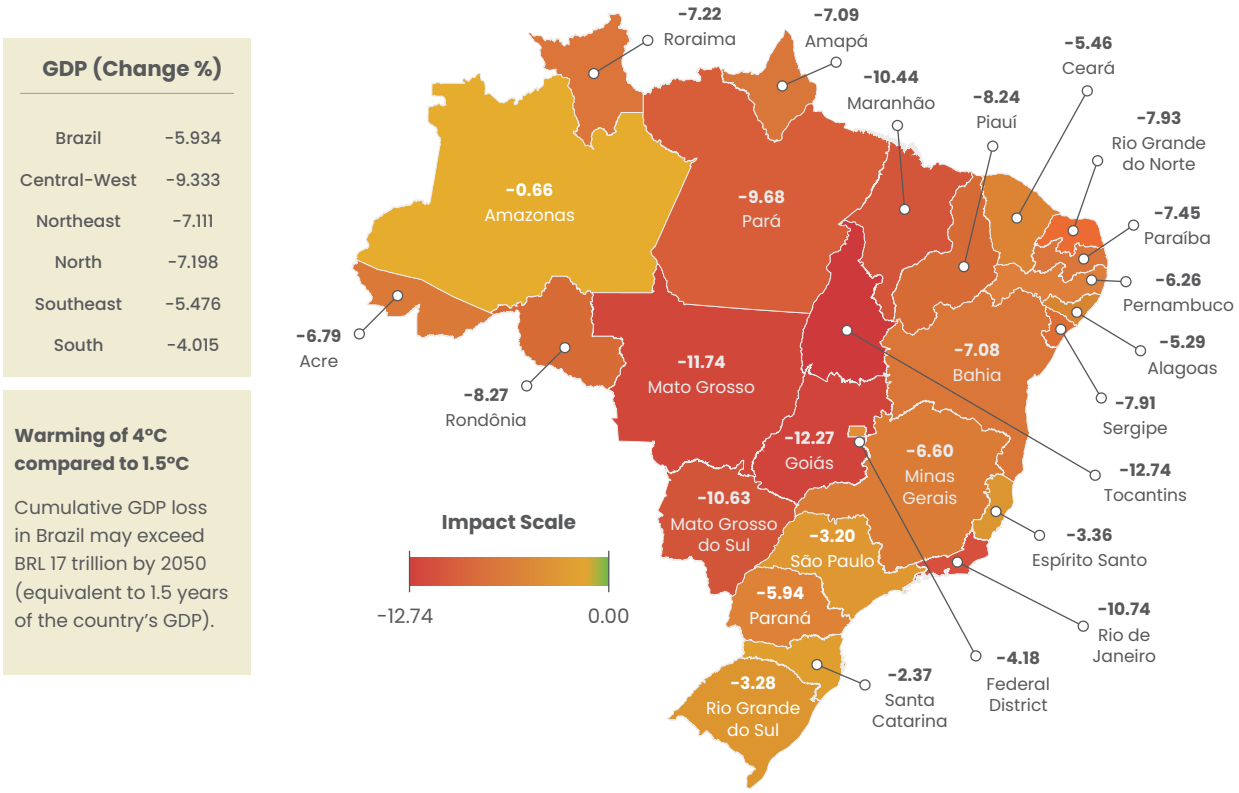
Risks related to social inequalities are also evident in several sectors. The Family Farming Plan identifies reduced availability of and access to land as a critical factor (Brasil, 2025h), while the Racial Equality and Combating Racism Plan highlights increased food and nutrition insecurity, morbidity, and associated deaths, as well as the loss of territories, biodiversity, and cultural assets. It also highlights how the risk of forced displacement and poor access to urban infrastructure intensify inequalities and exacerbate structural racism (Brasil, 2025f). With regard to coastal areas, the Ocean and Coastal Zone Plan highlights risks of changes in the ways of life, use of space, and access to natural resources by traditional coastal peoples and communities (Brasil, 2025q). Similarly, the Indigenous Peoples Plan highlights risks of food and water insecurity associated with a decline in food production, as well as a reduction in the bioeconomy and handicraft production due to climate events, which affect their ways of life (see **Box 4.7**) (Brasil, 2025d). The Traditional Peoples and Communities Plan highlights risks related to a reduction in economic autonomy, linked to food and water insecurity, and the loss of territories, cultural identity, and knowledge of Traditional Peoples and Communities (Brasil, 2025g). In addition, the Food and Nutrition Security Plan highlights the increase in socioeconomic vulnerability (Brasil, 2025e), while the tourism sector points to risks of changes in ways of life, culture, and the economy in tourist destinations (Brasil, 2025r).

Taken together, these sectoral and social risks demonstrate that the impacts of climate change are not limited to specific sectors, but accumulate and spread throughout supply chains and territories, with direct implications for aggregate economic performance, income generation, and the labor market. Recent projections indicate that different levels of global warming have varying effects on the Brazilian economy. Projections of 4ºC and 1.5ºC warming for different macro-regions and federative units in Brazil show that, although all indicate growth in Gross Domestic Product (GDP) and levels of economic activity over time, higher levels of warming are associated with progressive declines in economic performance, due to the intensification of extreme events and of their effects on food production, water availability, and production systems (Brasil, 2025p).

In turn, limiting global warming to 1.5ºC by the end of the century will result in higher GDP growth compared with the 4ºC scenario, with a significant cumulative difference through 2050 at both

the national and regional levels. Under the 4°C scenario, there will be no absolute decline in GDP, but rather a significant slowdown in its growth over time, with cumulative losses relative to a 1.5°C warming pathway estimated at approximately BRL 17 trillion by 2050. In other words, the global cost of inaction in the face of climate change will result in a loss for the country equivalent to 1.5 times its GDP by 2050. The macro-regions with lower relative GDP in the country (North, Northeast, and Central-West) will be more severely affected by extreme events, with states located along the agricultural frontier (Mato Grosso, Mato Grosso do Sul, Goiás, and Tocantins) being particularly affected. Therefore, climate change tends to exacerbate regional inequalities (Figure 4.59). Together, the results suggest that higher levels of global warming may be associated with a decline in economic dynamism and in the average income of the population (Brasil, 2025v).

Figure 4.59 Cumulative impact on national and regional GDP and annual costs of inaction (% and BRL in millions) between the 4°C and 1.5°C scenarios by 2050



Source: Brasil, 2025v.

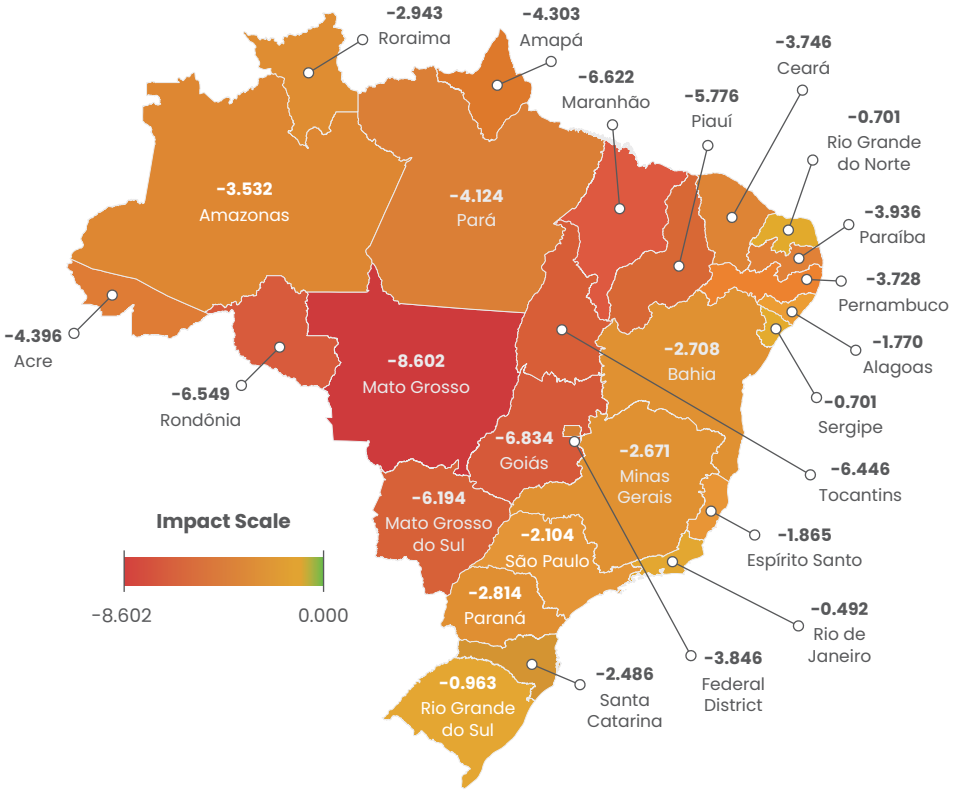
The intensification of extreme events over time will lead to a reduction in job creation. It is estimated that, in the absence of global climate action, 4.4 million jobs will be lost in Brazil by 2050 (Figure 4.60). The reduction will have the greatest impact on the agriculture sector; that is, as the severity and frequency of droughts increase, there will be structural unemployment in rural areas, particularly in regions dedicated to the production of agricultural commodities. Given the regional asymmetry of impacts, rural-to-urban migration from the North, Northeast, and Central-West regions to the South and Southeast is likely to increase, exacerbating regional inequalities (Brasil, 2025v).

Figure 4.60 Cumulative impact on jobs at the national and regional levels (% and millions) under the 4°C and 1.5°C scenarios by 2050

Employment (Change %)	
Brazil	-4.098
Central-West	-7.991
Northeast	-5.216
North	-5.629
Southeast	-3.056
South	-2.612

Warming of 4°C compared to 1.5°C

4.4 million jobs may be lost in Brazil due to climate change by 2050.



Source: Brasil, 2025v.

Vulnerabilities

The vulnerabilities associated with climate change in Brazil reflect the interaction between dependence on climate conditions, the sensitivity of production systems, and the structural limitations of different sectors and territories, manifesting themselves differently across biomes, economic activities, and social groups, in contexts marked by environmental racism (Brasil, 2025i, 2025f, 2025h, 2025l; 2025v). This territorial distribution is consistent with the patterns of socioeconomic inequality presented in section **4.1. National circumstances**. Climate impacts and risks tend to be more severe in contexts of greater socioeconomic vulnerability, where the most exposed populations have lower adaptive capacity (O'Neill *et al.*, 2022).

The vulnerabilities identified in the sectoral and thematic plans can be understood as interrelated dimensions, organized around dependence on production systems, structural limitations regarding access to resources, and social and territorial inequalities, as summarized below.

- **Dependence on climate-sensitive production systems and economic activities**: Production systems such as agriculture, fisheries, extractive industries, and tourism are highly sensitive to climate variability and extreme events. Such sensitivity is often associated with low levels of diversification in production and income sources. This condition increases susceptibility to production losses, economic instability, and disruptions to supply chains, especially in contexts

of low diversification and limited access to resources (Fiorini *et al.*, 2024; Brasil, 2025g, 2025h, 2025i, 2025l, 2025r, 2025v).

- **Degradation of natural resources as a basis of production vulnerability**: Dependence on natural resources subject to water scarcity, soil salinization, loss of soil fertility, declines in pollinators, increases in pests and diseases, and biodiversity loss constitutes a structural basis of vulnerability, as it undermines the ecological base of production systems and livelihoods (see **Box 4.7**) (Brasil, 2025g; Brasil, 2025h; Brasil, 2025i).
- **Structural racism and urban infrastructure**: Constraints on access to land, water, credit, technical assistance, technologies, and public instruments, combined with inadequate infrastructure and services, limit adaptive capacity and increase susceptibility to climate impacts (Brasil, 2025f, 2025g, 2025h, 2025v).
- **Geographical isolation and barriers to accessing services, technologies, and information**: The location of Indigenous Lands in remote or hard-to-reach areas, combined with mobility limitations and logistical, linguistic, and sociocultural barriers, can hinder timely access to services, technologies, markets, and information, especially during extreme weather events such as prolonged droughts and floods, thereby increasing vulnerability to these impacts (Brasil, 2025d).
- **Traditional systems, territoriality, and pressures on territory**: Indigenous Peoples and traditional communities maintain production systems and ways of life that are intrinsically linked to the territory, which sustain their subsistence, food, culture, and social practices. Vulnerability is associated with external pressures — including changes in environmental and climate conditions, degradation processes, and disputes over land use and occupation — that undermine the natural resource base and the conditions necessary for social, cultural, and economic reproduction, potentially leading to displacement (see **Box 4.2**), loss of ways of life, and the exacerbation of structural racism (Brasil, 2025d, 2025f, 2025g).
- **Inequalities in access to essential resources and livelihoods**: Inequalities in access to food, water, land, and livelihoods increase the susceptibility of socioeconomically vulnerable populations to fluctuations in the availability, access, and prices of essential resources (see **Box 4.7**) (Brasil, 2025e, 2025g).
- **Structural inequalities among social groups**: Inequalities associated with income, race, gender, and access to opportunities constitute structural conditions that increase the vulnerability of Black populations, Indigenous Peoples, traditional peoples and communities (including Quilombola communities, traditional *terreiro* peoples and communities and those of African origin, and Roma peoples), women, and young people, influencing their exposure, sensitivity, and adaptive capacity to climate change impacts (Brasil, 2025d, 2025f, 2025g).
- **Structural racism and access to housing**: Structural racism, combined with precarious housing conditions and inadequate infrastructure and services, constitutes a structural vulnerability factor, especially in urban peripheries and territories occupied by racialized populations (Brasil, 2025f).
- **Dependence on tourism-sensitive local economies and territorial pressures**: The dependence on tourism activities that are sensitive to environmental conditions, combined with pressure on natural resources and territorial dynamics, in contexts of low economic diversification, can increase the susceptibility of local communities, affecting ways of life, cultural practices, and conditions for remaining in the territory (Brasil, 2025r).

Together, these vulnerabilities highlight the interdependence between natural and economic systems, as well as the influence of structural and territorial inequalities on their distribution, reinforcing the fact that the impacts of climate change manifest themselves in a systemic and unequal manner across sectors, social groups, and regions of the country (Brasil, 2025h, 2025v).

BOX 4.7 INDIGENOUS PEOPLES AND TRADITIONAL COMMUNITIES IN BRAZIL: WATER, FOOD, AND WAYS OF LIFE IN THE FACE OF CLIMATE CHANGE

Access to water and food among Indigenous Peoples and traditional peoples and communities in Brazil is marked by the interaction of structural inequalities, infrastructure limitations, and direct dependence on natural systems, and is exacerbated by the effects of climate change, which act as a risk multiplier (Brasil, 2025d, 2025e, 2025h). In 2022, only 54% of the Indigenous population had access to piped water, considering different forms of access, such as through the public water supply network; springs, water sources, rivers, lakes, and wells; and cisterns, water tanker trucks, and other sources. Regional disparities are significant: while access for this population reaches 88.9% in the Southeast, the percentages are significantly lower in the North and Central-West, at 38.5% and 43.6%, respectively (ANA, 2025a). In these regions, reliance on alternative water sources is a strategy for securing access to water, especially in areas with limited infrastructure coverage. However, access alone does not guarantee adequate water quality for human consumption. Water sources remain vulnerable to changes in the hydrological regime, such as prolonged droughts and water contamination, which can have an impact on the health and food production of these populations (Brasil, 2025d, 2025e, 2025g, 2025h).

These inequalities are even more critical when access to sanitation is considered: only 19.8% of the Indigenous population has access to a sewage collection network and sewage treatment or to a septic tank, with extremely low levels in the North (7.6%) and Central-West (18.1%) (ANA, 2025a). In the North Region, of the 78% of residents who identify as Black, only 46.4%, less than half of its 17.2 million inhabitants, have access to basic sanitation (Brasil, 2025d). The combination of limited access to water and a lack of adequate sanitation (an issue also addressed in NG3: 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) increases the risks of water contamination and disease, especially in contexts of climate variability, highlighting the interdependence between infrastructure, health, and climate vulnerability (Brasil, 2025h, 2025j). Although, in aggregate terms, there are only slight differences in access to water between men and women in Brazil (94.8% and 95.5%, respectively), the impacts of poor water services disproportionately affect women and girls, who bear most of the responsibilities related to caregiving, hygiene, and household water management. In situations of water scarcity, they are also primarily responsible for collecting water, which increases their unpaid workload and their exposure to health risks (ANA, 2025a).

In addition to their effects on health, these conditions affect the availability of water to Indigenous Peoples and traditional peoples and communities (such as Quilombola, terreiro, and Roma peoples and communities, and people of African origin) for consumption and for carrying out ancestral and religious practices, as well as for food production, compromising the production systems and ways of life of these populations (Brasil, 2025d, 2025f, 2025g). In the case of Indigenous Peoples and traditional peoples and communities, whose production systems are directly based on agriculture, fisheries, and extractive activities, climate variability affects the availability of natural resources and jeopardizes their physical and cultural reproduction (Brasil, 2025d, 2025g). The intensification of droughts, floods, and other extreme events is associated with production losses and a reduction in food supply, with impacts on food security and on the economic autonomy of these populations (Brasil, 2025h). These effects are also reflected in rising and volatile food prices, affecting access

to and the stability of food systems, especially among the populations in situations of greater vulnerability (Brasil, 2025e). In Indigenous and traditional territories, heavy reliance on natural resources increases exposure to climate impacts. Changes in rainfall regime, prolonged droughts, and environmental degradation compromise food production, fish stocks, and forest resources, directly affecting the food security and ways of life of these populations, with significant impacts on the Black population, traditional communities and, in particular, women who are heads of low-income households (Brasil, 2025g, 2025j).

Food insecurity, in turn, also exhibits a strong gender dimension: in 2023, 27.6% of Brazilian households were experiencing food insecurity, with 59.4% headed by women; at the moderate or severe levels, this proportion was 10.8% among female-headed households, compared to 7.8% among male-headed households (IBGE, 2024e). Women play a central role in food systems, but they face restrictions on access to production resources, and in times of scarcity, they tend to reduce their own consumption in favor of other family members. Climate change exacerbates these inequalities by compromising food production and increasing the workload, thereby reinforcing the need for adaptation strategies that promote food security with gender equity (Brasil, 2025d, 2025e).

In areas such as the northeastern semi-arid region, the effects of climate variability are particularly severe. The dry spell between 2012 and 2016, one of the longest in the past century, was marked by persistent water shortages and rainfall reduction, which reached its lowest levels since 1961, affecting large areas of the Northeast. During this period, the hydrological conditions in the São Francisco River Basin reflected the decline in precipitation, with volumes corresponding to approximately 73.6% of the long-term average (Marengo *et al.*, 2018). These events had a direct impact on ways of life in the region, including crop losses and reduced access to water. Studies on the perceptions of Indigenous Peoples also show their recognition of rising temperatures and its connection to decreased rainfall and the disappearance of springs, linking these changes to impacts on food production and cultural practices (Bernal *et al.*, 2020).

These impacts tend to be particularly severe for Indigenous and traditional peoples, whose livelihoods, food security, culture, and well-being are closely linked to the integrity of Amazonian ecosystems. Prolonged droughts reduce water availability and quality, hinder navigation on rivers, and compromise activities essential to the ways of life of these populations, thereby exacerbating food insecurity, health risks, and the socioeconomic vulnerability of these populations. In this context, the region may be approaching critical tipping points (see **Box 4.5**), increasing cascading social risks, including impacts on health, livelihoods, and cultural erosion (Boulton *et al.*, 2025). Environmental changes also undermine traditional management practices, ecological knowledge, and cultural expressions associated with forest use, contributing to the loss of intangible cultural heritage and the erosion of the cultural and spiritual values of Indigenous and traditional peoples (Rodrigues, 2025; Brando *et al.*, 2025), thereby undermining the ecological base of these production systems (Brandão *et al.*, 2022). Fish, the main source of protein for much of the Amazonian population, is also heavily affected by changes in the hydrological and thermal regimes, with direct implications for food and nutrition security (Val and Almeida-Val, 2026).

In the Amazon, recent climate variations, such as extreme heat and drought events, have reduced the production of fruits and forest products, with direct impacts on socio-biodiversity, compromising the income of extractive households and local supply chains

(Gómez Soto *et al.*, 2025; Brandão, 2022). In the case of Brazil nuts, estimates indicate that each increase in temperature may reduce annual production, with temperature accounting for up to 42% of the observed variability in productivity. Projections also indicate that the reduction in environmentally suitable areas for forest species over the coming decades could compromise the ecological base of these production systems, with repercussions for the regional socioeconomy and the ways of life of forest-dependent populations (Brandão *et al.*, 2022, 2024).

Of particular note is the strategic role of Indigenous Peoples and traditional communities in the conservation of ecosystems and the maintenance of environmental services. Territorial and environmental management initiatives, such as the National Policy for Quilombola Territorial and Environmental Management (PNGTAQ, Política Nacional de Gestão Territorial e Ambiental Quilombola, see Dataframe 4.6), strengthen environmental management in Quilombola territories and value traditional practices related to ecosystem conservation, contributing to the protection of socio-biodiversity and natural resources and to strengthening the living conditions and ways of life of these communities. Protected areas, including Indigenous Territories and traditional territories, contribute to maintaining ecological connectivity and the hydrological cycles that are essential to water and food security (Armenteras and Ribas, 2025; Brasil, 2025d; Encalada *et al.*, 2024). At the same time, these territories face growing pressures, including deforestation, forest degradation, threats to territorial rights, loss of traditional knowledge, and limited technical and financial support, factors that undermine the capacity to manage, adapt to, and protect these socio-ecological systems (Armenteras and Ribas, 2025). In addition, environmental changes associated with climate change produce cascading social impacts, contributing to increased food, nutrition, and water insecurity, the worsening of health conditions, and, in some cases, leading to population displacement (Brasil, 2025d, 2025f, 2025g, 2025j; Boulton *et al.*, 2025) (see **Box 4.2**).

The relationship between territory, water, and food is central to life in these contexts, as expressed in the inseparability of body and territory, whereby ecosystem health directly shapes the health of the populations (Brasil, 2025j). These impacts also have significant nutritional implications. Although a decline in the production of forest products may compromise the availability of micronutrients and part of the dietary base, nutrition security in the Amazon depends heavily on aquatic systems. These effects are unevenly distributed, requiring a gender approach integrated with territorial, ethnic-racial, and socioeconomic dimensions, since women, especially among Indigenous Peoples and traditional communities, tend to be more affected due to their role in providing for their families and managing natural resources (Brasil, 2025d). In this context, climate change acts as a factor that intensifies pre-existing vulnerabilities with combined effects on the livelihoods, water, food, and nutrition security, and adaptive capacity of these populations. The combination of structural inequalities, environmental racism, infrastructure limitations, and greater exposure to climate risks creates a situation of dual social and environmental exposure, highlighting the central role of these peoples and their respective territories in adaptation and climate justice strategies in Brazil (Brasil, 2025d, 2025h, 2025j).

NG8: Protect cultural heritage and preserve cultural practices and heritage sites in the face of climate change-related risks

Observed impacts

The observed impacts of climate change show adverse effects on cultural heritage across three integrated dimensions: territorial, tangible and intangible, and biocultural. In the territorial dimension, there is a loss and breakdown of traditional territories as the bases for cultural, social, and economic reproduction, as well as instances of forced displacement. In the tangible dimension, there is evidence of deterioration in buildings, archaeological sites, historic centers, and cultural landscapes. In the intangible and biocultural dimension, there has been a loss of traditional knowledge and ways of life, cultural practices, and traditional production systems.

Extreme events, such as floods, prolonged droughts, fires, and sea level rise, have caused the deterioration of archaeological sites, historic urban ensembles, heritage collections, and cultural landscapes (Paixão, 2025). Between 2021 and 2022, historic Brazilian cities such as Petrópolis (Rio de Janeiro state), Paraty (Rio de Janeiro state), Ouro Preto (Minas Gerais state), and Recife (Pernambuco state) were directly affected by high rainfall levels. The floods in the state of Rio Grande do Sul in May 2024 also caused damage to cultural facilities. An initial assessment identified damage to 56 libraries, 47 museums, 51 houses of culture and cultural centers, 31 Gaucho Tradition Centers (CTGs, Centros de Tradições Gaúchas), 25 community clubs and cultural recreational societies, 11 theaters, and 8 music and marching band halls, among others.

From 2011 to 2017, a prolonged drought affected the semiarid region of the Northeast, which is home to approximately 27 million people. Of this total, about 40% live in rural areas, primarily family farmers, Indigenous Peoples, and traditional peoples and communities, whose ways of life and livelihoods have been severely threatened by water scarcity. The socio-environmental impacts associated with water stress, however, were mitigated by policies aimed at social protection and promoting water security (*Bolsa Família* (Family Allowance), the Cisterns Program, PAC – Growth Acceleration Program (Programa de Aceleração do Crescimento) - *Água Para Todos* (Water for All), the National School Feeding Program (PNAE, Programa Nacional de Alimentação Escolar), and the Food Procurement Program), which helped increase the adaptive capacity of affected populations in the region (Lindoso *et al.*, 2018; Gaivizzo *et al.*, 2019; CAVALCANTE *et al.*, 2020; ALMEIDA *et al.*, 2020).

However, these impacts are not limited to the tangible aspect of the assets. They also impact the processes of intergenerational transmission of cultural knowledge and practices, affecting the continuity of cultural systems and collective identities (ICOMOS-Brasil, 2025). Thus, climate impacts become systemic in nature, as they simultaneously undermine physical structures and sociocultural dynamics, affecting the tangible and intangible conditions necessary for the good living of the bearer communities (see **Box 4.8**).

In addition to the impacts on sites and tangible cultural heritage, heritage bearers and communities have been directly affected. The undermining of traditional territories and the pressure placed on production practices and ways of life associated with sociobiodiversity constitute observed impacts of climate change across multiple biomes and social contexts (Brasil, 2025a, 2025g, 2025h, 2025q).

In the case of Indigenous Peoples, there have been reports of the destruction of homes, community infrastructure, and sacred sites; forced displacement; cosmological and psychosocial disruption; and impacts on traditional medicine, cultures, and the integrity of sacred territories (Brasil, 2025d; Lynn *et al.*, 2013). These impacts affect not only the physical space but also the spiritual, identity-related, and organizational aspects of Indigenous communities.

Quilombola territories have also experienced the loss of tangible and intangible assets and cultural heritage, with direct impacts on their territories and ways of life (Oviedo *et al.*, 2024; Brasil, 2025f). In this context, the exacerbation of historical vulnerabilities and the deepening of structural inequalities can be seen, which exacerbate climate injustice and cultural risk.

In cities, there is a loss of historical, identity-related, and cultural ties, linked to the degradation of tangible and intangible cultural heritage in the face of extreme events and environmental deterioration (ICOMOS, 2019; Brasil, 2025a). Urban heritage is, therefore, compromised, as are the right to memory and to collective identity.

The food sector also faces observed impacts of climate change that go beyond food availability. Family farmers have been experiencing a loss of cultural identity and social ties, as well as a loss of traditional knowledge and ways of life (Brasil, 2024c). This is compounded by genetic erosion and the loss of landrace seeds, agrobiodiversity, and associated knowledge (Abreu *et al.*, 2022; Brasil, 2024c, 2025h). Agri-food and biocultural heritage is affected alongside food security, regional food cultures, and traditional production systems.

Future risks

The *Brazilian Charter on Cultural Heritage and Climate Change*[42] highlights the intensification of climate risks to cultural heritage throughout the national territory over the coming decades. Similarly, the publication "*Memórias para o Futuro*" (Memories for the Future) highlights that the absence of structured action may result in further cultural erasure and jeopardize the continuity of traditional practices and knowledge (ICOMOS Brasil, 2025; Paixão *et al.*, 2025). From this perspective, cultural heritage and the associated knowledge emerge both as affected dimensions and as elements present in the social dynamics of responding to climate change.

In this context, the sectoral and thematic plans of the Climate Adaptation Plan identify a set of future risks associated with cultural heritage, cultural practices, and heritage sites (Figure 4.61) as described below:

- Thematic Plan for Indigenous Peoples (Brasil, 2025d)
  - Risk of loss of territories, homes, and sacred sites.
  - Risk of loss of the bioeconomy and handicraft production due to climate-related events.
  - Forced displacement of Indigenous communities.
  - Undermining the integrity of sacred territories.

42 The *Brazilian Charter on Cultural Heritage and Climate Change* is a strategic document that sets forth guidelines for the protection of cultural heritage in the face of the impacts of climate change, with a focus on Brazil's six biomes. It serves as a reference for the formulation of public policies and for professionals and institutions in the sector. It is the result of a joint effort by the Brazilian Committee of the International Council on Monuments and Sites (ICOMOS Brasil) and the Brazilian Committee of the International Council on Museums (ICOM Brasil), with support from the National Institute of Historic and Artistic Heritage (IPHAN, Instituto do Patrimônio Histórico e Artístico Nacional), the Brazilian Institute of Museums (IBRAM, Instituto Brasileiro de Museus), and the Oswaldo Cruz House (COC, Casa de Oswaldo Cruz/Fiocruz (Oswaldo Cruz Foundation)).

- Thematic Plan for Traditional Peoples and Communities (Brasil, 2025g)
  - Loss or degradation of traditional territories as a result of extreme events (droughts, fluvial floods, fires).
  - Changes in production practices and ways of life associated with socio-biodiversity.
- Thematic Plan for the Ocean and Coastal Zone (Brasil, 2025q)
  - Risk of changes to ways of life, land use, and natural resources in the territories of coastal Traditional Peoples and Communities.
  - Displacement of coastal communities.
- Thematic Plan for Racial Equality and Combating Racism (Brasil, 2025f)
  - Loss of territories, biodiversity, and cultural assets.
  - Forced displacement and territorial conflicts.
  - Loss of tangible and intangible cultural assets and heritage, as well as the ways of life and cultural references of the communities and heritage bearers.
- Sectoral Plan for Cities (Brasil, 2025a)
  - Increased exposure of tangible assets from Cultural Heritage — urban ensembles, buildings, and sites of historical, landscape, artistic, and archaeological value — to floods, coastal erosion, and extreme events.
  - Loss of cities' historical, identity-related, and cultural ties.
- Sectoral Plan for Tourism (Brasil, 2025r)
  - Risk of damage to historic sites, cultural heritage, and cultural expressions as a result of extreme weather events.
  - Degradation of cultural attractions linked to tourism.
- Sectoral Plan for Family Farming (Brasil, 2025h)
  - A reduction in the availability of and access to land for family farming.
  - An increase in migration and forced displacement of farming families.
  - Loss of cultural identity and social ties.
  - Genetic erosion and the loss of landrace seeds and of agrobiodiversity, and associated knowledge.
- The Thematic Plan for Biodiversity is indirectly related to cultural heritage (Brasil, 2025l)
  - Loss of ecosystem services that sustain traditional knowledge associated with biodiversity.

Figure 4.61 Summary of climate risks and their dimensions, as identified by IPHAN and by sectoral and thematic adaptation plans



Source: Compiled by the authors.

Together, the projected risks create a scenario characterized by the physical destruction of cultural assets, population displacement, the progressive loss of traditional knowledge, and deepening territorial inequalities. Cultural risk, thus, becomes cumulative and potentially irreversible (ICOMOS Brasil, 2025; Paixão *et al.*, 2025). Furthermore, the multisectoral nature of climate risk to cultural heritage is evident, as it cuts across territorial, urban, production, socio-environmental, and identity-related dimensions.

Vulnerabilities

The vulnerability of cultural heritage to climate change is territorially differentiated and socially unequal. The *Brazilian Charter on Cultural Heritage and Climate Change* recognizes that climate impacts affect historically marginalized groups and territories with less institutional capacity for heritage protection and management more severely (ICOMOS Brasil, 2025). Similarly, "*Memórias para o Futuro*" highlights that communities with less access to public policies and heritage education instruments have a reduced capacity to safeguard their cultural assets and practices in the face of extreme events (Paixão *et al.*, 2025).

Among the priority groups, the following stand out:

- Indigenous Peoples, whose territories are home to tangible and intangible cultural assets and whose sociocultural organization is intrinsically linked to the territory. Direct dependence on natural resources and exposure to droughts, fires, and extreme events increase cultural vulnerability (Brasil, 2025d; Lynn *et al.*, 2013).
- Quilombola communities and the Black population in vulnerable territories, who face the loss of tangible and intangible cultural assets and impacts on traditionally occupied territories, in a context of structural inequalities and environmental racism (Oviedo *et al.*, 2024; Brasil, 2025f).
- Traditional Peoples and Communities, whose ways of life are linked to socio-biodiversity and local ecological cycles, and who are particularly sensitive to environmental degradation and to the occurrence of extreme events (Brasil, 2025g; Almeida *et al.*, 2020).
- Family farmers, especially in semi-arid regions and areas with limited access to land, who face a reduction in territorial availability, genetic erosion, and the loss of knowledge associated with traditional production systems (Abreu *et al.*, 2022; Brasil, 2024a, 2025h; Lindoso *et al.*, 2018); and

- Workers in the cultural, creative, and tourism industries (Itaú Foundation (Fundação Itaú, 2024)).

In addition, among the priority territories, the aforementioned sectoral and thematic plans identify:

- Semiarid region, characterized by high exposure to prolonged droughts and socioeconomic vulnerability (Lee and Romero, 2023);
- Coastal zones, which are subject to sea-level rise, erosion, and extreme events that threaten both traditional communities and urban historical heritage sites (Brasil, 2025a);
- Historic urban centers and peripheral areas exposed to floods and environmental degradation processes that compromise tangible cultural assets and historical and identity-related ties (ICOMOS, 2019; Brasil, 2025a);
- Indigenous and Quilombola territories facing land-related pressures, where the combination of climate-related hazards and territorial conflicts increases cultural risk; and
- Cultural practices rooted in specific territories, as well as festivals and other forms of cultural expression.

The vulnerability of cultural heritage, thus, stems from the intersection of climate exposure, structural inequalities, and institutional limitations. Cultural risk is inseparable from social and territorial risk, and is exacerbated by factors such as precarious land tenure, structural racism, the fragility of urban infrastructure, soil and water degradation and pollution, and direct dependence on specific ecosystems, as well as data gaps and lack of indicators that provide the knowledge and evidence needed for decision-making.

Another vulnerability worth mentioning is the lack of recognition and recording of traditional knowledge. In Brazil, for example, 87% of the records in the National System for the Management of Genetic Heritage and Associated Traditional Knowledge do not identify the traditional knowledge associated with the registered biodiversity item (C de Cultura/Outra Onda Conteúdo, 2024).

An analysis of the most exposed and vulnerable peoples and territories highlights that cultural risk is inseparable from social and territorial risk and is exacerbated by factors such as insecure land tenure, structural racism, inadequate urban infrastructure, and direct dependence on specific ecosystems (CAVALCANTE *et al.*, 2020). In addition, the identified priority groups and territories are not only more exposed to climate-related hazards, but also have greater sociocultural significance for the preservation of practices, knowledge, and collective identities, which increases the potential severity of the losses associated with climate change (Gaivizzo *et al.*, 2019).

BOX 4.8 MULTIDIMENSIONAL CLIMATE IMPACTS AND CULTURAL HERITAGE

Extreme weather events have left a deep mark on Brazil's cultural heritage, revealing the vulnerability of tangible and intangible cultural assets to climate change throughout the territory.

In 2010, the flood that affected São Luiz do Paraitinga (São Paulo state) destroyed the São Luís de Tolosa Parish Church and buildings within the urban ensemble, also affecting the traditional festival "*Festa do Divino*". However, the disaster mobilized the community, which drew upon cultural and religious practices to strengthen local identities and raise funds for reconstruction, with support from IPHAN in heritage designation processes that took on new meanings (Paixão *et al.*, 2025). This example demonstrates the importance of social and cultural cohesion during a disaster and in the reconstruction process for increasing adaptive capacity. However, it has long-term impacts, such as "ill health, depression, and social suffering" in the aftermath of the disaster (Marchezini, 2018, p. 59).

In 2024, the floods in Rio Grande do Sul caused irreparable losses: human lives, homes, documents, photos, and objects that held family and community memories, as well as damage to approximately 650 archaeological sites, 28 heritage sites, and expressions of the intangible heritage of the Quilombola and Indigenous communities (Paixão *et al.*, 2025).

In the Amazon region, the severe drought from 2023 to 2025 exposed riverbeds and caused widespread mortality among aquatic fauna, placing riverine communities, fishers, Indigenous Peoples, and Quilombola communities in vulnerable situations and jeopardizing their cultural practices. Paradoxically, the lack of water revealed traces of human history in the forest: faces carved into stones at the Ponta das Lajes site, the ruins of the São Francisco Xavier Fort (18th century), and the Costa do Goiabeira site, with funerary urns and petroglyphs. This duality between destruction and discovery characterizes the current state of Amazonian cultural heritage, where the climate crisis acts simultaneously as an agent of erasure and discovery (Paixão *et al.*, 2025).

The resilience of communities in the face of these impacts is manifested in various ways. In São Luiz do Paraitinga, the reconstruction of the Parish Church became a symbol of reaffirming local identity, demonstrating how tangible heritage serves as an anchor for social cohesion. In the Amazon, traditional communities are seeking to adapt their knowledge and practices to new environmental conditions, preserving ways of life that are threatened by alternating extreme floods and prolonged droughts (Paixão *et al.*, 2025). However, the recurrence of these events in areas that have already been affected can increase the vulnerability of these territories and populations (O'Neill, 2022).

Note: Box inspired by the publication edited by IPHAN, "*Memórias para o futuro: patrimônio cultural, educação patrimonial e mudanças climáticas*" (Memories for the Future: Cultural Heritage, Heritage Education and Climate Change) (Paixão *et al.*, 2025).

NG9: Strengthen the vital role of the ocean and coastal zone in tackling climate change

Observed impacts

The impacts of climate change on the ocean and coastal zones are diverse and heterogeneous, ranging from the loss of marine biodiversity and natural resources to damage to infrastructure and the economy (Brasil, 2025p). Section **4.2.1.2 Current climate change trends** of this report presented evidence on trends in acidification, rising mean sea level, and sea surface temperature (SST) in the Brazilian Coastal-Marine System over the past few decades.

In Brazil, climate change, interacting with local stressors, is already affecting fishing, mariculture, and tourism activities, with impacts on the growth, reproduction, and survival of fish, invertebrates, and algae, as well as on the suitability of beaches for bathing. The spatial distribution and abundance of fish and marine algae populations are being altered by ocean warming, reducing the generation of economic benefits (Gorman *et al.*, 2020; Seixas *et al.*, 2023). Losses are already being observed, including losses associated with tourism and reduced food security among traditional coastal communities that depend directly on marine resources (Brasil, 2025q).

The fourth global mass coral bleaching event, which occurred between 2023 and 2025, was the most extensive on record, affecting 84% of the world's total coral reef area. The 2024 event is considered the most severe ever recorded in Brazil, although its impact varied by region. The Northeast and the oceanic islands (Fernando de Noronha, Trindade-Martim Vaz) recorded high DHW[43] (Degree Heating Weeks) for several weeks and bleaching rates close to or exceeding 90%, with mortality ranging from 28% to 88% of corals in the most affected regions along the Northeast coast (Mies *et al.*, 2025). Studies indicate that mortality can persist for months and years after heat waves, even in the absence of visible bleaching in all colonies (Ferreira and Prates, 2025; Bender *et al.*, 2023).

The increasing frequency and intensity of extreme oceanographic events are intensifying coastal erosion, causing flooding, changes in tidal range and sediment hydrodynamics, and resulting in loss of assets, restricted services, reduced habitable space, and loss of biodiversity and fisheries production (Brasil, 2025p). In recent decades, Latin America has seen an increase in the frequency of extratropical cyclones (Castellanos *et al.*, 2022), particularly in the South and Southeast of Brazil, the far south of Brazil and Uruguay, and the Southeast of Argentina. In coastal cities, rising sea level has contributed to the salinization of water sources and intensified coastal flooding, leading to disasters that cause damage and compromise economic activities such as tourism (Brasil, 2025q).

Throughout Brazil's coastal region, erosion is reducing beach width, removing mangrove fringes, and destroying sidewalks and infrastructure, with negative impacts on the economy of the municipalities and the lives of residents. It is estimated that in some states, around 60% of the coastline is already undergoing an erosion process, while in others, around half of the coastline shows an erosion trend. Annual coastline retreat rates of around 5 meters have been observed, for example, along sections of the Piauí coast (Brasil, 2018). In Rio de Janeiro, a 13 cm rise in mean sea level was observed between 1990 and 2020 (UN, 2024). This scenario contributes to an increase in the number of homeless people or climate refugees, triggering

43 A standard metric used worldwide to estimate heat stress affecting coral reefs.

migration processes among both the Caiçara population living in these areas and the riverside population living along the banks of major rivers (Brasil, 2025q). This is the case for the Caiçara community on Ilha do Cardoso (off the coast of São Paulo), which has already been affected by coastal erosion and flooding, as detailed in **Box 4.2**.

Finally, although the impacts of climate change on the ocean and coastal zones are often associated with coastal communities, it is important to recognize that the importance of the ocean goes beyond the geographical boundaries of the coastline, having a direct or indirect influence on the entire Brazilian territory and population, including the economy (Brasil, 2025q). The warming of the Tropical Atlantic Ocean, for example, has led to significant variations in rainfall patterns throughout the country, highlighting its regional importance in climate regulation and the interdependence between the terrestrial and oceanic systems (Brasil, 2025p, 2025; Marengo *et al.*, 2019).

Future risks

The Thematic Plan for Ocean and Coastal Zone Adaptation identifies six priority risks (Brasil, 2025q):

1. Risk of changes in coastal and marine dynamics and loss of biodiversity;
2. Risk of loss of ecosystem services and of the well-being of the population;
3. Risk of loss of life, damage to and losses of assets and services, and forced displacement of coastal populations;
4. Risk of changes to ways of life, land use, and natural resources in the territories of coastal Traditional Peoples and Communities;
5. Risk of damage to infrastructure in the coastal zone; and
6. Risk of saltwater intrusion and adverse impacts on water supply.

Climate projections indicate a sharp increase in coastal risks over the coming decades. Mean sea level rise, combined with the increasing frequency and intensity of extratropical cyclones, storm surges, storms, and extreme rainfall, is expected to intensify erosion, flooding, and coastline retreat processes, with direct impacts on cities, critical infrastructure, and vulnerable human settlements. Future scenarios indicate that ecosystems such as coral reefs, seagrass meadows, kelp forests (such as rhodolith beds[44]), and mangroves will face limits to adaptation and may experience massive impacts under warming above 1.5°C, resulting in loss of marine genetic heritage, especially under a scenario in which coastal pollution persists or worsens (Brasil, 2025q).

Climate projections indicate that, without robust mitigation measures, severe annual coral bleaching events could become the norm between 2040 and 2050. The synthesis literature used by the IPCC indicates a 70-90% loss of coral reefs at 1.5°C of warming and up to 99% at 2°C, with a trend toward tipping points already underway in parts of the Southwestern Atlantic. Brazil is estimated to have one million artisanal fishers, who account for half of the country's fisheries production, with coral reefs and associated environments, such as mangroves and seagrass meadows, being essential ecosystems for maintaining productivity in oligotrophic tropical waters. These scenarios entail the collapse of services (coastal protection, fisheries, tourism) and rising adaptation and restoration costs (Ferreira and Prates, 2025).

44 Fields of unattached calcareous algae that form rich habitats essential for marine life.

In the case of mangroves, sea level rise and reduced riverine sediment supply, combined with human occupation of tidal flats, increase the risk of erosion and salinization of estuaries and aquifers. The loss of connectivity among mangroves, seagrass meadows, and coral reefs weakens food webs and combined ecosystem services (coastline protection, pollutant retention, and support for fisheries). Without curbing deforestation, pollution, and human occupation of landward migration zones (*apicum)*, some mangroves become trapped, with no possibility of migrating to higher ground, and are unable to keep pace with the rate of sea level rise. This may lead to the collapse of coastal protection services in the most vulnerable areas (including urban areas) and place additional burdens on infrastructure and local budgets (Bernardino and Copertino, 2025).

Saltwater intrusion into estuaries and coastal aquifers poses a growing risk to water supply, irrigated agriculture, and soil health, affecting municipalities along the coastline and in coastal plains. The intensification of ocean acidification and the decline in dissolved oxygen tend to jeopardize entire food webs, altering fish distribution patterns and affecting industrial and artisanal fisheries (Brasil, 2025q). These factors jeopardize the food security of Brazilians, especially those in situations of greater vulnerability.

Other risks with economic implications include disruptions to port operations, losses in the tourism sector, damage to public and private infrastructure, and increased costs for urban adaptation. In particular, coastal zones characterized by unplanned urban expansion, human occupation of areas at geo-hydrological risk, and a lack of public policies that take the climate dimension into account are expected to experience substantial economic and social losses. These risks are exacerbated by the convergence of ecological and social vulnerabilities and are strongly linked to socio-environmental inequalities (Brasil, 2025q).

Low-income groups, peripheral communities, artisanal fishers, Indigenous populations, Quilombola and Caiçara communities that depend directly on coastal zones and marine resources for their survival and ways of life experience disproportionately greater impacts, resulting in scenarios of climate injustice. The provision of ecosystem services is severely affected by climate change, altering the livelihoods and food security of traditional communities that depend heavily on marine resources and affecting their culture and identity (Brasil, 2025q).

Vulnerabilities

The vulnerability of Brazil's coastal zone is exacerbated by anthropogenic pressures and socioeconomic inequality. A range of economic activities are carried out across the ocean and coastal zones. These activities coexist and may give rise to conflicts over the use of the territory, involving competition for resources such as energy, food, and water. The convergence within the same territory of factors such as environmental degradation, real estate market pressures, uneven urban expansion, the relaxation of territorial planning instruments, and a history of racial and gender inequality exacerbates social and ecological vulnerability across extensive stretches of the country's coastline (Brasil, 2025q).

Approximately 54% of Brazil's population lives within 150 kilometers of the coast, and a large share of strategic economic activities depends directly on the sustainable use of natural resources. The economy of Brazil's coastal zone plays a central role in the country, encompassing significant activities such as ports, tourism, fisheries, mariculture, aquaculture, shipping, and energy production, which drive essential sectors and contribute significantly to national

development. It is estimated that the ocean accounts for 19% of Brazil's GDP, and its importance to the country's economy is recognized by about 9 out of 10 Brazilians (Brasil, 2025q). According to modeling studies, coral reefs generate up to BRL 167 billion for Brazil through coastal protection and tourism services. In the Northeast alone, revenue from recreation and leisure activities at coral reef sites amounts to BRL 7 billion per year (Fundação Boticário, 2023).

However, this economic significance coexists with structural factors that increase climate vulnerability. The presence of critical infrastructure and developments located very close to the sea increases exposure to coastal erosion, sea-level rise, storms, and marine heat waves. In addition, practices such as overfishing reduce ecological resilience and compromise the balance of fish stocks. In Brazil, 25 species or groups of species account for approximately 60% of marine fisheries production, and bycatch (i.e., the capture of non-target species in fishing activities) exceeds the catch of target species (Dias-Neto, 2015). This situation undermines economic activities that depend on these ecosystems and increases food insecurity in traditional communities, while also placing pressure on highly sensitive ecosystems such as mangroves, *restingas*, and coral reefs. The adaptive capacity of these ecosystems varies depending on differences in species, structures, intensity of use, and other stressors (Brasil, 2025q; Bender *et al.*, 2023).

The degradation of native vegetation and riparian forests, as well as the deterioration of watersheds, also constitute vulnerability factors. The loss of restingas, mangroves, seagrass meadows, and coral reefs — ecosystems that act as natural barriers, filter sediments, stabilize soils, and reduce wave energy — exacerbates the physical vulnerability of urban areas and existing infrastructure. In addition, the lack of transition areas hinders species adaptation, leading to the extinction of some species and compromising fisheries resources and marine biodiversity as a whole (Brasil, 2025q).

Coral reefs, seagrass meadows, kelp forests, and rocky reefs are the most susceptible ecosystems, with low adaptive capacity due to their sensitivity to ocean warming, marine heat waves, and acidification (IPCC, 2019). Furthermore, the presence of these ecosystems outside of Conservation Units is a factor that reduces their climate resilience, as they are more exposed and vulnerable to local stressors, such as urban expansion, pollution, overfishing, and predatory tourism. In Brazil, 26.7% of the Exclusive Economic Zone is located within Marine Protected Areas, but only 2% of that total is located on the continental shelf. Limitations in the enforcement and implementation of management plans in these areas may reduce their effectiveness in providing protection (Brasil, 2025q; Bender *et al.*, 2023).

Brazil has approximately 1.1 million hectares (ha) of mangroves (the second-largest area in the world), but it is estimated that 11,000 hectares are lost each year due to anthropogenic pressures (conversion to shrimp farming, urban and port expansion) and climate-related pressures (severe droughts/El Niño, sea-level rise). The degradation of these ecosystems reduces natural protection against storms and storm surges, water purification, and the provision of nursery habitats for fisheries. In urbanized areas, human occupation of *apicum* and *salgado*[45] areas prevents the natural landward migration of mangroves in response to sea level rise. In Brazil, the most vulnerable areas include the Amapá–Maranhão Arc (the world's

45 *Apicum* and s*algado* are natural coastal transition areas between mangroves and dry land. The *apicum* is a higher-elevation zone that is highly saline, flooded only during very high tides, and with little or no tree vegetation. *Salgado* is an area that is flooded more frequently, has low-growing vegetation adapted to saline conditions, and serves as a transition zone between mangroves and drier areas.

largest continuous stretch) and densely occupied estuaries in the Northeast and Southeast, where human occupation of *apicum/salgado* areas and inadequate sanitation increase risks (Bernardino and Copertino, 2025).

The rapid increase in population density in coastal regions, combined with the lack of adequate land use planning and effective implementation of coastal management instruments, such as zoning, master plans, and land use planning regulations, substantially exacerbates climate risks. Unplanned urban expansion and real estate speculation in environmentally protected areas lead to human occupation of areas susceptible to flooding, erosion, and mass movements. Additionally, the lack of basic sanitation and the deficit in urban infrastructure increase levels of water, soil, and air pollution, compromising environmental health, adversely affecting mariculture, and increasing the risk of collapse in already fragile coastal ecosystems (Brasil, 2025q).

Populations that depend directly on natural resources, such as artisanal fishers, female shellfish gatherers, and other coastal traditional peoples and communities, face worsening vulnerabilities. These groups have strong economic, cultural, and identity-based ties to marine and coastal ecosystems, and are disproportionately affected by environmental degradation, overfishing, species displacement, and changes in ecosystem cycles. Many of these territories have limited land titling or face barriers to land titling, which intensifies land conflicts and limits their capacity to adapt and remain in traditionally occupied areas. The combination of economic dependence on natural resources, low adaptive capacity, and historical socioeconomic pressures results in greater vulnerability and lower resilience to climate change, creating a scenario of environmental racism and climate injustice (Brasil, 2025q).

Finally, the construction of coastal protection structures without adequate technical guidelines, as well as public disinvestment and the lack of maintenance of physical infrastructure essential to the development and protection of territories, exacerbate problems such as coastal erosion and flooding. The lack of planning instruments and the poor implementation of public policies on coastal management limit the institutional capacity to mitigate risks and promote adaptive interventions (Brasil, 2025q). In addition, controlling local stressors, such as pollution and overfishing, should be considered as a way to reduce climate-related vulnerabilities and risks (Horta *et al.*, 2020).

4.2.3. Methodological approach

4.2.3.1. Observed trends

To perform the analyses listed in section **4.2.1.2, Current climate change trends,** the following databases were used (Table 4.4).

Table 4.4 Characteristics of the data used for analyses of observed climate change trends

Data	Period	Spatial resolution	Frequency	Variable
CHIRPS	1981-2025	0.05° x 0.05° latitude and longitude (5 km)	Daily	Precipitation
GPCP v3.3	1983-2024	0.5° x 0.5° latitude and longitude	Monthly	Precipitation
ERA5 reanalysis	1961-2024	0.25° x 0.25° latitude and longitude (25 km)	Daily	Maximum temperature
NOAA SST V2 High Resolution	1981-2025	0.25° x 0.25° latitude and longitude (25 km)	Monthly and daily	Sea Surface Temperature (SST)
Ocean Carbon and Acidification Data System (OCADS)	1960-2020	1° x 1° latitude and longitude (1 km)	Decadal	pH on the total scale
COPERNICUS sea level anomalies	1993-2023	0.25° x 0.25° latitude and longitude (25 km)	Monthly	Sea level anomaly

Source: Compiled by the authors.

Daily maximum temperature (Tmax) data for the period 1981-2024 were obtained from the ERA5 reanalysis dataset developed by the European Centre for Medium-Range Weather Forecasts (ECMWF). ERA5 is the fifth generation of ECMWF reanalysis for global climate and weather over the past eight decades (Hersbach *et al.*, 2020), with data available from 1940 and continuously updated to the present. The reanalysis combines model data with observations from around the world into a globally complete and consistent dataset, using the laws of physics. It provides hourly estimates for many atmospheric, ocean wave, and land surface variables at various heights. The spatial resolution chosen for these data was 0.25° × 0.25° latitude and longitude.

Precipitation data were obtained from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) (Funk *et al.*, 2015), which was developed by the United States Geological Survey (USGS) and the Climate Hazards Group at the University of California, Santa Barbara (UCSB). CHIRPS has a spatial resolution of 0.05° × 0.05° latitude and longitude (approximately 5 km) near the equator, with geographic coverage from 50°S to 50°N, and is available as daily, monthly, and annual datasets. CHIRPS data are available for the period from 1981 to the present[46].

According to the Expert Team on Climate Change Detection and Indices (ETCCDI), for climate indices to provide a satisfactory characterization of the climate, the data must have a daily measurement frequency and the time series must span more than 30 or 40 years. Given

46 Available at: https://www.chc.ucsb.edu/data/chirps. Accessed on: Sep. 06, 2026.

these limitations, the CHIRPS daily dataset, available from 1981 onward, was selected, enabling a consistent characterization of precipitation variability and extremes and fully meeting the criteria required for the calculation of climate indices.

To prepare Figure 4.16, a classification was performed based on the magnitude of the anomalies in the climate indices and maximum temperature, calculated for the period 2011-2024 relative to the 1981-2010 reference climatology.

For each index, thresholds were defined, taking into account its variability. Thus, the magnitude of the variables was classified as "High," "Medium," and "Low," according to Table 4.5 below.

Table 4.5 Thresholds used to classify regions based on the anomalies obtained

Index	LOW magnitude	MEDIUM magnitude	HIGH magnitude
Tmax (°C)	< 0.06	0.06 to 0.09	≥ 0.09
CDD (days)	< 0.30	0.30 to 0.70	≥ 0.70
RX5day (mm/day)*	< 0.30	0.30 to 0.70	≥ 0.70

* For RX5day, the magnitude is assessed based on the absolute value of the anomaly, regardless of its sign.

Source: Compiled by the authors.

Regarding the territorial dimensions adopted, a few considerations should be made. The Atlantic Forest biome exhibits large latitudinal variability, as it extends across a broad swath of the Brazilian territory and spans different climate zones across latitudes (Alvares *et al.*, 2013). The latitudinal range controls the amount of solar radiation received at the biome's surface throughout the year, directly influencing mean temperatures (Ramos *et al.*, 2018). In the northernmost regions, higher temperatures and lower annual variability predominate, while in the south, lower temperatures and a greater temperature range are observed (Prata *et al.*, 2018). In addition, rainfall regimes, the frequency of extreme events, and interannual rainfall variability vary across the biome (Oliveira F.º and Fontes, 2000). Therefore, Tmax and precipitation results for the Atlantic Forest biome may present uncertainties regarding climate trends for the period from 1981 to 2024.

Analysis of ocean variables

To further our understanding of how ocean variables are changing as a result of changes in climate patterns, a research study was conducted using consolidated global databases for three variables: ocean acidification, sea surface temperature, and mean sea level rise. To define the oceanic area of interest, the shapefile delineating the boundary of Brazil's Coastal-Marine System, provided by the Brazilian Institute of Geography and Statistics (IBGE), was used. This official boundary, established in accordance with Brazilian legislation and cartographic standards, was used to clip the ocean fields and standardize the analysis area[47]. The databases and methods used in the analyses for each variable are described below.

47 Available at: https://www.ibge.gov.br/geociencias/informacoes-ambientais/estudosambientais/15842-biomas.html?edicao=41055&t=acesso-ao-produto. Accessed on: Jun. 06, 2026

Ocean Acidification

Information on ocean acidification patterns was obtained from the Ocean Carbon and Acidification Data System (OCADS) platform. OCADS has developed an interface that provides access to pre-plotted maps of Global Surface Ocean Acidification Indicators from 1750 to 2100 at decadal and annual temporal frequencies. The spatial resolution of this product is 1º x 1º latitude and longitude. This collection contains a complete series of data on global surface ocean acidification indicators, produced by merging data collected by ocean observing platforms with data from numerical modeling (Jiang *et al.*, 2023).

In this study, the pH (total scale) variable was used for the period from 1970 to 2020. This variable can represent ocean acidification and corresponds to the decrease in pH due to the high uptake of atmospheric carbon dioxide (CO_2).

The analysis covered the Atlantic Ocean adjacent to South America, including Brazil's coastal zone, in order to understand how ocean acidity patterns have evolved. However, it is important to note that the dataset used has a relatively coarse spatial resolution when compared to typical scales of local analysis. As this is a global product derived from reanalyses and biogeochemical syntheses, the spatial grid size does not allow for an adequate representation of small-scale variations, such as those associated with bays, estuaries, river discharges, inner continental shelves, and, particularly, port areas and urban coastal environments. Thus, the data do not provide sufficient detail for sector-specific analyses at the level of municipalities, coastal cities, or specific stretches of the Brazilian coastline.

Therefore, the results presented should be understood as assessments at the regional scale and at the scale of broad oceanographic domains, suitable for identifying large-scale trends and general patterns of acidification, but not for capturing local heterogeneities or microscale processes that directly influence water quality in urban or estuarine contexts.

Sea Surface Temperature (SST)

Sea Surface Temperature (SST) data from the NOAA OI SST Version 2 High Resolution (V2-HR) were used, provided by the National Oceanic and Atmospheric Administration (NOAA). These data are generated by combining *in situ* observations (buoys and ships) and satellite measurements, adjusted using the Optimum Interpolation (OI) method, which allows for the estimation of continuous SST fields globally, even in regions where direct observations are lacking. The data were obtained from the repositories of NOAA/ESRL's Physical Sciences Laboratory (PSL) and the National Centers for Environmental Information (NCEI)[48].

The NOAA OI SST V2 High Resolution has a spatial resolution of 0.25º x 0.25º and provides daily analyses, allowing for the capture of SST variations on regional and seasonal scales in greater detail (Reynolds *et al.*, 2007; Huang *et al.*, 2021). This product integrates observations from the Advanced Very High Resolution Radiometer (AVHRR) sensor, microwave data, and in situ measurements, providing improved spatial coverage, particularly in areas with persistent cloud cover, such as South America. The anomalies indicate how much the sea surface temperature is above or below the historical average, making it possible to identify patterns of warming, cooling, and changes relevant to the Brazilian coast.

48 Available at: https://psl.noaa.gov/thredds/catalog/Datasets/noaa.oisst.v2.highres/catalog.html. Accessed on: Sep. 06, 2026.

Mean sea level rise

A gridded daily sea level dataset for the global ocean was used (Taburet *et al.*, 2019; Legeais *et al.*, 2021), distributed by the Copernicus Climate Change Service (C3S)[49], which contains sea level anomalies relative to a mean sea surface. This dataset provided daily and monthly global mean estimates of sea level anomaly, based on satellite altimetry measurements. Sea level anomaly is defined as the height of the water above the mean sea surface for a given period and region. In this dataset, sea level anomalies are calculated based on a twenty-year mean reference period (1993-2012), from 1993 to the present, using up-to-date altimeter standards. The spatial resolution of this product is 0.25° x 0.25°.

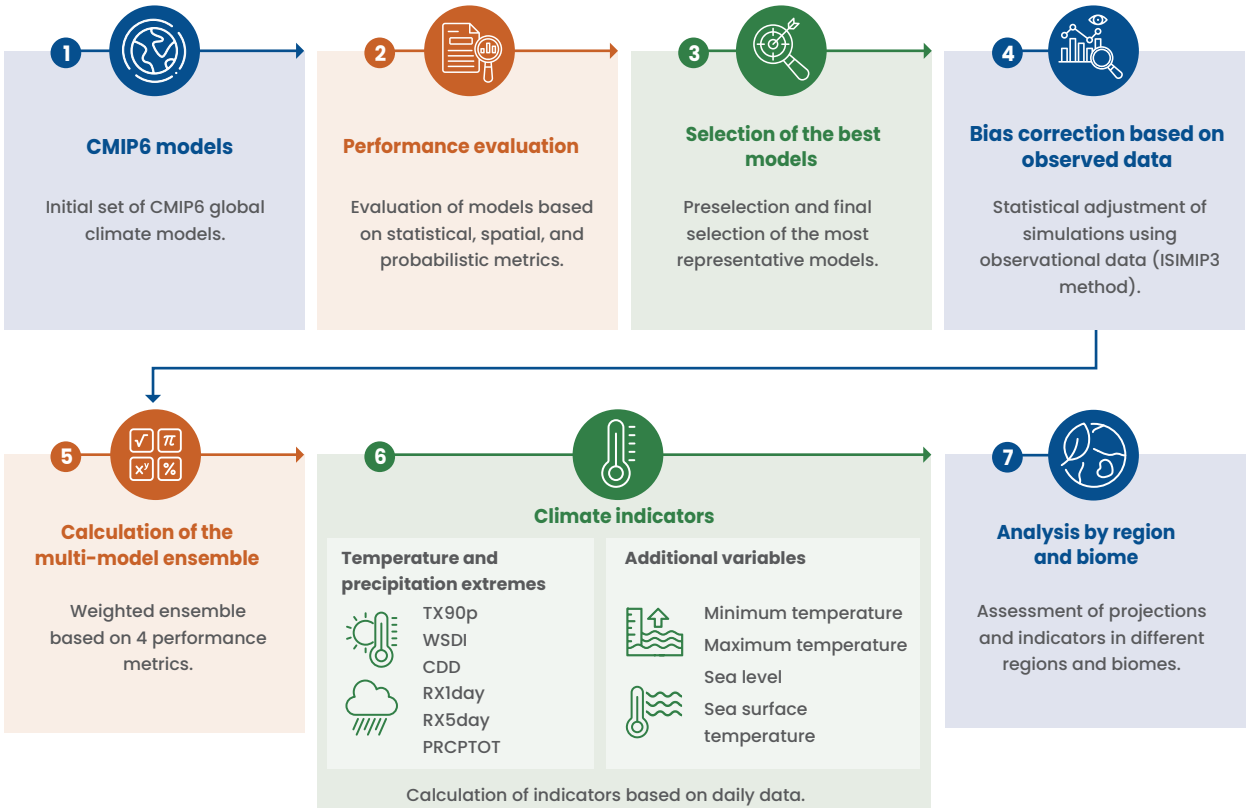
To investigate the relationship between ocean surface thermal variability and sea level response, a correlation analysis between SST and the SLA variable was conducted. The coefficient of determination (R^2) was used to quantify the strength and proportion of the variability in SLA that can be explained by fluctuations in SST. This approach made it possible to assess the physical consistency between surface warming, thermal expansion, and sea level rise in the ocean region adjacent to Brazil. However, it is important to note that the SLA product has inherent limitations related to its spatial resolution. Although this scale is suitable for regional analyses and for identifying large-scale coastal patterns, it does not allow for the capture of oceanic processes or variations in local heterogeneities typical of urban coastal environments, such as ports, bays, narrow estuaries, or small coves.

4.2.3.2. Projected climate trends and climate-related hazards

The methodological approach adopted for the analysis of future climate change scenarios in Brazil is summarized in Figure 4.62, which schematically presents the main stages of the analytical process, from the selection of climate models to the derivation of indicators and regional analysis. The methodological workflow includes model performance evaluation, the selection of more representative subsets, bias correction based on observational data, the construction of a weighted multi-model *ensemble*, and the calculation of climate indicators relevant to the assessment of extremes.

49 Available at: https://cds.climate.copernicus.eu/datasets/satellite-sea-level-global?tab=download. Accessed on: Sep. 06, 2026.

Figure 4.62 Schematic diagram of the methodological approach adopted in this study



Note: The workflow begins with the selection of CMIP6 climate models, followed by performance evaluation and the selection of the best-performing models. Next, bias correction is performed based on observational data, followed by the calculation of the multi-model *ensemble*. Finally, climate indicators are derived, which inform the integrated analysis by region and biome.

Source: Compiled by the authors.

Climate Models

The climate data used in this study were obtained from global models participating in CMIP6, which represents the state of the art in climate modeling. The initial selection included 46 models, of which 19 were chosen for detailed analysis based on performance and structural independence criteria.

For the analysis, simulations of the historical experiment covering the period from 1981 to 2014 were used, ensuring compatibility with the reference observational data, which were selected based on their widespread use in the scientific literature and the spatial and temporal consistency required for the evaluation of climate models. For future projections, three emission scenarios were considered: SSP1-2.6, which represents a sustainability scenario with lower GHG emissions; SSP2-4.5, representing an intermediate stabilization scenario; and SSP5-8.5, characterizing a high-emissions scenario.

The 19 global climate models selected for the detailed analysis, which are part of CMIP6, are presented in Table 4.6 along with their respective modeling centers and countries of origin. This *ensemble* includes models developed by different international institutions, reflecting

the diversity of approaches used to represent climate system processes. The technical documentation and detailed specifications for each model can be found in the respective references and in the CMIP6[50] documentation.

Table 4.6 CMIP6 climate models analyzed in this report

Model	Modeling center[51]	Country/ Region	Spatial Resolution (approximate value)	Bibliographic Reference
ACCESS-ESM1-5	CSIRO / BOM	Australia	208 km	(Ziehn *et al.,* 2020)
AWI-CM-1-1-MR	AWI	Germany	100 km	(Semmler *et al.,* 2020)
CanESM5	CCCma	Canada	311 km	(Swart *et al.,* 2019)
CESM2	NCAR	United States	100 km	(Danabasoglu *et al.,* 2020)
CMCC-ESM2	CMCC	Italy	100 km	(Lovato *et al.,* 2022)
CNRM-ESM2-1	CNRM-CERFACS	France	155 km	(Séférian *et al.,* 2019)
E3SM-1-1-ECA	DOE / LLNL	United States	100 km	(Burrows *et al.,* 2020)
EC-Earth3	EC-Earth Consortium	Europe (consortium)	77 km	(Döscher *et al.,* 2022)
GFDL-ESM4	NOAA / GFDL	United States	100 km	(Dunne *et al.,* 2020)
GISS-E2-1-G	NASA / GISS	United States	222 km	(Kelley *et al.,* 2020)
HadGEM3-GC31-MM	MOHC	United Kingdom	92 km	(Andrews *et al.,* 2020)
IITM-ESM	IITM	India	208 km	(Swapna *et al.,* 2018)
IPSL-CM6A-LR	IPSL	France	277 km	(Boucher *et al.,* 2020)
MIROC6	JAMSTEC / University of Tokyo / NIES	Japan	155 km	(Tatebe *et al.,* 2019)
MPI-ESM1-2-HR	MPI-M	Germany	104 km	(Gutjahr *et al.,* 2019)
MRI-ESM2-0	MRI	Japan	125 km	(Yukimoto *et al.,* 2019)
NorESM2-MM	NCC	Norway	139 km	(Seland *et al.,* 2020)
TaiESM1	RCEC	Taiwan	139 km	(Wang *et al.,* 2021)
UKESM1-1-LL	MOHC	United Kingdom	208 km	(Mulcahy *et al.,* 2023)

Source: Compiled by the authors.

50 Available at: https://airtable.com/appYNLuWqAgzLbhSq/shrvRybShvNSE1Szp/tblC0DBPiCm7gjJqx. Accessed on: Sep. 06, 2026

51 AWI: Alfred Wegener Institute; BOM: Bureau of Meteorology; CCCma: Canadian Centre for Climate Modelling and Analysis; CMCC: Centro Euro-Mediterraneo sui Cambiamenti Climatici; CSIRO: Commonwealth Scientific and Industrial Research Organisation; DOE: United States Department of Energy; GFDL: Geophysical Fluid Dynamics Laboratory; GISS: Goddard Institute for Space Studies; IITM: Indian Institute of Tropical Meteorology; IPSL: Institut Pierre-Simon Laplace; JAMSTEC: Japan Agency for Marine-Earth Science and Technology; LLNL: Lawrence Livermore National Laboratory; MOHC: Met Office Hadley Centre; MPI-M: Max Planck Institute for Meteorology; MRI: Meteorological Research Institute; NASA: National Aeronautics and Space Administration; NCAR: National Center for Atmospheric Research; NCC: Norwegian Climate Centre; NIES: National Institute for Environmental Studies; NOAA: National Oceanic and Atmospheric Administration; RCEC: Research Center for Environmental Changes.

Observational Data

The observational data used as a reference in this study were selected based on their widespread use in the scientific literature and the spatial and temporal consistency required for the evaluation of climate models. The main characteristics of the observational databases used in this study, including variables, spatial resolution, and coverage period, are summarized in Table 4.7.

Table 4.7 Observational databases used

Database	Variable	Horizontal resolution	Period	Bibliographic Reference
GPCP v3.3	Precipitation	0.5° × 0.5°	1983-2014	Huffman *et al.*, 2025
CPC	Precipitation	0.5° × 0.5°	1983-2014	Xie *et al.*, 2007
MERGE	Precipitation	0.1° × 0.1°	1998-2014	Rozante *et al.*, 2010, 2020
ERA5-Land	Maximum and minimum temperatures	0.1° × 0.1°	1983-2014	Muñoz-Sabater *et al.*, 2021

Source: Compiled by the authors.

For the precipitation variable, three independent databases were considered: the Global Precipitation Climatology Project (GPCP) (Huffman *et al.*, 2025), the Climate Prediction Center (CPC) (Xie *et al.*, 2007), and the MERGE dataset (Rozante *et al.*, 2010, 2020), which combines satellite data and *in situ* observations, providing greater robustness in the representation of precipitation variability.

For near-surface air temperature, including maximum and minimum temperatures, the ERA5-Land dataset (Muñoz-Sabater *et al.*, 2021) was used. It is a high-resolution reanalysis product developed by the European Centre for Medium-Range Weather Forecasts (ECMWF). This dataset integrates observations and numerical modeling to provide a consistent representation of atmospheric conditions at the global scale.

The climatological period used was from 1983 to 2014, ensuring compatibility with the historical simulations of the climate models analyzed. As an exception, the MERGE dataset is available from 1998 onward and was used for analyses covering the period corresponding to its temporal coverage. The use of multiple precipitation databases and a consolidated reanalysis product for temperature helps reduce uncertainties associated with observations and increase the robustness of model performance evaluations.

Model Selection

The selection of climate models was conducted in two complementary stages, combining qualitative and quantitative performance criteria. In the first stage, a preliminary selection was made based on previous studies that evaluated the performance of CMIP6 models in representing relevant climate variables. In addition, we sought to avoid structural redundancies among models from the same modeling center, prioritizing versions of the Earth System Model

type (ESM) or those with higher spatial resolution, as they provide a more comprehensive representation of physical and biogeochemical processes.

In the second stage, a quantitative performance evaluation was conducted, based on statistical, spatial, and probabilistic metrics applied to key variables and atmospheric phenomena relevant to Brazil's climate. These phenomena were identified based on objective criteria defined according to their physical characteristics and spatiotemporal scales. The phenomena assessed were the Intertropical Convergence Zone (ITCZ), the South Atlantic Convergence Zone (SACZ), the South American Monsoon, the Subtropical Highs over the Atlantic and Pacific, the Northeast Trough, the Atlantic Dipole, the Bolivian High, and the Subtropical Jet Stream.

The models' performance was summarized using an integrated set of metrics, which was then combined using the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method. The weights assigned to each metric were defined based on Shannon entropy, allowing for objective weighting and reducing subjectivity in the process (Shannon, 1948). The method was applied individually to each atmospheric phenomenon, resulting in specific rankings of the models' performance.

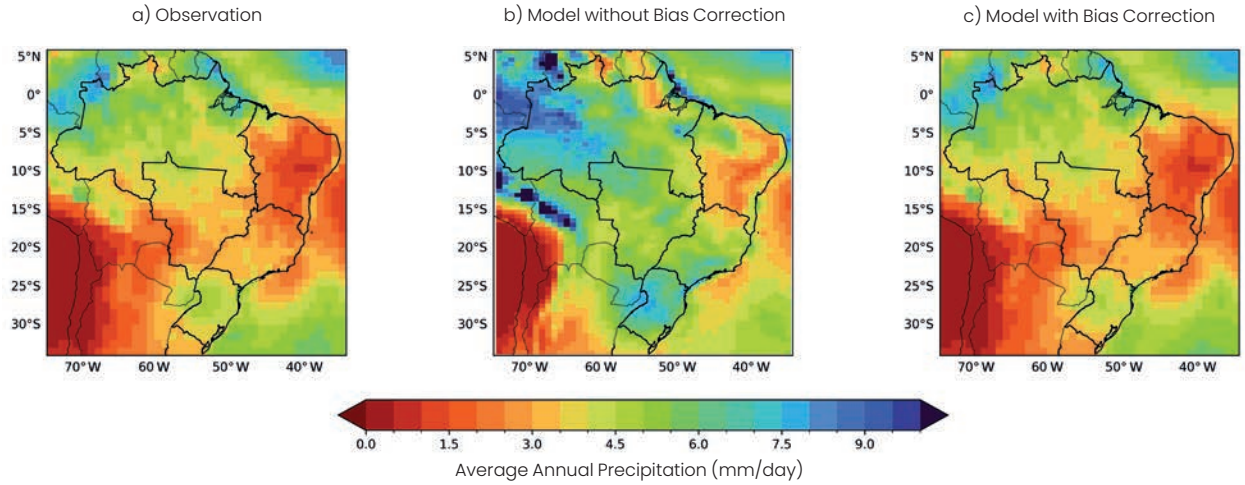
The resulting rankings were subsequently aggregated to produce an overall classification, assigning equal weights to the different phenomena to ensure a balanced assessment of the models' ability to represent different climate processes. Finally, the final subset of models was defined based on the elbow method, which identifies an inflection point in the performance distribution, establishing an objective threshold for retaining the models with the best relative performance.

Model bias correction

Bias correction of the climate models was performed using the method adopted by the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP3), which is widely used in the literature for the statistical adjustment of climate variables (Ito *et al.*, 2020). This method uses observational data as a reference to systematically correct deviations in the distributions simulated by the models, while preserving the consistency of the projected trends.

The application of bias correction resulted in significant improvements in the representation of temperature and precipitation distributions, reducing systematic errors and increasing the reliability of the projections. Figure 4.63 shows the effect of the bias correction procedure applied to precipitation data from the climate models. It should be noted that, prior to the correction, the model exhibited significant discrepancies from the observed pattern, including errors in the magnitude and spatial distribution of precipitation. After applying the correction, there was a substantial improvement in spatial representation, with better alignment with the observed values, especially in the reproduction of regional gradients. This adjustment is essential for improving the reliability of climate projections derived from models.

Figure 4.63 Comparison between (a) observed mean annual precipitation, (b) simulation from a model without bias correction, and (c) simulation from a model after bias correction



Note: The colors represent mean annual precipitation (mm/day).

Source: Compiled by the authors.

Ensemble of models

The multi-model *ensemble* was constructed using a weighted approach, in which the weights assigned to each model were defined based on four statistical performance metrics: correlation, mean squared error, relative bias, and standard deviation ratio. These metrics make it possible to assess, respectively, the models' ability to reproduce the observed temporal or spatial variability, the magnitude of errors, systematic deviations from the reference data, and the representation of climate variability.

The models were weighted in such a way as to assign greater weight to those with the best overall performance across these metrics, thereby reducing the influence of those that were less capable of representing the variables and processes under analysis. This strategy aims to produce more robust projections by combining information from multiple models, while simultaneously taking into account relative differences in performance among them.

The use of weighted *ensembles* is recognized as a robust approach for synthesizing climate projections, as it combines information from multiple models, reducing uncertainties associated with individual model errors and increasing the reliability of the results.

Climate indicators

The assessment of climate change was conducted by calculating indicators derived from daily data, which are widely used in the analysis of climate extremes. The following climate indicators were considered:

- CDD: maximum number of consecutive dry days;
- RX1day: maximum daily precipitation;
- RX5day: maximum accumulated precipitation over five consecutive days;
- PR: mean precipitation;

- TXx: highest annual maximum temperature (hot days);
- TNn: lowest annual minimum temperature (cold nights);
- WSDI: Warm Spell Duration Index (heat waves);
- Sea surface temperature (SST): projected variations associated with climate change;
- Sea level: projected variations associated with climate change.

These indicators make it possible to characterize not only changes in climate means, but also changes in the frequency and intensity of extreme events, which are essential for the assessment of impacts.

Analysis of the projected climate change

The projected climate change was analyzed based on the differences between the historical reference period and the CMIP6 future projections, taking into account different emissions scenarios. The assessment included thematic maps and summary charts, featuring continuous spatial analysis and the aggregation of results by Brazilian political-administrative regions and biomes.

For temperature and precipitation indicators, the analyses were organized according to global warming levels of 1.5ºC, 2ºC, and 3ºC, associated with the SSP1-2.6, SSP2-4.5, and SSP5-8.5 scenarios. This approach makes it possible to compare the response of climate extremes under different levels of global warming.

For sea surface temperature (SST) and sea level, projected changes were assessed based on the time horizons defined by the IPCC: short term (2021-2040), medium term (2041-2060), and long term (2081-2100), considering the SSP2-4.5 and SSP5-8.5 scenarios.

The statistical significance of the projected differences was assessed using Welch's t-test (Welch, 1947), with a significance level of 5% ($p < 0.05$). Regions with statistically significant differences were highlighted in the maps and regional analyses, allowing for a more robust interpretation of the projected climate change signals.

Uncertainties and challenges

Climate projections are subject to various sources of uncertainty, including internal variability in the climate system, structural differences among models, and dependence on emission scenarios. In addition, limitations associated with the observational databases used as references also represent a significant source of uncertainty. In Brazil, the uneven spatial distribution of the meteorological monitoring network, particularly in areas of the Amazon and the country's central region, can affect the quality and representativeness of historical data, influencing both model performance evaluations and bias correction processes. Databases that include satellite-based estimates of parameters such as precipitation and temperature are used to complement measurements made by instruments at weather stations and are particularly useful in regions with a low density of stations. However, these satellite-based estimates do not replace measurements taken by ground-based instruments; they merely supplement them. It is important to note that satellite-based estimates of parameters are also a source of uncertainty.

Limiting the historical period used may restrict the representation of low-frequency variability, while uncertainties associated with the parameterization of physical processes, especially at subgrid scales, remain a significant challenge in global climate models. Finally, the uncertainty associated with future socioeconomic scenarios is itself a key factor in determining the range of projections.

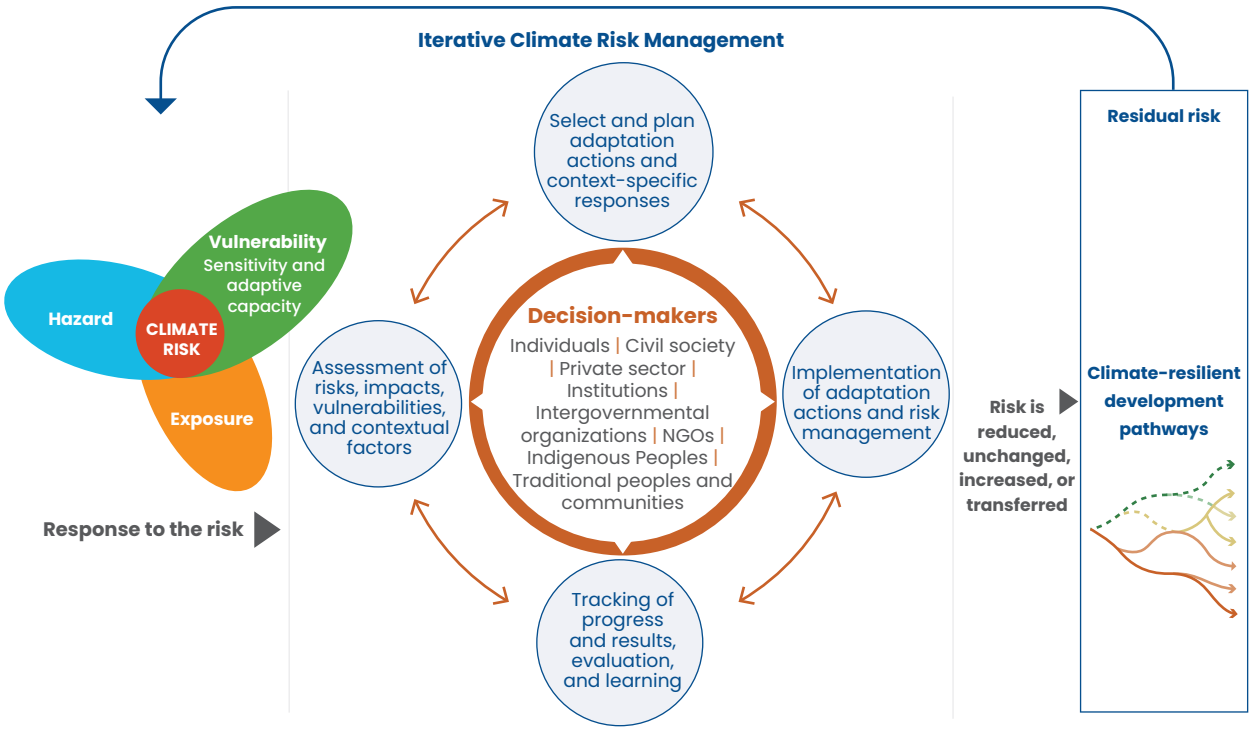
In the case of ocean variables, such as sea surface temperature and mean sea level, there are additional uncertainties related to the representation of ocean circulation, heat exchange processes between the ocean and the atmosphere, and regional coastal dynamics. With regard to sea level, factors such as thermal expansion of the oceans, the contribution of melting glaciers and ice sheets, and regional effects associated with oceanic and atmospheric circulation can lead to significant differences between models and scenarios. In addition, the limited availability of continuous and homogeneous coastal observational data series in some regions of the Brazilian coast poses a significant constraint on the validation of these projections.

Despite these uncertainties, the results presented confirm that ongoing global warming is not limited to increases in mean temperatures, but triggers a series of interconnected changes throughout the climate system. Thus, to better assess potential projected impacts, one challenge is to increase the spatial resolution of climate projections in order to better quantify projected impacts at the local and regional levels. This work is underway under AdaptaBrasil MCTI and will soon provide an *ensemble* of projection models with a spatial resolution of 10 kilometers for all of South America.

4.2.3.3. Climate Adaptation Plan and the iterative cycle

The Climate Adaptation Plan is the main planning instrument for Brazil's national climate change adaptation policy. For this reason, it served as the primary source of information for section **4.2.2. Impacts, risks, and vulnerabilities for sectors and themes of strategic importance to Brazil**. The methodological approach adopted was based on the iterative adaptation cycle proposed by the United Nations Framework Convention on Climate Change (UNFCCC) and the IPCC's conceptual framework for climate risk, with risk and impact assessment being the first stage of the iterative adaptation cycle (Figure 4.64) (Brasil, 2025p, 2025s).

Figure 4.64 Schematic representation of the conceptual frameworks for iterative climate risk management adopted in the Climate Adaptation Plan



Note: A schematic representation of the decision-making process for climate risk management, as introduced in Chapter 1 of AR6, Working Group 2, and the key elements of this section that address additional aspects of this process. Climate risk management (central box) is presented as the iterative response (that is, what society can do and how it can be done) to climate risks, producing outcomes (ideally, risk reduction) that can support (or, potentially, hinder) climate-resilient development.

Source: Translated and adapted from New (2022).

National Adaptation Goals (NG)

The Climate Adaptation Plan outlines nine National Adaptation Goals (NG)[52] (Brasil, 2025s):

- NG1. Increase the resilience of populations, cities, territories and infrastructure to the climate emergency;
- NG2. Promote sustainable and resilient production and regular access of the population to healthy food of adequate quality and quantity;
- NG3. 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;
- NG4. Protect, conserve, restore and strengthen ecosystems and biodiversity, while ensuring the provision of ecosystem services;
- NG5. Promote, protect and recover the health and well-being of populations, while respecting the ways of life of traditional peoples and communities;
- NG6. Ensure energy security in a sustainable and accessible manner;
- NG7. Promote socioeconomic development and reduce inequalities;

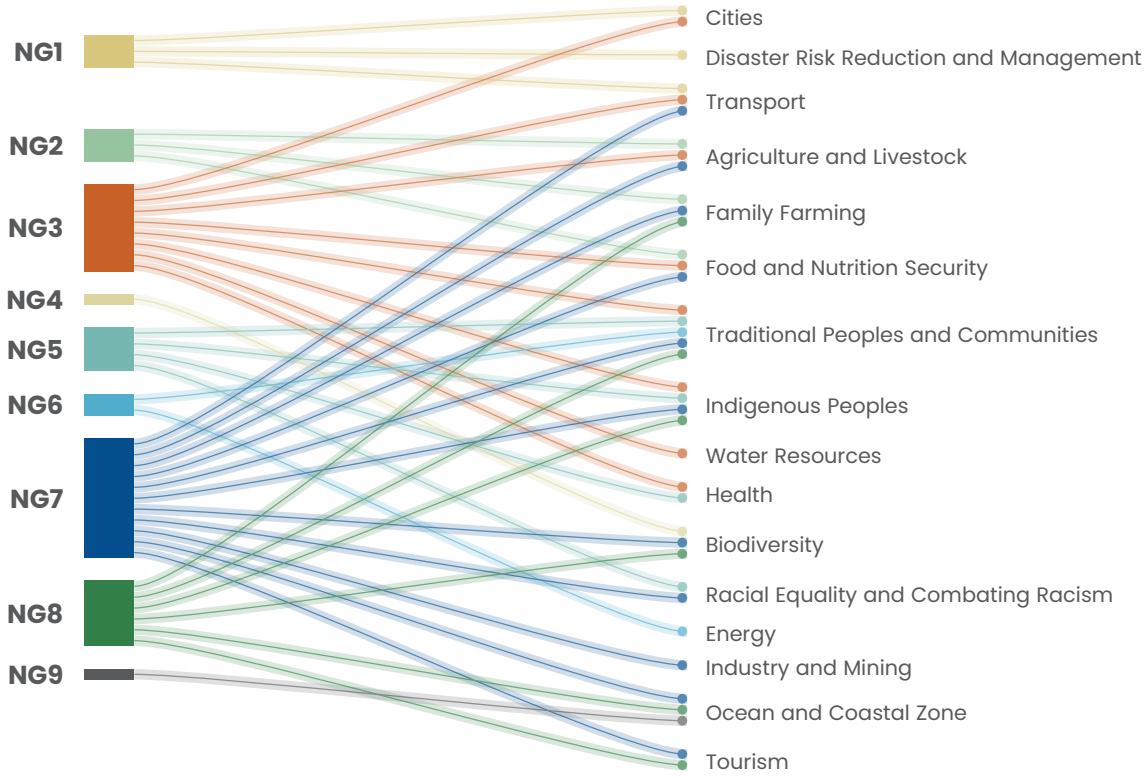
52 The definitions of these nine National Adaptation Goals can be found in the Climate Adaptation Plan (Brasil, 2025a).

- NG8. Protect cultural heritage and preserve cultural practices and heritage sites in the face of climate change-related risks; and
- NG9. Strengthen the vital role of the ocean and coastal zone in tackling climate change.

To facilitate the implementation of the adaptation agenda and the achievement of the National Goals, 16 Sectoral or Thematic Plans were developed, aligned with the themes of the National Adaptation Goals (Figure 4.65). In this context, the reporting of section **4.2.2, Impacts, risks, and vulnerabilities for sectors and themes of strategic importance to Brazil** is, therefore, organized based on the NGs. Thus, the key themes of the adaptation agenda are addressed in the assessment of the main climate impacts and vulnerabilities.

To structure the analysis presented in this section, the 16 Sectoral and Thematic Adaptation Plans were reviewed to identify the climate risks considered in them and their correspondence with the nine National Adaptation Goals (Figure 4.66). The link between plans and goals was established by identifying climate risks that contribute to the achievement of each national goal, given that a single plan may address risks related to more than one goal. This analysis made it possible to organize the content of the plans according to the NGs and to guide the summary of the main impacts, risks, and vulnerabilities presented below.

Figure 4.65 Relationship between the National Goals and the Sectoral and Thematic Plans of Brazil's Climate Adaptation Plan, as referenced in the sections of this report



Source: Compiled by the authors.

To ensure greater consistency among the various sectoral and thematic plans, a template was developed, structured around the concept of climate risk and the iterative adaptation cycle (Figure 4.66). This template organized the plans into five main components: (i) institutional context and the relevance of adaptation to the sector or theme; (ii) identification of the main climate risks and vulnerabilities; (iii) definition of adaptation goals, targets, and actions; (iv) management and implementation of the plan; and (v) final considerations, including lessons learned and recommendations. This framework helped to harmonize content and strengthen coordination among sectoral public policies (Brasil, 2025s).

Figure 4.66 Template for the development of Sectoral Plans



Source: Brasil, 2025s.

In addition, a comprehensive effort was made to systematize the available scientific knowledge on climate impacts, risks, and vulnerabilities in Brazil. Rede Clima, through designated focal points, played a central role in guiding the process of selecting references, as well as in reviewing the abstracts prepared for each theme or sector addressed. More than 700 bibliographic references were identified, of which 220 were selected as the most relevant, given the national context, to be included in this Technical-Scientific Synthesis Report on Impacts, Vulnerabilities, and Adaptation in Brazil. This contribution reviewed the most recent scientific literature available at the time of its preparation (between 2023 and early 2024) (Brasil, 2025p).

The use of the iterative adaptation cycle and the IPCC's approach to climate risks, the materials provided in the syntheses, as well as the template, have strengthened the institutional capacity to plan and implement public policies on climate adaptation. This approach, reflected in the Sectoral and Thematic Plans, feeds into Brazil's climate transparency efforts and guides the reporting of impacts, risks, and vulnerabilities, in line with the main references of the Enhanced Transparency Framework.

It is important to note that the assessment of climate impacts, risks, and vulnerabilities involves uncertainties, which were explicitly stated and taken into account throughout the preparation process. These uncertainties are associated, among other factors, with differences in the characteristics of the data, including equivalence of time periods, levels of aggregation or disaggregation, level of territorial representation, or data collection methodologies. Compounding these uncertainties is the complexity of the interactions among exposure, sensitivity, and adaptive capacity, which manifest differently depending on the territories and the sectoral risk assessment. In addition, the regional heterogeneity of impacts and the influence of socioeconomic dynamics, such as changes in land use and land cover, urbanization processes, and patterns of inequality, make it difficult to understand risks and identify the most vulnerable groups and territories. In this context, the adoption of a climate-risk-based approach, grounded in the IPCC's conceptual framework and the UNFCCC's iterative adaptation cycle, has made it possible to incorporate different levels of evidence, explicitly state the uncertainties, and guide ongoing updates as new information becomes available. Nevertheless, the Climate Plan faces challenges related to the integration of multiple sources of knowledge and methodological harmonization across sectors, especially given the data limitations and structural inequalities that shape climate vulnerability.

4.2.3.4. AdaptaBrasil MCTI: methodology adopted in risk assessment by strategic sector

AdaptaBrasil is a platform established by the MCTI to consolidate, integrate, and disseminate information on observed and projected climate change impacts in Brazil, thereby informing adaptation policies and actions. The system was developed through cooperation among INPE, the National Education and Research Network (RNP), and the MCTI and uses a scientific framework based on public data and sectoral indicators, which are combined to construct aggregate climate impact risk indices for strategic sectors such as water, food, energy, and health. The platform's development is based on the principles of co-production of evidence for public policy, integrating the technical expertise of managers with the scientific work of researchers in various fields related to the adaptation agenda.

The platform's methodology involves the production, analysis, and validation of risk indicators and indices, in collaboration with partner institutions such as the National Water and Basic Sanitation Agency (ANA), the Oswaldo Cruz Foundation (Fiocruz), COPPE at the Federal University of Rio de Janeiro (COPPE/UFRJ), the Brazilian Agricultural Research Corporation (Embrapa), the National Center for Monitoring and Early Warnings of Natural Disasters (CEMADEN), and Rede Clima. These indicators make it possible to assess and communicate sectoral climate risks, supporting decision-making and adaptation planning at different levels (Andrade *et al.*, 2023).

The AdaptaBrasil MCTI platform features a climate risk assessment based on socio-ecological contexts (Gallopín, 2006), which are reinterpreted as sectoral risk assessment levels, with boundary conditions and specific ranges of capacity to cope with impacts (coping ranges) (Jones and Boer, 2004). Nine strategic sectors are available: Water Resources, Food Security, Energy Security, Health, Port Infrastructure, Geo-hydrological Disasters, Rail Infrastructure, Road Infrastructure, and Biodiversity. The following subsectors are also available: Food Availability, Access to Food, Malaria, Arboviral Diseases, Access to Energy, and Energy Availability. The platform also presents climate risks at the subnational level, primarily at the municipal level, covering all Brazilian municipalities (Andrade *et al.*, 2023). There are two ways to represent risk indices in AdaptaBrasil MCTI: the National Dashboard and the Cities Dashboard. In the first case,

priority is given to the cartographic representation of a specific selected indicator across the entire country. The Cities Dashboard, on the other hand, provides a summary of the indicators for a municipality selected by the user.

Climate risk assessment in AdaptaBrasil MCTI is based on the concurrent relationship among three dimensions of climate risk defined by the IPCC (2022): hazard, exposure, and vulnerability. These dimensions are expressed through a hierarchical and mathematical combination of indicators and indices, in which different levels of data are progressively aggregated to produce the final climate risk index.

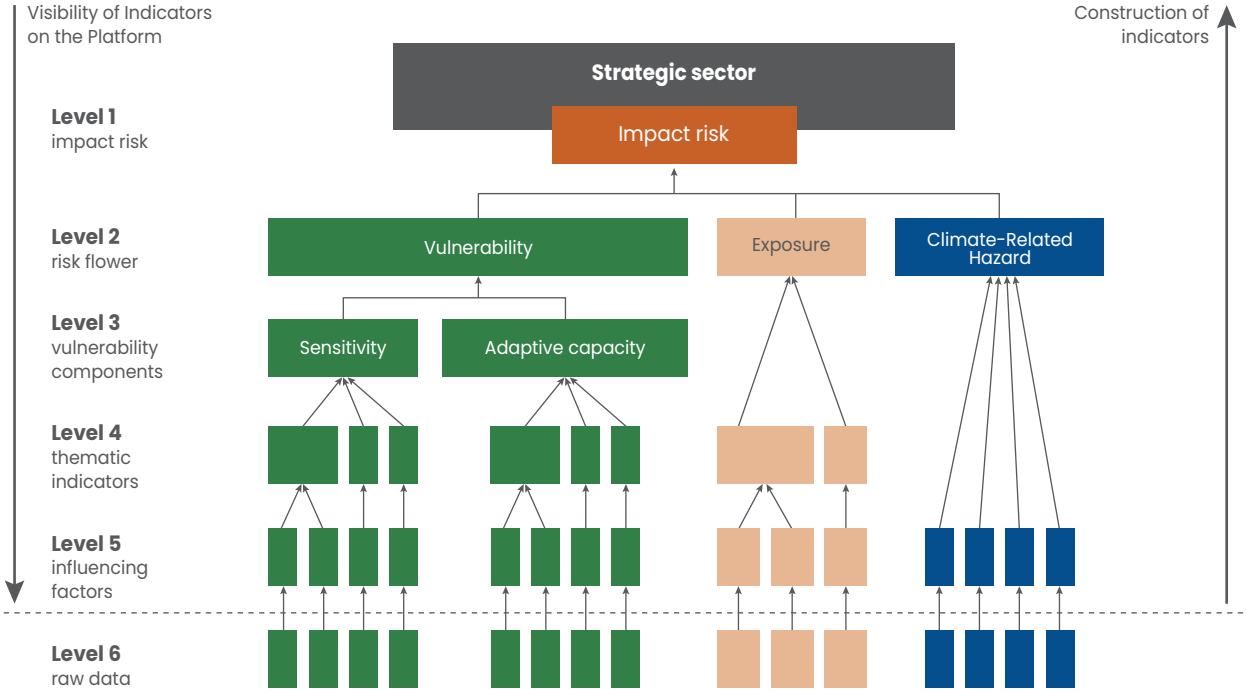
Methodological rigor in the construction and analysis of risk on the AdaptaBrasil MCTI platform begins at the indicator selection stage, which is conducted based on technical criteria and multiple statistical analysis procedures applied to the available data, such as consistency assessment, treatment of data gaps, and correlation analysis. In addition, the whole process is continuously supported by technical validation involving experts from partner institutions with recognized expertise in the different sectors analyzed, ensuring conceptual coherence, alignment with scientific evidence, and the reliability of the results produced.

In simplified terms, this structure can be described in six levels within a given sectoral dimension (Figure 4.67):

1. Climate Risk Index: represents the final risk index for the sector under analysis (e.g., water stress risk).
2. Risk dimensions (IPCC): climate hazard, exposure, and vulnerability.
3. Components of vulnerability: sensitivity and adaptive capacity.
4. Thematic indicators: they group indicators related to specific aspects of risk assessment in a strategic sector, such as anthropogenic pressures, susceptibility conditions, socioeconomic conditions, recurrence of outcomes, response capacity, management, governance, and planning.
5. Indicators: raw data that undergo mathematical processing consistent with the dimension to which they belong, taking into account weighting, outlier treatment, and normalization (Becker et al., 2019).
6. Raw data: raw data collected from official Brazilian databases, which may include socioeconomic or environmental and climate data. This level is not represented on the Platform.

This approach allows information to be integrated into a framework that enables comparisons across sectors, facilitating the analysis and communication of climate risks (Andrade *et al.*, 2023).

Figure 4.67 Example of a hierarchical framework for combining AdaptaBrasil MCTI risk indicators and indices for the water resources sector



Source: AdaptaBrasil, 2026m.

Regarding the spatial scale of analysis, the AdaptaBrasil MCTI platform adopts different levels of granularity according to the characteristics of the sectors assessed. For the infrastructure sectors, linear infrastructure (federal highways and railways) and point infrastructure (ports) were considered. In the energy sector, the analysis is conducted at the state level, reflecting the integrated and systemic nature of energy generation and distribution. In the other sectors, the approach predominantly uses the municipal level, enabling a broader territorial assessment aligned with local public management and the planning of adaptation actions. A summary of the structural and methodological aspects of the AdaptaBrasil MCTI platform by strategic sector is presented in Annex 1.

Among the existing challenges and gaps, the methodology of the AdaptaBrasil MCTI platform, as it is based on a combination of indicators and indices, aims to promote the concise communication of the risk assessment to a broad audience. The aim is not to provide an exhaustive assessment, but rather to serve as a guide for more in-depth analyses by researchers, managers, and decision-makers.

In this context, there are recognized challenges to achieving and improving the results of the climate risk indices and of the platform as a whole, such as:

a. Official data with a temporal frequency and spatial scale of representation that are compatible with each strategic sector and across sectors;

b. Few sources in the literature that provide reference levels for each data point or indicator to represent resilience in the respective sectors;

c. The lack of available data on the occurrence of climate impacts from an objective perspective, as well as difficulties in quantifying potential impacts for each level of climate risk;

d. Limited availability of official intra-urban data with representation at the municipal level.

4.3. Adaptation priorities and barriers

This section presents nationally identified adaptation priorities, challenges, gaps, and barriers, in alignment with paragraph 108 of the MPGs. The primary reference for identifying this information was the National Adaptation Strategy of the Climate Plan, presented in **Chapter 1, National context,** and in **section 4.1. National circumstances, institutional arrangements and legal framework.**

4.3.1. National adaptation priorities

The Climate Adaptation Plan, updated in 2026 and described in **Chapter 1, National context,** identified priorities for the country's adaptation planning, defining 16 sectors and themes with specific plans and a set of strategic guiding elements, including goals, targets, and guidelines. The sectors and themes that developed specific adaptation plans were: Agriculture and Livestock; Family Farming; Cities; Energy; Risk and Disaster Reduction and Management; Industry and Mining; Health; Food and Nutrition Security; Transport; Tourism; Biodiversity; Racial Equality and Combating Racism; Ocean and Coastal Zones; Traditional Peoples and Communities; Indigenous Peoples; and Water Resources - which, together, set out 312 sectoral targets to be achieved through 810 actions.

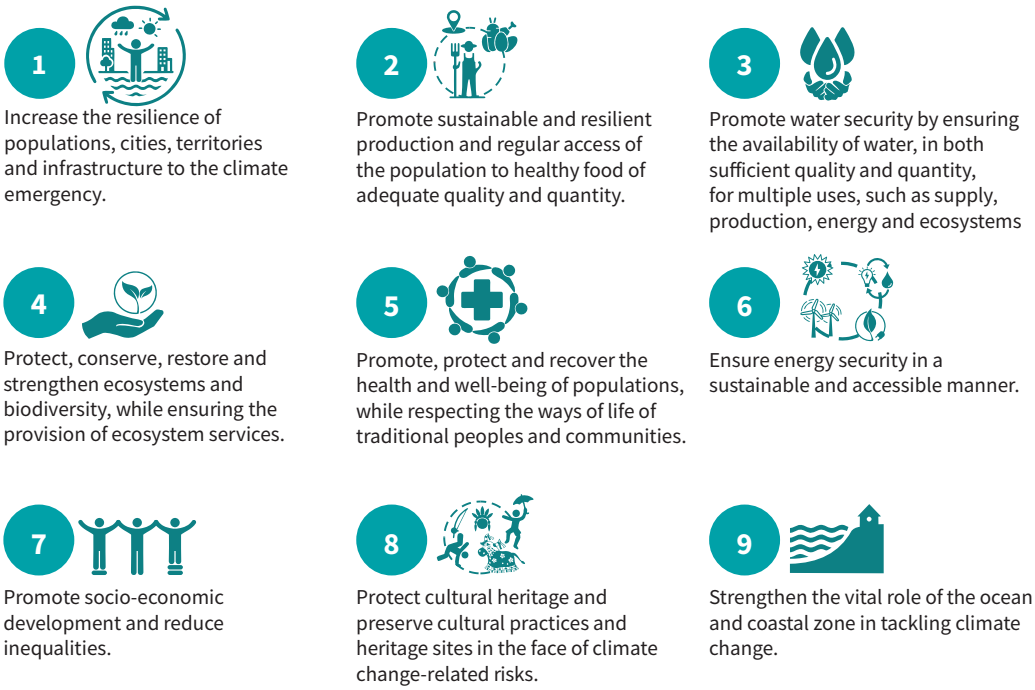
There is still no assessment of progress regarding these national priorities, since the current Climate Adaptation Plan was published in 2025 and a monitoring and evaluation system was agreed upon in the Cross-Cutting Strategy for Monitoring, Management, Evaluation, and Transparency, which was approved the following year, in 2026. Further details regarding the process and methodology of this system are described in section **4.6. Monitoring and evaluation of adaptation actions and processes**.

The nine national goals outlined in the Climate Adaptation Plan comprise nationally agreed-upon priorities and align with the seven thematic targets of the global adaptation goal, highlighting that adaptation to climate change involves both specific actions at the national level and contributions to broader global targets. The sectors prioritized in the UAE Framework for Global Climate Resilience were taken into account, with adjustments and additions related to specific priorities identified in the national context, such as energy security and the ocean and coastal zone. In addition, the National Goals were developed through a collaborative process among the members of the Technical Adaptation Working Group, comprised of representatives from sectoral ministries, during the preparation of the Climate Adaptation Plan. This report was organized based on these priorities, presenting the main impacts, risks, and vulnerabilities, as well as the actions planned and implemented for each National Adaptation Goal.

To guide national ambitions, a set of 12 national adaptation targets and their respective indicators, anchored in these goals, was established. Thus, the aim is to guide initiatives at Federal Government level and indicate to subnational entities, as well as private actors, actions that should be strengthened through the coordination of efforts. Progress has also been made

in developing indicators for the targets, which will be presented in **section *4.6. Monitoring and evaluation of adaptation actions and processes*** of this report. The National Adaptation Goals and Targets will be presented below (Figure 4.68 and Dataframe 4.2).

Figure 4.68 National Adaptation Goals



Source: Brasil, 2025s.

Dataframe 4.2 National Adaptation Targets

National Adaptation Targets	
1	By 2035, ensure that all states and at least 35% of Brazilian municipalities have Adaptation Plans.
2	By 2035, provide disaster risk prevention infrastructure to at least 4 million people exposed to geohydrological disaster risk.
3	By 2035, expand vegetation cover in urban areas by 180,000 hectares, prioritizing municipalities at greater climate risk.
4	By 2035, reduce to 7.5% the total number of municipalities with the minimum level of water security.
5	By 2035, ensure that 100% of the projects for infrastructure works to be supported by the Federal Government consider climate risks.
6	By 2035, reduce, by at least 30%, operational interruptions in federal transport 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.
8	By 2035, connect 30% of the national territory through ecological corridors between protected areas and Other Effective Area-Based Conservation Measures - OECMs, prioritizing territories at greater risk from climate change and climate refugia.

National Adaptation Targets	
9	By 2030, expand the adoption of diversified, sustainable and resilient agricultural production systems by 72.68 million hectares.
10	By 2035, eradicate severe food and nutrition insecurity.
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 to climate change.
12	By 2035, ensure that 100% of the power expansion planning takes climate risks into account.

Source: Brasil, 2025s.

The Plan contains guidelines that guide the adaptation agenda at the federal, state, and municipal levels (Figure 4.69), reflecting elements relevant to the national context. These elements should be considered in a cross-cutting manner and include climate justice, sustainable development, transparency, Ecosystem-Based Adaptation (EbA), and the integration of adaptation into sectoral policies, programs, and projects.

Figure 4.69 Adaptation guidelines included in the National Adaptation Strategy



Source: Brasil, 2025s.

Cross-cutting elements

Certain elements contained in the Climate Adaptation Plan guidelines were given greater emphasis in the sectoral and thematic plans, which included training for the stakeholders involved in the process of assessing climate risks and developing targets and actions. Of particular note in this context are climate justice and Ecosystem-Based Adaptation (EbA), whose concepts and applications within the scope of the Plan will be presented below. It is important to note that other factors were considered to be cross-cutting in the Climate Plan, through specific strategies, as detailed in **Chapter 1, National context**, and in section **4.4.2. How the best available science, gender perspectives and Indigenous, traditional, and local knowledge are integrated into adaptation**.

Climate Justice: The Climate Adaptation Plan adopted climate justice as a guiding principle for its development, incorporating it into every stage of the iterative adaptation cycle. This approach seeks to understand how climate risks affect different populations, social groups, and territories in distinct ways, taking into account preexisting inequalities and varying adaptation capacities. This perspective is reflected in the strategic elements of the Plan, which incorporate aspects related to reducing inequalities, respecting the ways of life of traditional peoples and communities and Indigenous Peoples, promoting gender equity, and expanding access to services and infrastructure. In addition, the sectoral and thematic plans identified, for each listed climate risk, the aspects of climate justice and gender to which it was related, thereby contributing to the development of more inclusive and equitable adaptation responses.

Ecosystem-Based Adaptation (EbA): Ecosystem-Based Adaptation (EbA) was a cross-cutting approach considered in all sectoral and thematic plans. The conservation and restoration of ecosystems were identified as fundamental to adaptation strategies. Recognizing that biodiversity and ecosystem services have the potential to mitigate the impacts of climate change, the Plan acknowledges that ecosystem-based adaptation (EbA) can contribute to the success of actions across the various thematic areas covered, as these areas depend on or benefit from EbA, either directly or indirectly. In this regard, the Climate Adaptation Plan adopts EbA as a guideline for defining and implementing adaptation actions.

4.3.2. Challenges, gaps and barriers

The challenges, gaps, and barriers presented in this BTR2 were identified by updating the information reported in BTR1, supplemented by evidence from technical documents, participatory processes, and analyses conducted in the context of the Climate Adaptation Plan. The inputs considered included, among others, challenges and barriers identified in the Sectoral and Thematic Plans; findings from thematic workshops involving representatives of government, academia, and civil society; surveys of the perceptions of stakeholders involved in coordinating and developing the Sectoral and Thematic Plans; and studies on the Climate Plan development process.

The information was systematized according to the stages of the iterative adaptation cycle (Dataframe 4.3), enabling the identification of persistent challenges, emerging gaps, and barriers related to risk assessment (some of which have already been addressed in section **4.2.3. Methodological approach**), planning, implementation and monitoring, evaluation, and learning. Challenges of a cross-cutting nature were also identified, related to governance, social participation, institutional capacities, and the production and use of knowledge, dimensions that serve as enabling conditions for progress in adaptation.

Challenges, gaps, and barriers throughout the iterative adaptation cycle

Dataframe 4.3 Challenges, gaps, and barriers identified according to the stages of the iterative adaptation cycle

Stage of the iterative adaptation cycle	Challenges, gaps and barriers
Assessment of risks, impacts, and vulnerabilities	Generation and availability of information: Limited or intermittent availability of up-to-date information on observed impacts; the need for continuous updating of climate scenarios in line with advances in global, regional, and national models, as well as for communicating this information and incorporating it into sectoral policies and plans; gaps in the availability of disaggregated data at different geographic scales, including limitations related to the statistical visibility of traditional peoples and communities and to specific records on Indigenous territories; low interoperability and interaccessibility between databases and systems; meeting the growing demand for systematized, integrated, and continuous data; and knowledge gaps regarding historical and potential loss and damage to the country's strategic sectors and themes, as well as observed impacts in sectors such as biodiversity, cities, industry, economic development, reduction of inequalities, and oceans and coastal zone. Understanding the risks: Gaps in understanding compound and cascading risks, as well as risks at different spatial scales; limitations in the establishment of methodologies and guidelines for defining and prioritizing risks; and difficulty in translating global and regional climate projections into local and territorial decision-making. Knowledge integration and use: Gaps in the consideration of local and traditional knowledge when characterizing impacts, vulnerabilities, and risks; and difficulties in translating and incorporating scientific knowledge into decision-making processes through the co-production of evidence.
Adaptation planning	Integration and planning: Incorporation of climate risks and of the climate agenda into sectoral and territorial planning instruments remains uneven and inconsistent; limitations in the integration of adaptation and mitigation; and challenges regarding coordination across sectors given the systemic and interdependent nature of climate risks. Methodologies and prioritization: Methodological limitations in assessing and prioritizing adaptation measures; difficulties in selecting among multiple adaptation options under uncertainty; complexity in assessing the effectiveness and efficacy of adaptation actions; challenges in incorporating equity and climate justice criteria into the selection and prioritization of measures; and gaps in the assessment of co-benefits and trade-offs between adaptation actions and between adaptation and mitigation actions.

Stage of the iterative adaptation cycle	Challenges, gaps and barriers
	Institutional capacities: Heterogeneous technical and institutional capacities across sectors and levels of government (municipal, state, and federal); inequalities in the availability of staff, resources, and technical expertise; the impact of staff turnover and changes in focal points on the continuity of planning processes; and gaps in technical capacity, particularly at the state and municipal levels. Operationalization of risks: Difficulties in translating information on climate risks into operational criteria for regulatory instruments, infrastructure planning, and investment decisions at the national and subnational levels; uncertainties associated with future climate risks; data scarcity; and the absence or insufficiency of agreed parameters for adequate levels of resilience.
Implementation of adaptation actions	Institutional capacity and sustainability: Insufficient and uneven technical and institutional capacities across the national, state, and municipal levels; insufficient specialized technical staff, particularly at the subnational level; weaknesses related to the continuity and institutionalization of adaptation processes; and challenges in ensuring long-term institutional sustainability. Transformation and scale: Implementation of transformational adaptation actions remains limited; difficulties in expanding participatory processes during the implementation phase; and difficulties in replicating and scaling up successful adaptation actions in different territorial contexts.
Monitoring, evaluation, and learning	Monitoring and indicators: The monitoring and evaluation system for the Climate Adaptation Plan is still being developed; challenges in defining and applying process, result, and impact indicators and in establishing baselines; fragmentation of databases and systems relevant to monitoring; insufficient regularity and systematization of information on implementation and results; and challenges in establishing continuous cycles of review and improvement. Adaptive learning: The challenge of strengthening continuous learning mechanisms, as well as incorporating them into the periodic review of policies, strategies, and plans; difficulties in establishing an evaluation process that takes uncertainty and long-term horizons into account.

Source: Compiled by the authors.

In addition, cross-cutting challenges, gaps, and barriers were identified that influence multiple stages of the iterative adaptation cycle and serve as enabling conditions for strengthening adaptation in the country. These elements include:

- Multilevel governance and coordination
    - Weaknesses in the permanent mechanisms for coordination among the federal, state, and municipal levels;
    - Challenges to the institutionalization of intersectoral coordination;
    - Risks to institutional continuity and the stability of implementation processes.

- Social participation and inclusion
  - Social participation in adaptation processes remains limited;
  - Challenges in ensuring the effective participation of Black populations, Indigenous Peoples, and traditional peoples and communities, including Quilombola communities, traditional *terreiro* peoples and communities and those of African origin, and Roma peoples;
  - Challenges in ensuring the participation of women, youth, and other vulnerable groups;
  - Challenges in ensuring that participatory processes adopt territory-tailored, accessible, and culturally appropriate mechanisms, valuing direct representation, listening to people in the territories, and social oversight;
  - Persistence of barriers to access to participatory processes.
- Interface between science and policy
  - Few permanent mechanisms for the co-production of knowledge;
  - Difficulties in translating scientific evidence into planning and decision-making instruments;
  - Fragmentation of mechanisms for making evidence available and communicating it, hindering its use by decision-makers.
- Climate justice and structural inequalities
  - Integration of the gender, race, age group, and territory dimensions into adaptation strategies remains uneven;
  - Gaps in disaggregated data that contribute to the low statistical visibility of segments of Indigenous Peoples and traditional peoples and communities, including Quilombola communities, traditional *terreiro* peoples and communities and those of African origin, and Roma peoples;
  - Insufficient disaggregated data and indicators to characterize exposure and vulnerability to climate risks and support the prioritization of adaptation actions, including information on access to water and sanitation, food security, loss and damage, access to adaptation policies, and climate finance, when methodologically feasible and respecting self-identification, constituting a gap for the next monitoring cycles; risk of perpetuating or exacerbating existing socioeconomic inequalities;
  - Limitations in the availability of disaggregated data to support vulnerability assessments and the prioritization of actions.
- Integration of scientific, local, and traditional knowledge
  - Methodological and institutional limitations regarding the systematic incorporation of different knowledge systems, including knowledge, practices, their own technologies, and territorial relationships of different peoples and communities, into evaluation, planning, and decision-making processes;
  - Challenges in promoting and strengthening approaches that value local and traditional knowledge, including knowledge, practices, their own technologies, and territorial relationships of different peoples and communities, as part of the development of adaptive solutions;
  - Challenges in ensuring that the co-production of adaptation solutions respects self-determination, the safeguarding of traditional knowledge, and the participation of the holders of such knowledge, avoiding its appropriation out of context.

- Behavioral changes and transformation of development patterns

  - Persistence of development, territorial occupation, production, consumption, and infrastructure models that may exacerbate current and future climate risks;
  - Reliance on established development practices and models, coupled with institutional, economic, and behavioral barriers that hinder changes that promote climate-resilient development.

- Institutional capacities

  - Significant disparities in capacity among sectors, institutions, and territories;
  - Limited permanent technical capacities at different levels of operation;
  - Challenges in ensuring the continuity and institutional sustainability of adaptation processes.

Progress and lessons learned

Several challenges identified in BTR1 remain relevant, although significant progress has been made in the period between the two reporting cycles. During this period, there was an increase in the production and systematization of technical and scientific evidence on the impacts, risks, and vulnerabilities associated with climate change in Brazil, contributing to the advancement of knowledge on topics such as observed health impacts, loss and damage, as well as climate risks in different sectors and territories. Progress has also been made in structuring and strengthening national climate governance, including within the framework of the Interministerial Committee on Climate Change (CIM), although challenges still remain with regard to the consolidation of permanent mechanisms for intersectoral and federative coordination, and the consolidation of mechanisms for coordination among government institutions, the scientific community, and other actors involved in the adaptation agenda.

Under the Climate Adaptation Plan, the process of developing sectoral and thematic plans has contributed to progress in adaptation planning through the development and application of common frameworks based on the concept of climate risk. There was also a strengthening of science-policy interface mechanisms, with knowledge co-production serving as a guiding principle in the development of the Plan. The development of the plans fostered coordination among government institutions, the scientific community, and other actors involved in the adaptation agenda, seeking to better align knowledge production with the needs of planning and decision-making.

Among the lessons learned from the process, particular importance was placed on: methodologies that combine technical rigor with applicability across different sectoral and territorial contexts; the involvement of sectors from the initial stages of methodological development; the maintenance of permanent mechanisms for intersectoral and interfederative coordination; and the continuous strengthening of institutional capacities. The process also demonstrated the importance of permanent collaboration strategies between government and the scientific community, particularly the role played by Rede Clima in the Climate Plan in expanding the generation, translation, and incorporation of evidence into policymaking.

The experience of developing the Climate Plan also demonstrated that differences in institutional capacity across sectors and levels of government require tailored strategies to support and strengthen the adaptation agenda within the administration, and that continuity in teams and institutional arrangements is important for preserving institutional memory, learning, and implementation capacity. Coordination between adaptation and mitigation, as well as across different sectors, has proven equally necessary to address systemic risks and avoid trade-offs among policies, actions, and measures.

Some of the challenges identified in BTR1 are currently being addressed in the Climate Adaptation Plan. The recent start of implementation in the various federative entities marks the start of a new phase in strengthening coordination between the national and subnational levels to translate national planning into actions tailored to specific territories. The next cycles of implementation, monitoring, evaluation, and review will enable further learning about the effectiveness of these arrangements and guide their continuous improvement.

4.4. Adaptation strategies, policies, plans, goals and actions to integrate adaptation into national policies and strategies

This section presents the main adaptation strategies, policies, plans, and actions identified at the national level, in accordance with paragraph 109 and items a, b, c, d, e, f, g, and h of the MPGs. As the country's most recent and comprehensive instrument, the Climate Adaptation Plan is the main reference for the content of this section. To complement the Climate Plan, recently developed initiatives that address climate change adaptation have been identified and included. Actions currently in the planning phase will be presented in this section, and those that are making progress in implementation will be presented in section **4.5. Progress in implementation**.

The actions described were presented according to the National Adaptation Goals, which are considered important frameworks that structure the Climate Adaptation Plan. This systematization also facilitates the tracking of actions in line with the GGA, as the National Adaptation Goals are aligned with the seven thematic targets established in the UAE Framework for Global Climate Resilience, as per Dataframe 4.4.

Dataframe 4.4 Correspondence between National Adaptation Goals and GGA targets

National Goal	GGA target
1  Increase the resilience of populations, cities, territories and infrastructure to the climate emergency.	9e. Increasing the resilience of infrastructure and human settlements to climate change impacts to ensure basic and continuous essential services for all, and minimizing climate-related impacts on infrastructure and human settlements.
2  Promote sustainable and resilien production and regular access of the population to healthy food of adequate quality and quantity.	9b. Attaining climate-resilient food and agricultural production and supply and distribution of food, as well as increasing sustainable and regenerative production and equitable access to adequate food and nutrition for all.
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	9a. Significantly reducing climate-induced water scarcity and enhancing climate resilience to water-related hazards towards a climate-resilient water supply, climate-resilient sanitation and access to safe and affordable potable water for all.
4  Protect, conserve, restore and strengthen ecosystems and biodiversity, while ensuring the provision of ecosystem services.	9d. Reducing climate impacts on ecosystems and biodiversity, and accelerating the use of ecosystem-based adaptation and nature-based solutions, including through their management, enhancement, restoration and conservation and the protection of terrestrial, inland water, mountain, marine and coastal ecosystems.
5  Promote, protect and recover the health and well-being of populations, while respecting the ways of life of traditional peoples and communities.	9c. Attaining resilience against climate change-related health impacts, promoting climate-resilient health services and significantly reducing climate-related morbidity and mortality, particularly in the most vulnerable communities.
6  Ensure energy security in a sustainable and accessible manner.	9e. Increasing the resilience of infrastructure and human settlements to climate change impacts to ensure basic and continuous essential services for all, and minimizing climate-related impacts on infrastructure and human settlements.
7  Promote socio-economic development and reduce inequalities.	9f. Substantially reducing the adverse effects of climate change on poverty eradication and livelihoods, in particular by promoting the use of adaptive social protection measures for all.

National Goal	GGA target
 Protect cultural heritage and preserve cultural practices and heritage sites in the face of climate change-related risks.	9g. Protecting cultural heritage from the impacts of climate-related risks by developing adaptive strategies for preserving cultural practices and heritage sites and by designing climate-resilient infrastructure, guided by traditional knowledge, Indigenous Peoples' knowledge and local knowledge systems.
 Strengthen the vital role of the ocean and coastal zone in tackling climate change.	9d. Reducing climate impacts on ecosystems and biodiversity, and accelerating the use of ecosystem-based adaptation and nature-based solutions, including through their management, enhancement, restoration and conservation and the protection of terrestrial, inland water, mountain, marine and coastal ecosystems.

Source: Brasil, 2025s.

4.4.1. Targets, actions, goals, commitments, initiatives, efforts, adaptation plans, strategies, policies, priorities, programs, and efforts aimed at strengthening resilience

The nationally determined goals, targets, priorities, and commitments are detailed in section **4.3.1. National adaptation priorities.** In this section, the focus will be on describing the general scope of the Climate Adaptation Plan and summarizing the actions outlined in the sectoral and thematic plans. Other policies, programs, initiatives, actions, and efforts will be listed in the next sections, focusing on specific aspects, and in section **4.5. Progress in implementation**.

The Climate Adaptation Plan represents a development of the first National Adaptation Plan, published in 2016, incorporating lessons learned from previous monitoring and evaluation cycles and strengthening the country's institutional capacity to address climate impacts (Brasil, 2025t). The main strategic elements of the Climate Plan, such as national goals, targets, and guidelines, were described previously in section **4.3.1. National adaptation priorities**.

The following is a summary of the scopes of the planned adaptation actions contained in the sectoral and thematic plans, in accordance with the National Adaptation Goals (NGs).

1



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

It includes the improvement of climate information systems, the incorporation of adaptation into regulations and planning instruments, support for disaster prevention with a focus on the most vulnerable territories, and the development of integrated protocols for monitoring, early warning, communication, and emergency response. Risk and vulnerability assessments are also planned for strategic sectors, such as industry, mining, and transport, in addition to the adaptation of road and port infrastructure. Priority is given to inclusive and territory-tailored approaches, such as ethno-development and territorial management plans, emergency response protocols tailored to Indigenous Peoples, national disaster monitoring systems, and support mechanisms for populations affected by disasters.

2



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

In the area of agriculture and livestock, the measures focus on risk reduction and sustainable production, including compliance with environmental legislation, the restoration of degraded areas, the adoption of sustainable production practices using an integrated landscape approach, and the expansion of risk management instruments, such as agricultural insurance and weather warning systems. They aim to increase the agricultural sector's adaptation capacity, ensuring continuous production even in the face of adverse weather events. Actions focused on family farming and food and nutrition security prioritize social inclusion and support for vulnerable groups, providing them with access to land, credit, technical assistance, and sustainable technologies. Key actions include promoting agroecology, agroforestry systems, and sustainable soil management, as well as implementing solutions for efficient water use and strengthening food support networks in the most exposed territories.



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

The planned measures include improving watershed management instruments, expanding aquifer monitoring, revising permit-granting criteria in critical areas, and incorporating climate scenarios into the planning and financing of adaptation actions. In addition, practical solutions are promoted to increase water availability and efficient water use, such as social technologies for water collection, storage, distribution, and conservation for human consumption and agricultural production. The actions also include strategies for mediating conflicts over water use, especially during droughts and floods, and studies on reservoirs that balance water security, power generation, and other multiple uses.



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

The initiatives focus on the restoration of degraded areas, the conservation of species, and the reduction of threats to ecosystems, especially in the face of the adverse effects of climate change. Key initiatives include the restoration of degraded lands, such as in the Caatinga (2 million hectares), and the promotion of ecological connectivity and climate refugia, which are essential for biodiversity adaptation. They also include integrated fire management measures, *ex situ* conservation of threatened species, and the implementation of species reintroduction programs, focusing on species that are key to ecosystem functioning, such as pollinators and seed dispersers. Actions in rural areas promote the restoration of native vegetation and the conversion of degraded areas, while in cities they encourage nature-based solutions for infrastructure and climate adaptation. In Indigenous territories, the actions strengthen fire prevention and suppression, while with regard to water resources, they prioritize the protection of water sources and the restoration of wetlands and aquifer recharge areas.



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

The actions for this goal aim to prepare the healthcare system and public institutions to address the impacts of climate change on the population's health. The focus is on strengthening the resilience of the Brazilian National Health System (SUS) by establishing guidelines for the healthcare network, incorporating climate indicators into planning, and expanding preparedness, surveillance, and response capacity for public health emergencies associated with extreme weather events. In addition, the initiatives promote knowledge production on climate-related health risks, including studies on the costs of non-adaptation and research on occupational health and safety in sectors such as industry and mining. Capacity-building and risk communication actions for health managers and healthcare professionals are also planned, strengthening institutional capacity to protect vulnerable populations and ensure more effective responses to disasters and climate-related emergencies, while respecting territorial and sociocultural specificities.



Ensure energy security in a sustainable and accessible manner.

These actions focus on strengthening the resilience and efficiency of Brazil's energy system in the face of the impacts of climate change. This includes conducting studies to identify new strategic reservoirs that contribute simultaneously to water security and power generation, as well as analyses to increase the robustness of the electricity system in the face of extreme events. In addition, emphasis is placed on modernizing the sector through the deployment of energy storage systems, such as pumped-storage hydropower plants, and the establishment of minimum energy efficiency standards for equipment and buildings, promoting more rational and sustainable energy use. These initiatives promote technological innovation and the diversification of the energy matrix, with a focus on research, development, and innovation in biofuels and renewable energy. In the industrial sector, R&D&I programs focused on energy efficiency and new technologies are encouraged, with particular emphasis on promoting women's leadership in these processes.



Promote socio-economic development and reduce inequalities.

In an urban context, investments in resilient infrastructure in *favelas* and communities, with active social participation, are particularly noteworthy, as they aim to reduce risks and improve living conditions. In the theme of racial equality, initiatives include addressing environmental racism, training managers and council members on climate change and racial equity, and building the capacity of community agents to respond to climate-related emergencies, thereby strengthening inclusive governance. In addition, sustainable economic strategies based on the sociobioeconomy and the strengthening of traditional peoples and communities and Indigenous Peoples are promoted through projects that combine environmental conservation and income generation and the valuing of their culture. This includes support for activities such as agroforestry systems, artisanal fishing, and sustainable management, as well as the creation of specific funds for climate adaptation that focus on traditional peoples and communities and tourism service providers. The tourism sector also includes actions to promote community-based tourism and access to credit for sustainable practices, contributing to more equitable and resilient development that is aligned with local realities.



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

The main initiative provides for the implementation of a national climate adaptation program focused on the infrastructure of cultural and natural heritage sites located in tourist destinations, promoting the conservation of these assets and reducing their vulnerability to extreme weather events and environmental degradation processes. By integrating the tourism, culture, and climate adaptation agendas, these initiatives contribute to the preservation of cultural identity, collective memory, and the natural resources that sustain local economic activities and ways of life. The goal is to ensure that sites of historical, cultural, and environmental importance remain protected and accessible to future generations.



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

The actions under this goal focus on the conservation and sustainable management of marine and coastal ecosystems, recognizing their importance for climate adaptation, the protection of biodiversity, and the provision of ecosystem services. Among the key initiatives are the expansion of marine protected areas, marine spatial planning throughout Brazil's oceanic territory, and the implementation of specific strategies for the conservation of coastal ecosystems of high ecological importance, such as coral reefs and mangroves. In addition to conservation, this goal aims to strengthen the coastal zone's capacity to adapt. To this end, it provides for the assessment of the vulnerability of coastal municipalities to erosion, flooding, sea-level rise, and extreme events, thereby informing the planning and prioritization of adaptation measures.

Source: Compiled by the authors based on Brasil, 2025s.

4.4.2. How the best available science, gender perspectives and Indigenous, traditional, and local knowledge are integrated into adaptation

Scientific knowledge was drawn upon throughout the Climate Plan development process, based on sound methodologies and established evidence, such as that presented in the IPCC's Sixth Assessment Report (AR6), as well as recent scientific literature. In addition, a series of workshops were held to promote conceptual alignment among the ministerial representatives involved in the development of the Plan. In addition, the academic community participated actively through Rede Clima, with researchers specializing in different sectors engaging in the workshops and in the review of the sectoral plans. These experts also contributed to the development of technical and scientific inputs for the sectoral and thematic plans.

As a result of this process, the Technical-Scientific Synthesis Report on Impacts, Vulnerabilities, and Adaptation in Brazil (Brasil, 2025p) was developed for the Climate Adaptation Plan. Additional information on the incorporation of science into the Climate Adaptation Plan can be found in the First BTR and in section **4.2.3. Methodological approach** of this report.

Within the governance framework, the Scientific Advisory Chamber (CAC, Câmara de Assessoramento Científico) was established with the goal of integrating science into the process of developing and evaluating the national climate agenda. More information about the CAC was presented in **Chapter 1, National context.**

With a cross-cutting approach, the Climate Plan's Strategy for Education, Capacity-building, Research, Development, and Innovation (ET-ECAPI, Estratégia Transversal de Educação, Capacitação, Pesquisa, Desenvolvimento e Inovação) recognizes science, technology, and

innovation as central elements for strengthening Brazil's response to the challenges posed by climate change (Brasil, 2026d). In this context, the Research, Technological Development, and Innovation pillar seeks to expand the production of scientific knowledge about the new climate reality, promoting interdisciplinary approaches capable of informing public policy and generating solutions for mitigation and adaptation that have a social and territorial impact. This pillar also provides for strengthening the country's scientific, technological, and digital infrastructure; consolidating national and international research networks and innovation ecosystems; and integrating science, traditional knowledge, civil society, and productive sectors. Furthermore, it promotes the development of open and interoperable platforms for climate data and evidence, expanding access to information and improving decision-making. Finally, it focuses on transforming knowledge into innovative and inclusive solutions that contribute to reducing inequalities, promoting diversity, and strengthening the socio-environmental resilience of territories, thereby expanding the relevance of Brazilian science and its contribution to a just and sustainable climate transition.

In addition to the technical and scientific contribution, the Climate Adaptation Plan development process sought to incorporate territorial perspectives and Indigenous, traditional, and local knowledge through the participation of the ministries responsible for these agendas, workshops and public consultations, and consideration of these themes, particularly in the Indigenous Peoples and traditional peoples and communities plans. This approach made it possible to take into account sociocultural specificities, ways of life, distinct forms of territorial management, and differentiated relationships with ecosystems in the formulation of planned adaptation actions.

The incorporation of a gender perspective and of local and traditional knowledge was another important element in the Climate Plan development process, as also described in the First Biennial Transparency Report. Recognition that the impacts of climate change are not evenly distributed across the population has led to the adoption of specific approaches aimed at reducing inequalities and strengthening the resilience of groups in situations of greater vulnerability. In this context, particular emphasis is placed on the development of the Cross-Cutting Strategy on Women and Climate (ETMC, Estratégia Transversal Mulheres e Clima), coordinated by the Ministry of Women, which provides a comprehensive assessment of the differentiated impacts of climate change on women, a theme also addressed in **Box 4.4**.

The ETMC is based on the understanding that gender inequalities can be exacerbated by the impacts of climate change and, therefore, proposes the systematic integration of this perspective into Brazilian climate policies. Its general goal is to integrate a gender perspective into national climate policy, ensuring that the mitigation and adaptation actions set out in the Climate Plan also contribute to promoting gender equality and strengthening women's rights. To guide its implementation, the Cross-Cutting Strategy on Women and Climate is structured around six National Goals aimed at strengthening women's economic autonomy; promoting access to natural and productive resources, land, and territory; preventing and addressing gender-based violence in climate-related contexts; increasing women's participation in governance and decision-making spaces; strengthening essential public policies and services; and promoting women's access to and leadership in climate finance, including improvements in the generation and use of data disaggregated by gender, age, race, and ethnicity (Brasil, 2026b).

To implement these goals, the ETMC establishes a set of guidelines to guide the implementation, improvement, and restructuring of the actions set out in the Climate Plan from a gender and intersectionality perspective. In addition, the ETMC presents an Action Plan aimed at supporting

ministries and other institutions in mainstreaming a gender perspective throughout the Climate Plan. The Plan brings together 64 targets organized according to different stages of the public policy cycle and includes actions aimed at promoting the systemic and intersectional integration of gender equality into the planning, implementation, and monitoring processes of climate policies. In addition, each action was linked to the National Adaptation Goals, strengthening the connection between the gender equality and climate resilience agendas and contributing to a more inclusive, equitable, and effective implementation of the planned actions.

4.4.3. Development priorities related to climate change adaptation and its impacts

In Brazil, the development agenda is intrinsically linked to the climate change adaptation agenda. This vision is embedded in the strategic framework of the Climate Plan, which adopts sustainable development and climate justice as cross-cutting principles, reflected both in its general and national goals and in its guidelines. Among the national goals, National Goal 7 stands out, as it is focused on promoting economic development and reducing inequalities, highlighting the understanding that adaptation is a fundamental element in building a more resilient, inclusive, and sustainable development model.

The Climate Plan guidelines reinforce this approach by promoting sustainable development, climate justice, and the integration of adaptation into policies, programs, and projects, with a focus on foundational and long-term initiatives. The broad scope of the Sectoral and Thematic Plans also demonstrates the importance given to the adaptation of sectors that are strategic to the national economy, such as agriculture, tourism, and industry, while also taking into account groups in situations of greater vulnerability, including Indigenous Peoples, traditional peoples and communities, and the Black population.

As detailed in section **4.2. Impacts, risks, and vulnerabilities**, the effects of climate change pose significant challenges to the achievement of the country's development goals. In this context, adaptation is an essential strategy for reducing vulnerabilities, strengthening the resilience of socioeconomic systems, and safeguarding progress toward sustainable development and the reduction of inequalities.

Another important aspect of the Climate Plan is its integration with the 2030 Agenda and the Sustainable Development Goals (SDGs). During the development of the plan, the SDGs were taken into account in the establishment of national targets and indicators, incorporating good practices and aligning international commitments with national goals. In addition, during the process of detailing the actions of the Sectoral and Thematic Plans, the identification of the SDG targets related to each proposed action was encouraged, establishing a direct link between adaptation efforts and the achievement of the global Sustainable Development Goals. Thus, adaptation planning contributes to progress toward all the SDGs, strengthening the consistency of public policies and ensuring that Brazil fulfills the commitments it has made.

4.4.4. Mitigation co-benefits

Some actions outlined in the sectoral and thematic plans of the Climate Adaptation Plan have been identified as having the potential to generate mitigation co-benefits, in accordance with paragraph 109(e) of Decision 18/CMA.1. These co-benefits result from actions that, while

strengthening the adaptive capacity of socio-ecological systems and reducing their vulnerability to the impacts of climate change, also contribute to reducing greenhouse gas emissions or to conserving and expanding carbon stocks.

Although mitigation co-benefits have not been systematically identified during the development of the Climate Adaptation Plan, an exploratory analysis of the planned actions reveals various interfaces between adaptation and mitigation in the sectoral and thematic plans. Based on this analysis, the main mechanisms associated with the generation of co-benefits can be tentatively organized into six broad categories: (i) ecosystem conservation and restoration; (ii) resilient production systems; (iii) water security and landscape restoration; (iv) urban adaptation solutions; (v) energy transition and efficiency; and (vi) land use planning and management.

Overall, co-benefits are observed in connection with conservation and restoration and resilient production systems, with a direct interface with the Agriculture, Forestry and Other Land Use (AFOLU) sector and with the energy sector, particularly through energy efficiency and energy transition. In this context, the interfaces between the protection and management of Indigenous and Quilombola territories and Conservation Units and the adaptation and mitigation goals also stand out, considering their contribution to ecosystem conservation, the reduction of vulnerabilities, and the maintenance of carbon stocks. These different interfaces highlight the potential for adaptation and mitigation to complement each other, especially in actions related to the sustainable management of natural resources and the reduction of climate vulnerability.

As an area for improvement, there is a need to further develop and systematize the analysis of co-benefits, synergies, and trade-offs between the adaptation and mitigation initiatives envisaged in the national climate planning system. In certain contexts, measures adopted in one sector can have positive or negative implications for others, as in the case of potential competition for water resources between power generation and food production. Further developing these analyses in future planning cycles can help improve consistency among public policies, strengthen cross-sectoral integration, and support the implementation of the actions planned to achieve the National Adaptation Goals.

4.4.5. Initiatives to integrate climate change into development efforts, as well as into plans, policies, and programs, including related capacity-building activities

In addition to the actions outlined in the Climate Plan, other initiatives are already making progress in incorporating climate change into sectoral plans with development goals. Below is a list of plans, policies, programs, and standards that now include the dimension of risks and vulnerabilities as strategic criteria or goals, thereby aligning with the adaptation agenda.

The actions that are already being implemented and have achieved results, even if only intermediate, will be detailed in section **4.5. Progress in implementation**.

Dataframe 4.5 Policies, programs, and actions that incorporate climate change

Main National Goal	Policy / Program / Plan / Action	Description and results
NG1 - Cities and infrastructure	National Urban Tree Coverage Plan[53]	A federal instrument aimed at expanding and improving tree coverage in Brazilian cities, with the goal of increasing urban tree coverage, promoting biodiversity, and generating environmental, social, and climate benefits. With a time horizon extending to 2045, the Plan establishes long-term guidelines, targets, and actions to strengthen urban planning, reduce urban heat islands, improve stormwater management, and enhance green infrastructure, recognizing trees as an essential element of cities.
	Programa Periferia Viva (Live Urban Periphery Program)	The program integrates *favela* urbanization, land tenure regularization, housing improvements, and urban infrastructure in vulnerable territories. The program has a strong interface with the climate agenda by addressing conditions that increase the exposure of populations in urban peripheries to floods, landslides, heat islands, and other extreme events.
	Guidelines for the allocation of resources under highway concession contracts aimed at developing resilient infrastructure, mitigating greenhouse gas (GHG) emissions, and advancing the energy transition (Ministry of Transport (MT, Ministério dos Transportes) Ordinance No. 622 of June 28, 2024)[54]	New highway concession projects must allocate at least 1% of gross revenue to the development of resilient infrastructure, with the aim of reducing climate change impacts on highway infrastructure.
	National Logistics Plan – PNL (Plano Nacional de Logística) 2050[55]	The PNL establishes a long-term vision for Brazilian transport infrastructure. It identifies medium- and long-term needs and opportunities for the national passenger and freight transport network. A climate risk model was adopted to anticipate climate hazards that may cause disruption to the transport system, in order to guide investments in infrastructure resilience.
	PRO-AdaptaVias Program[56]	Established by MT Ordinance No. 64 of January 23, 2025, as an instrument aimed at strengthening the climate adaptation and resilience of federal land transport infrastructure through strategic planning, risk management, innovation, research, engineering solutions, and nature-based solutions. It also seeks to promote institutional capacity-building, technical cooperation, access to financing, the production and dissemination of information, economic analyses, and continuous monitoring to guide the implementation and improvement of adaptation actions.
	Capacidades (Capacities)	The program aims to offer courses specifically focused on climate change, climate adaptation, and sustainable urban development.

53 Available at: https://www.gov.br/mma/pt-br/assuntos/meio-ambiente-urbano-recursos-hidricos-qualidade-ambiental/cidades-verdes-resilientes/areas-verdes-e-arborizacao-urbana/planau. Accessed on: Sept. 06, 2026.

54 Available at: https://www.gov.br/transportes/pt-br/assuntos/noticias/2024/07/novo-marco-verde-ministerio-dos-transportes-exige-sustentabilidade-em-concessoes-rodoviarias. Accessed on: Sep. 06, 2026.

55 Available at: https://pit.infrasa.gov.br/wp-content/uploads/2026/08/Plano-Nacional-de-Logistica-2050-Relatorio-Completo-1a-Edicao-Agosto-2026.pdf

56 Available at: https://www.in.gov.br/en/web/dou/-/portaria-n-64-de-23-de-janeiro-de-2025-611281695

Main National Goal	Policy / Program / Plan / Action	Description and results
NG2 - Food production and access	Ministry of Agrarian Development and Family Farming (MDA, Ministério do Desenvolvimento Agrário e Agricultura Familiar) Ordinance No. 83/2026, which establishes regulations for the Climate Adaptation Strategy for Family Farming (EACAF, Estratégia de Adaptação Climática da Agricultura Familiar)[57]	The EACAF is a public policy instrument under the *Garantia-Safra* (Harvest Guarantee) Program aimed at strengthening the productive resilience of family farming in semiarid regions and addressing climate change, through the integration of income protection and productive inclusion policies for family farmers. The EACAF is complementary and foundational in nature and does not replace the payment of financial benefits under the *Garantia-Safra* Program.
NG3 - Water security and multiple uses	Brazilian Action Plan to Combat Desertification and Mitigate the Effects of Drought (PAB Brasil)[58]	PAB Brasil 2025-2043 includes strategic pillar 2: Climate Change Adaptation and Mitigation of the Effects of Drought. This pillar aims to strengthen agricultural institutions, NGOs, universities, and environmental enforcement agencies, as well as to foster research and innovation while promoting landrace seeds and the restoration of ecosystems. Integrated water resources management is central, promoting the right to water and improving water storage and distribution infrastructure. The use of social technologies, such as cisterns and desalination systems, combined with adaptive agriculture, aims to ensure resilience and active community participation in decision-making.
NG4 - Biodiversity and ecosystem services	National Biodiversity Strategy and Action Plan (EPANB, Estratégia e Plano de Ação Nacionais para a Biodiversidade)[59]	Brazil's main planning instrument for biodiversity conservation, sustainable use, and the fair and equitable sharing of benefits, establishing a long-term vision (through 2050), national targets for 2030, and a set of actions and mechanisms for monitoring, financing, and implementation. The Strategy integrates public policies and guides the fulfillment of the country's commitments under the Convention on Biological Diversity, including targets for ecosystem conservation, environmental restoration, and the reduction of pressures such as deforestation and pollution. Specifically, one of its targets is to minimize the impact of climate change on biodiversity.
NG7 - Development and inequalities	Technical study on Adaptive Social Protection and the Single Registry[60]	Development of a technical study on Adaptive Social Protection and the use of the Single Registry for risk analysis, currently in an advanced stage of development, including an analysis of regulatory instruments and territorial experiences. Additionally, an initiative is under development to establish emergency protocols aimed at strengthening Adaptive Social Protection and the integration of social protection with risk and disaster management.

57 Available at: https://www.in.gov.br/web/dou/-/portaria-mda-n-83-de-13-de-abril-de-2026-699947213. Accessed on: Sep. 06, 2026.

58 Available at: https://www.gov.br/mma/pt-br/centrais-de-conteudo/publicacoes/povos-e-comunidades-tradicionais/pab-brasil.pdf. Accessed on: Sep. 06, 2026.

59 Available at: https://www.gov.br/mma/pt-br/composicao/sbio/departamento-de-conservacao-e-uso-sustentavel-da-biodiversidade/epanb. Accessed on: Sep. 06, 2026.

60 Available at: https://www.gov.br/mds/pt-br/acoes-e-programas/calamidades-publicas-e-emergencias. Accessed on: Sep. 06, 2026.

Main National Goal	Policy / Program / Plan / Action	Description and results
NG8 - Cultural heritage and practices	National Strategy for Cultural Heritage and Climate Action[61]	Launched in July 2026, the strategy brings together actions to preserve cultural heritage in the face of the impacts of climate change on cultural assets, traditional territories, and ways of life, with equity and the valuing of traditional knowledge as its core values. The document was based on a series of regional dialogues held since 2023 on Cultural Heritage and Climate Action.
	National Culture Plan[62]	The National Culture Plan was established in 2025 and includes, among its pillars, Pillar 7: culture, good living, and climate action. This pillar includes the protection, valuing, and promotion of the cultures and knowledge of traditional peoples and communities, such as communities of African origin, and of Indigenous Peoples as a strategy for resilience, the promotion of good living, and climate action. It also includes promoting the adaptation, mitigation, and recovery of the cultural sector in response to the impacts of disasters and environmental and health emergencies, in coordination with cultural actors, groups, communities, and spaces.

Source: Compiled by the authors.

4.4.6. Nature-based solutions for climate change adaptation

Brazil has recognized Nature-based Solutions (NbS), particularly Ecosystem-Based Adaptation (EbA), as a central strategic pillar of the Climate Plan. This recognition has led to the establishment of a specific guideline on this theme and to the incorporation of national goals, such as **NG4: Protect, conserve, restore and strengthen ecosystems and biodiversity, while ensuring the provision of ecosystem services** and **NG9: Strengthen the vital role of the ocean and coastal zone in tackling climate change**, which reinforce the integration of climate adaptation and ecosystem conservation. In addition, the approach has been incorporated into the targets and actions of various sectoral and thematic plans, demonstrating its cross-cutting and foundational nature.

The national targets, described in section **4.3.1., National adaptation priorities**, also include dimensions related to the promotion of Nature-based Solutions (NbS) and Ecosystem-Based Adaptation (EbA). Notable examples include the national targets of expanding vegetation coverage in urban areas by 180,000 hectares, connecting 30% of the national territory through ecological corridors, and increasing the proportion of marine protected areas to 30%. Together, they recognize ecosystem services as strategic elements for climate adaptation in the country.

The feasibility of achieving these targets depends directly on protected areas and traditionally occupied territories, such as Indigenous and Quilombola territories and Conservation Units. In this regard, the thematic adaptation plans for Indigenous Peoples and traditional peoples and communities present NbS targets and actions, such as the restoration of 500,000 hectares of degraded areas, sloping land, riparian forests, and springs with native vegetation, integrated fire management, and land tenure regularization (Brasil, 2025d; Brasil, 2025g).

61 Available at: https://www.gov.br/iphan/pt-br/assuntos/noticias/iphan-lanca-estrategia-nacional-para-patrimonio-cultural-e-acao-climatica. Accessed on: Sep. 06, 2026.

62 Available at: https://www.gov.br/cultura/pt-br/centrais-de-conteudo/publicacoes/plano-nacional-de-cultura-2025-2035/PNC_digital.pdf. Accessed on: Sep. 06, 2026.

In line with the Climate Plan, Brazil has made progress in developing and implementing planning tools that promote the NbS and explicitly incorporate climate adaptation into their goals. Launched in 2025, the National Urban Tree Coverage Plan sets targets and guidelines aimed at increasing tree coverage in cities, thereby promoting environmental and climate benefits. The National Strategy for Nature-based Solutions (ENSBN, Estratégia Nacional de Soluções Baseadas na Natureza)[63], the development of which began in 2026 through workshops and public consultations, complements this effort.

In connection with these initiatives, recent studies have been strengthening the technical foundation and informing decision-making regarding NbS, particularly at the local level. Among these, notable examples include the mapping of federal initiatives related to NbS and the publication entitled *Estimating the Costs of Nature-based Solutions in SINAPI - National System for the Survey of Construction Costs and Indices (Sistema Nacional de Pesquisa de Custos e Índices da Construção Civil)*[64]*: Costs and References*, both developed by the Center for Strategic Studies and Management (CGEE, Centro de Gestão e Estudos Estratégicos), a social organization linked to MCTI through an institutional relationship formalized by a management contract. Also noteworthy is the booklet entitled *Community-based Nature-based Solutions: Adapting Vulnerable Territories to Climate Change*[65], published by the MMA in partnership with the Brazilian Collaborative Urbanism Network (Rede Brasileira de Urbanismo Colaborativo), which presents concepts and examples applicable to local communities in simple language, particularly in vulnerable areas such as urban peripheries.

When addressing the issue of urban peripheries, the Ministry of Cities developed the document called *NbS in Urban Peripheries*, with the aim of providing inputs to support the adaptation of these territories through the application of NbS. Also focusing on the urban environment, the MMA developed the *Practical Manual: Applicability of Nature-based Solutions in Brazilian Municipalities*[66], which provides simple and structured guidance for public officials, contributing to increasing adaptive capacity across territories.

In terms of implementation, the New Growth Acceleration Program (PAC, Programa de Aceleração do Crescimento) incorporated NbS as a selection criterion under its slope stabilization pillar, prioritizing proposals that include solutions of this kind and/or green and blue infrastructure in initiatives aimed at reducing landslide risk in vulnerable areas. In addition, through interministerial cooperation and resources from the Climate Fund, BRL 25 million in 2025 and 15 million in 2026 were allocated to the *Resilient Green Urban Peripheries* call for proposals[67] (see section **7.2.4, Non-formal climate education and educational initiatives**), which supports adaptation initiatives focused on NbS. Another notable initiative is the *ArborizaCidades (Greening Cities)* call for proposals[68], under the National Urban Tree Coverage Plan, which provides BRL 19 million

63 Available at: https://www.redus.org.br/estrategia-nacional-sbn. Accessed on: Sep. 06, 2026.

64 It is the main official cost reference for construction projects and services in Brazil, particularly with regard to buildings.

65 Available at: https://urban95.org.br/documents/58/solucoes-comunitarias-baseadas-na-natureza-1.pdf. Accessed on: Sept. 07, 2026.

66 Available at: https://www.gov.br/mma/pt-br/assuntos/meio-ambiente-urbano-recursos-hidricos-qualidade-ambiental/cidades-verdes-resilientes/SBN/digital___manual_pratico_sbn___versao_final_12_02_2026_compressed.pdf. Accessed on: May 07, 2026.

67 Available at: https://www.gov.br/mma/pt-br/composicao/secex/dfre/fundo-nacional-sobre-mudanca-do-clima/chamadas-editais-1/edital-2024. Accessed on: Sept. 07, 2026.

68 Available at: https://www.gov.br/mma/pt-br/assuntos/meio-ambiente-urbano-recursos-hidricos-qualidade-ambiental/cidades-verdes-resilientes/areas-verdes-e-arborizacao-urbana/planau/arborizacidades/arborizacidades. Accessed on: May 07, 2026.

to support municipalities in planning urban tree coverage, establishing nurseries, producing seedlings, and carrying out tree planting.

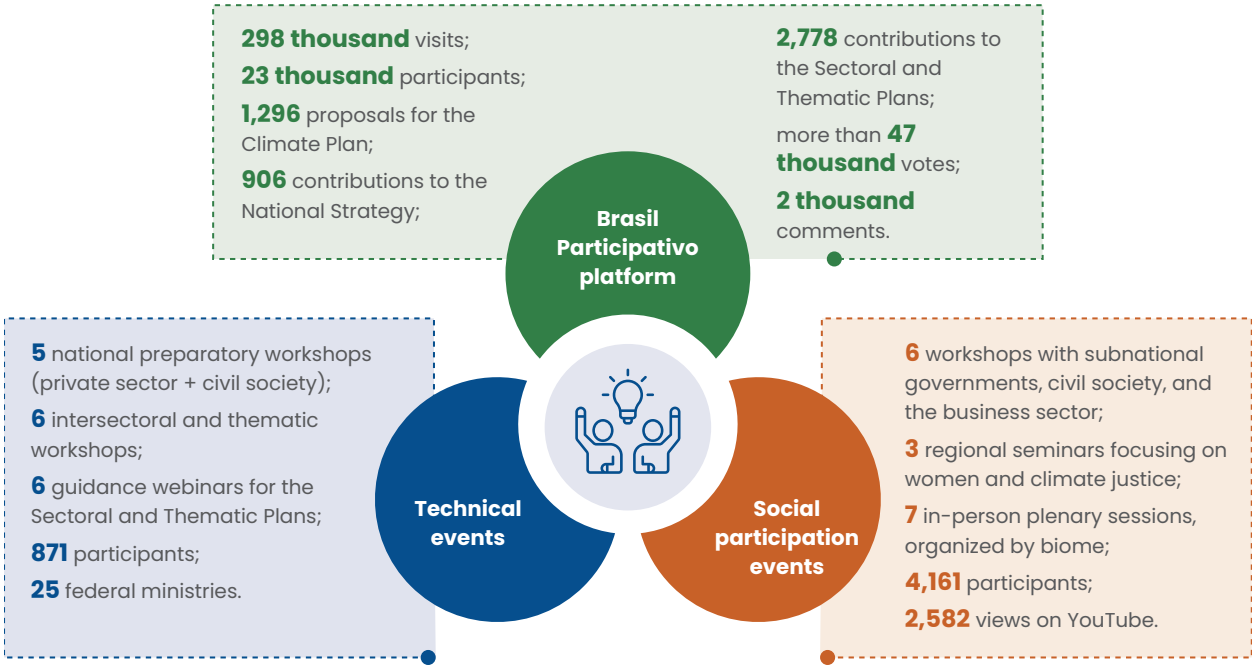
In this way, Brazil is making progress in policy development and in scaling up investments in nature-based solutions as a strategy for climate adaptation.

4.4.7. Stakeholder engagement, including plans, priorities, actions, and programs at the subnational, community, and private-sector levels

The Climate Adaptation Plan was developed between 2023 and 2025 and was carried out within the framework of federal climate governance, which was strengthened by the restructuring of the Interministerial Committee on Climate Change (CIM). Under the auspices of this committee, the Technical Adaptation Working Group was established, responsible for developing the National Adaptation Strategy and the Sectoral and Thematic Adaptation Plans. The process involved more than 25 ministries and various federal agencies, as well as collaboration from subnational governments, civil society organizations, the private sector, and the scientific community, reflecting the multisectoral and multilevel nature of the adaptation agenda (Brasil, 2025t).

Workshops and webinars were also held for public officials, as well as workshops open to both the general public and specific groups, including the business sector and civil society organizations. The process also included a digital platform for social participation, the *Brasil Participativo* platform (Participatory Brazil Platform), which allowed the public to submit contributions to the National Adaptation Strategy (ENA, Estratégia Nacional de Adaptação) and to the Sectoral and Thematic Plans. This combination of different engagement mechanisms broadened the diversity of perspectives considered in the development of the Plan and strengthened its participatory nature. Figure 4.70 presents the main figures related to public participation and the events held throughout the Climate Adaptation Plan development process.

Figure 4.70 Participatory process for the development of the Climate Adaptation Plan



Source: Brasil, 2025t.

Given Brazil's size, it is important to consider strengthening climate federalism[69] for the implementation of adaptation actions. Territory-tailored adaptation has been incorporated into the actions set out in the Climate Plan and into specific measures, with a view to tailoring strategies and solutions to the different realities and vulnerabilities across Brazil. In addition to the initiatives included in the Climate Plan itself, specific measures aimed at strengthening subnational capacities stand out, such as the *AdaptaCidades (Cities Adaptation)* program, which supports municipalities in developing local adaptation plans. Another is the Ministry of Cities (MCid, Ministério das Cidades) *"AdaptAÇÃO"* Project, which aims to integrate the adaptation agenda into the urban planning instruments of Brazilian municipalities. These initiatives contribute to enhancing the response capacity of federative entities and promoting more coordinated and effective implementation of climate policies.

Also worth noting is the establishment of the Interfederative Coordination Chamber of the Interministerial Committee on Climate Change (CIM), which serves as an important mechanism for coordination among the different levels of government (Brasil, 2025t). By increasing the participation and influence of states and municipalities in climate policy development and implementation processes, the Chamber strengthens multilevel governance and facilitates the development of more integrated responses to adaptation challenges.

4.5. Progress in implementation

A systematic and comprehensive evaluation of the adaptation actions currently being implemented in Brazil has not yet been conducted, as the monitoring and evaluation system for the Climate Adaptation Plan is still under development. In this context, this section presents a preliminary and non-exhaustive overview of policies, programs, and actions that have been implemented to some extent or that have made institutional progress, organized according to the National Adaptation Goals.

The Climate Plan has made significant progress in terms of institutional mobilization since its development. In particular, progress has been made in incorporating the adaptation agenda into planning processes and ongoing government actions, indicating advances in adaptation mainstreaming. This progress is reflected in greater coordination among existing public policies, regulations, sectoral plans, and programs, as well as in new initiatives currently under development, which are now directly aligned with the adaptation goals and are often incorporated into or aligned with the guidelines of the Climate Adaptation Plan.

In section **4.4., Adaptation strategies, policies, plans, goals, and actions to integrate adaptation into national policies and strategies,** the scope of the actions outlined in the Climate Plan and elsewhere within the Federal Government was presented. Dataframe 4.6 lists actions that have been identified as being implemented to some extent. It is expected that, in the next BTR reporting cycles, the Climate Plan monitoring system will enable the presentation of more systematic, comparable information based on consolidated indicators.

69 In Brazil, federalism is the political-administrative system under which the Federal Government, the states, the Federal District and the municipalities share governmental powers and responsibilities, as established by the Federal Constitution.

Dataframe 4.6 Federal government actions identified as being implemented to some extent

Main National Goal	Policy / Program / Plan / Action	Description and implementation stage
NG1 - Cities and infrastructure	*AdaptAção*[70]	The project aims to strengthen the capacity of Brazilian municipalities to incorporate climate change adaptation into urban planning, with a focus on reducing vulnerability and increasing the resilience of urban areas. The project is implemented through technical assistance to municipal teams, with the involvement of civil society and the academic community. The initiative develops methodologies, tools, and technical guidance to support the integration of climate risks into urban policy, while also promoting capacity-building and institutional coordination. Since implementation began in 2025, the in-person course "Urban Planning in the Face of Climate Change" has been launched, with four additional editions to be held in different regions, along with the publication entitled "Assessment of the Potential of Urban Policy Instruments".
	Periferia sem risco[71] (Risk-free urban peripheries)	A program aimed at reducing socio-environmental vulnerability and disaster risks in urban peripheral territories. The initiative aims to prevent and mitigate risks associated with hillside landslides, fluvial flooding events, flash floods, and other extreme weather events through integrated actions involving land use planning, infrastructure works, urbanization, knowledge production, and the strengthening of local capacities. Notable initiatives implemented include the development of: approximately 100 Municipal Risk Reduction Plans; a "Manual for the Development of Municipal Risk Reduction Plans: Technical and Methodological Guidance"; a guide for Community Risk Reduction and Climate Adaptation Plans; in addition to the launch of the publication "NbS in Urban Peripheries"; and the development of the educational campaign "Risk-Free Cities: Learning to Prevent."
	Programa Cidades Verdes Resilientes (Resilient Green Cities Program)[72]	The Resilient Green Cities Program (PCVR, Programa Cidades Verdes Resilientes), established in June 2024, aims to increase the environmental quality and resilience of Brazilian cities in the face of the impacts caused by climate change, by integrating urban, environmental and climate policies, encouraging sustainable practices and valuing the ecosystem services of urban greenery. The initiatives implemented include improvements to the Urban Environmental Registry (CAU, Cadastro Ambiental Urbano) platform and the development of a Project Database that contributes to sustainable urban solutions and provides a mapping of the Program's demand (see section **7.2.5, Vocational training and institutional capacity-building**). The Program also includes the Resilient Green Urban Peripheries Project, aimed at implementing Nature-based Solutions (NbS) in urban peripheries, with a focus on climate adaptation, environmental justice, and community leadership. The Project operates through partnerships with Civil Society Organizations (CSOs) with funds from the Ministry of Cities and the Climate Fund, with investments exceeding BRL 40 million.

70 Available at: https://www.gov.br/cidades/pt-br/acesso-a-informacao/acoes-e-programas/desenvolvimento-urbano-e-metropolitano/projeto-adaptacao. Accessed on: Sep. 06, 2026.

71 Available at: https://mapadasperiferias.cidades.gov.br/periferia_sem_risco. Accessed on: Sep. 06, 2026.

72 Available at: https://www.gov.br/mma/pt-br/assuntos/meio-ambiente-urbano-recursos-hidricos-qualidade-ambiental/cidades-verdes-resilientes. Accessed on: Sep. 06, 2026.

Main National Goal	Policy / Program / Plan / Action	Description and implementation stage
	New Growth Acceleration Program (PAC) – Sustainable and Resilient Cities pillar[73]	The New PAC is a federal government investment program structured around nine pillars. Among these, the Sustainable and Resilient Cities pillar stands out as particularly relevant to the adaptation agenda, as it coordinates interventions in urban infrastructure, such as environmental sanitation elements (water supply, sewage services, and solid waste management) that reduce vulnerability, as well as risk reduction and the improvement of living conditions in vulnerable areas. In this pillar, initiatives focused on the urbanization of *favelas* and disaster prevention, associated with sustainable urban drainage, are strategic for reducing the population's exposure to extreme events. They include drainage systems, stormwater management, and the reduction of surface water flooding events, floods, and fluvial flooding events in critical municipalities. Under the disaster prevention, slope stabilization, and drainage component, BRL 9.3 billion was allocated to investments in works and projects for sustainable urban drainage and stormwater management in 190 municipalities affected by recurrent fluvial flooding.
NG2 - Food production and access	*Programa Cozinha Solidária*[74] (Community Kitchen Program)	Community kitchens are a social technology for combating hunger, defined as an organized civil society initiative that produces and provides free meals to groups experiencing socioeconomic vulnerability and food insecurity, including people experiencing homelessness. They align with climate adaptation goals by expanding access to healthy food in more vulnerable territories in situations that may be exacerbated by the effects of climate change, such as disasters caused by extreme events. As of June 2026, the federal government had supported approximately 700 community kitchens.
	Alimenta Cidades + 1000[75] (Feeding the Cities + 1000)	The program of the Ministry of Development and Social Assistance, Family and Fight against Hunger (MDS, Ministério do Desenvolvimento e Assistência Social, Família e Combate à Fome) aims to promote integrated planning and intersectoral coordination of actions related to urban food systems, as well as to strengthen a rights-based approach encompassing both the right to the city and the human right to adequate food, thereby reducing social inequities. In Rio Grande do Sul, implementation is primarily linked to the climate agenda, given the recurrence of extreme weather events and the need for public policies focused on adaptation and the resilience of urban food systems. The initiative is being implemented in 102 municipalities across all regions, and in 2025, more than 1,000 municipalities (about 20% of the total) had joined the initiative.

73 Available at: https://www.gov.br/casacivil/pt-br/novopac/cidades-sustentaveis-e-resilientes/prevencao-a-desastres-contencao-de-encostas-e-drenagem. Accessed on: Sep. 06, 2026.

74 Available at: https://www.gov.br/mds/pt-br/acoes-e-programas/acesso-a-alimentos-e-a-agua/programa-cozinha-solidaria. Accessed on: Sep. 06, 2026.

75 Available at: https://www.gov.br/mds/pt-br/acoes-e-programas/promocao-da-alimentacao-adequada-e-saudavel/alimenta-cidades. Accessed on: Sep. 06, 2026.

Main National Goal	Policy / Program / Plan / Action	Description and implementation stage
	Reference Framework on Food Systems and Climate for Public Policies[76]	A joint initiative between the MDS and civil society, the Framework calls for a broad reflection on the relationship between food systems and climate, calling for the convergence, cooperation, and mobilization of policies, programs, and actions in support of the Human Right to Adequate Food and Climate Justice. Healthy, sustainable, and resilient food systems are essential to food sovereignty and to ensuring that all people have equitable access to adequate and healthy food. The framework was scheduled to be developed by 2027, in accordance with target No. 26 of the Climate Adaptation Plan - Food and Nutrition Security - and has already been completed and made available.
	Food Procurement Program (PAA, Programa de Aquisição de Alimentos) [77]	The PAA, which has been in place since 2003, has two main goals: to promote access to food, especially for the most vulnerable people, and to foster agricultural production by family farmers, Traditional Peoples and Communities (PCTs, Povos e Comunidades Tradicionais), and other social groups. To this end, through the PAA, the Federal Government purchases food produced by these groups and donates it to organizations in social assistance, public and philanthropic networks, as well as to education, health, and justice institutions and food and nutrition security facilities. In 2025, the share of PAA resources allocated to traditional peoples and communities (PCTs) reached 15%, representing progress toward achieving Target No. 10 of the Climate Adaptation Plan – Food and Nutrition Security, while climate vulnerability criteria were also included in the most recent calls for proposals. The target establishes that, by 2027, at least 25% of PAA suppliers must belong to traditional peoples and communities (PCTs).
NG3 - Water security and multiple uses	Cisterns Program[78]	The Cisterns Program aims to promote access to water for human consumption and food production through the implementation of simple, low-cost social technologies. Established as public policy in 2003, it is intended for low-income rural families and rural public facilities affected by drought or water shortages, with priority given to traditional peoples and communities. The Program supports adaptation policies by promoting access to water, particularly in areas that are more sensitive to climate impacts. Since 2023, 195,000 cisterns and other social technologies have been provided, of which 14,500 are intended for food production. The program's activities are concentrated in approximately 800 municipalities, located primarily in the semi-arid region and in the Amazon. Further information on the Program's results will be provided in **Box 4.12** of section **4.6 - Monitoring and Evaluation**.
	New PAC – Water for All pillar[79]	The goal of this pillar is to ensure water security. By the end of 2025, 291 desalination systems and 91 simplified water access systems had been delivered, sanitation improvements had been implemented in Indigenous villages, and 20 foundational water access works and projects had been completed.

76 Available at: https://www.gov.br/mds/pt-br/acoes-e-programas/promocao-da-alimentacao-adequada-e-saudavel/marco-de-referencia-sobre-sistemas-alimentares-e-clima-para-politicas-publicas. Accessed on: Sep. 06, 2026.

77 Available at: https://www.gov.br/mds/pt-br/acoes-e-programas/acesso-a-alimentos-e-a-agua/programa-de-aquisicao-de-alimentos. Accessed on: Sep. 06, 2026.

78 Available at: https://www.gov.br/mds/pt-br/acoes-e-programas/acesso-a-alimentos-e-a-agua/programa-cisternas. Accessed on: Sep. 06, 2026.

79 Available at: https://www.gov.br/casacivil/pt-br/novopac/agua-para-todos. Accessed on: Sep. 06, 2026.

Main National Goal	Policy / Program / Plan / Action	Description and implementation stage
NG4 - Biodiversity and ecosystem services	Establishment of Conservation Units[80]	Between 2024 and 2026, 154 new Conservation Units were established at the federal, state, and municipal levels, and four others were expanded in Brazil; these units play a significant role in providing ecosystem services, preserving biodiversity, and ensuring connectivity.
NG5 - Health	National Dashboard for Monitoring and Forecasting Excessive Heat and for Health Equity[81]	Launched in 2026, the Dashboard is the Ministry of Health's official tool for monitoring and forecasting excessive heat in all Brazilian municipalities, using the Excess Heat Factor (EHF) index and the Combined Risk indicator, which integrates EHF with socioeconomic vulnerability. It enables the forecasting of extreme heat up to five days in advance, supporting prevention and response efforts in heat-related public health situations. The tool is used to issue warnings to SUS managers, which, depending on the situation, can be shared with the public through the "*Meu SUS Digital*" (My Digital SUS) app and through the Civil Defense system.
	Ethnic-Racial Vulnerabilities, Environment, Climate, and Health Impacts Project (VERACIS, Vulnerabilidades Étnico-Raciais, Ambiente, Clima e Impacto na Saúde)	Implemented between 2024 and 2026, the project included six Brazilian biomes and urban and rural territories, with the goal of producing evidence and tools to understand how climate change and environmental factors affect populations in situations of vulnerability differently, with an emphasis on Black and Quilombola populations. The project promoted the strengthening of community-based surveillance across territories, as well as collecting biological and environmental samples in Quilombola communities, carrying out analyses related to physical and mental health, and monitoring air quality to support surveillance, planning, and decision-making within the SUS.
	Development of capacity-building programs and guides on climate change and health.	Capacity-building programs were developed to support the development of subnational health sector adaptation plans in line with the *AdaptaCidades* Program (further information below), with the plans for the states of Pará, Bahia, and Piauí finalized. The following guides were published: Guide for the Development of Health Sector Climate Change Adaptation Plans[82], Climate Change Pocket Guide for Healthcare Professionals, and Guide for Community-Based Health and Climate Emergency Surveillance[83].
	National Contingency Plan for Public Health Emergencies caused by heavy rainfall and associated disasters[84]	Launched by the Ministry of Health in 2025, it provides for actions in response to heavy rainfall and associated disasters. The Plan takes into account local and regional needs, coordinated response strategies, and the designation of responsible parties from a public health perspective.

80 Available at: https://cnuc.mma.gov.br/powerbi. Accessed on: Sep. 06, 2026.

81 Available at: https://clima.saude.gov.br. Accessed on: Sep. 08, 2026.

82 Available at: https://www.gov.br/saude/pt-br/centrais-de-conteudo/publicacoes/guias-e-manuais/2026/guia-para-elaboracao-de-planos-de-adaptacao-a-mudanca-do-clima-do-setor-saude-versao-final-preliminar.pdf/. Accessed on: Oct. 05, 2026.

83 Available at: https://ceara.fiocruz.br/serpovos/download/guia-de-vigilancia-popular-em-saude-e-emergencias-climaticas/#. Accessed on: Oct. 05, 2026.

84 Available at: https://www.gov.br/saude/pt-br/centrais-de-conteudo/publicacoes/svsa/vigilancia-ambiental/plano-de-contingencia-para-emergencias-em-saude-publica-por-chuvas-intensas-e-desastres-associados.pdf/view. Accessed on: Sep. 08, 2026.

Main National Goal	Policy / Program / Plan / Action	Description and implementation stage
	Contingency Plan for Public Health Emergencies Caused by Drought and Dry Spells[85]	Launched in 2026 by the Ministry of Health, the plan establishes guidelines for preparedness, surveillance, and response to public health emergencies resulting from drought and dry spells, strengthening the SUS's coordination capacity in responding to these events. The document defines risk scenarios, operational stages, indicators for activating response measures, institutional responsibilities, and preparedness, monitoring, risk communication, and response actions, with particular attention to the most vulnerable population groups. Its implementation strengthens the management of health risks associated with the impacts of climate change, contributing to the continuity of essential healthcare services and to increasing the sector's resilience in the face of extreme weather events.
NG7 - Development and inequalities	Social Assistance Surveillance[86]	The project aims to train managers and staff of the Brazilian National Social Assistance System (SUAS, Sistema Único de Assistência Social) in all states and in the Federal District, as well as in municipalities identified as the most vulnerable, by 2031. The initiative aims to strengthen the role of social assistance as part of integrated disaster risk management and to expand social protection against the adverse impacts of climate change-related events. Through the Brazilian National Social Assistance System Protection Force (FORSUAS, Força de Proteção do Sistema Único de Assistência Social), technical support missions were carried out in states and municipalities affected by disasters, along with the implementation of territorial actions and ongoing technical support to strengthen risk and disaster management within the SUAS framework.
	Rural Work Risk Management Program (PGRTR, Programa de Gerenciamento de Riscos no Trabalho Rural)	The Program includes measures related to protecting workers in extreme weather conditions, providing guidance on the procedures to be adopted and the interruption of activities when such conditions jeopardize workers' safety. It also includes work organization measures intended to reduce impacts on health and safety.
NG8 - Cultural heritage and practices	National Policy for Quilombola Territorial and Environmental Management (PNGTAQ, Política Nacional de Gestão Territorial e Ambiental Quilombola)[87]	A policy aimed at promoting territorial and environmental management of Quilombola territories, strengthening traditional ways of life, conserving socio-biodiversity, and improving the quality of life of Quilombola communities. The initiative contributes to climate change adaptation by strengthening the sustainable management of natural resources, food and water security, ecosystem conservation, and the resilience of Quilombola territories in the face of climate impacts, thereby reducing historically accumulated socio-environmental vulnerabilities.

85 Available at: https://www.gov.br/saude/pt-br/centrais-de-conteudo/publicacoes/svsa/vigilancia-ambiental/plano-de-contingencia-seca-e-estiagem.pdf/view. Accessed on: Sep. 08, 2026.

86 Available at: https://www.gov.br/mds/pt-br/acoes-e-programas/calamidades-publicas-e-emergencias. Accessed on: Sep. 08, 2026.

87 Available at: https://www.planalto.gov.br/ccivil_03/_ato2023-2026/2023/decreto/d11786.htm. Accessed on: Sep. 08, 2026.

Main National Goal	Policy / Program / Plan / Action	Description and implementation stage
	National Policy for Territorial and Environmental Management of Indigenous Lands (PNGATI, Política Nacional de Gestão Territorial e Ambiental de Terras Indígenas)	A policy established by Decree No. 7,747/2012, led by Indigenous movements and support organizations, which aims to promote the protection, restoration, conservation, and sustainable use of natural resources in Indigenous Lands. It adopts a tripartite, shared, and multi-level governance model (Brasil, 2025d), which includes a Technical Chamber on Climate Change, Environmental Services, and the Sociobioeconomy.
NG9 - Ocean and coastal zone	National Program for the Conservation and Sustainable Use of Brazil's Mangroves (*ProManguezal*)	The *ProManguezal* program aims to conserve, recover and sustainably use the biodiversity and ecosystem services associated with the country's mangroves, taking into account the various pressures on the ecosystem, including climate change. As part of implementation, the mapping of Brazil's mangroves was updated and an action plan with targets and indicators through 2030 was developed.
	National Strategy for the Conservation and Sustainable Use of Coral Reefs (*ProCoral*)[88]	It aims to implement, coordinate, and integrate public policies for the conservation, restoration, and sustainable use of these ecosystems in Brazil. The initiative covers various types of reef environments and their connectivity with other coastal ecosystems, promoting activities such as monitoring, restoration, research, and environmental education, with a focus on increasing ecological resilience and maintaining the services provided to human populations. It is directly aligned with the climate change adaptation agenda by strengthening the protection of highly vulnerable coastal ecosystems, which play a key role in reducing risks, protecting the coastal zone, and sustaining livelihoods in the face of climate impacts. In terms of progress under the Strategy, the National Action Plan for the Conservation of Coral Reef Environments (2025-2030) and the Synthesis Report on Coral Reef Bleaching by SIMACLIM - Synthesis Center on Environmental and Climate Change (Centro de Síntese em Mudanças Ambientais e Climáticas) were developed, and the Costa dos Corais Environmental Protection Area (APA, Área de Proteção Ambiental) was expanded by more than 89,000 hectares.
	Establishment of marine protected areas[89]	In 2026, the Albardão National Park was created in the state of Rio Grande do Sul, with approximately 1 million hectares. This is the country's largest marine park and performs important coastal functions, while also being important for migratory species.

Source: Compiled by the authors.

88 Available at: https://www.gov.br/mma/pt-br/composicao/smc/doceano/procoral. Accessed on: Sep. 08, 2026.

89 Available at: https://www.in.gov.br/en/web/dou/-/decreto-n-12.868-de-6-de-marco-de-2026-691137446. Accessed on: Sep. 08, 2026.

Subnational highlights

Recognizing the important role of the subnational level in implementing adaptation actions in the territory, some selected subnational actions that achieved innovative or sustainable results using different adaptation strategies are presented below.

AdaptaCidades

The *AdaptaCidades* Program (see section **4.8. Cooperation, good practices, experiences, and lessons learned** and section **7.2.5 Vocational training and institutional capacity-building**) is the largest initiative ever undertaken in Brazil to support municipalities in developing climate adaptation plans. The Program brings together the national government, states, municipalities, universities, international organizations, the private sector, and civil society around a common urban and climate resilience agenda. The initiative involves all 26 states, the Federal District, and more than 500 municipalities, with approximately 53 million people potentially benefiting across all regions of the country. To date, the initiative has achieved the following results: more than BRL 16 million in funding from the Green Climate Fund (GCF) for its implementation; 7,000 people trained through distance learning courses; and 2,000 participants in meetings, workshops, and mobilization activities held across all regions of the country.

In alignment with the National Health Sector Adaptation Plan (AdaptaSUS) target of having 100% of the health departments of the states and municipalities that are priority areas for climate emergencies mobilized to adapt SUS to climate change by 2035, engagement and capacity-building actions at the subnational levels are coordinated, in partnership with the *AdaptaCidades* Program, to support the development of subnational health sector adaptation plans. As a tool for this process, the Ministry of Health, in partnership with Fiocruz, developed the Guide for the Development of Health Sector Climate Change Adaptation Plans and has been providing technical support to states and municipalities in developing and implementing their adaptation plans. At the state level, the states of Bahia, Pará, Piauí, and São Paulo already have finalized health sector plans.

BOX 4.9 IMPLEMENTATION OF HEALTH AND CLIMATE INFORMATION CENTERS (CISC)

The Health and Climate Information Centers (CISC, Centros de Informação em Saúde e Clima) are an *AdaptaSUS* strategy that supports climate-related health surveillance within the framework of the Brazilian National Health System (SUS), integrating data from health surveillance, meteorology, the environment, geoprocessing, data science, and information on social vulnerability. The CISCs are expected to integrate data and carry out applied analyses, supporting surveillance and adaptation to extreme weather events, identifying triggers for early warnings, and establishing risk communication flows within the health sector that include guidance on adaptation measures tailored to the specific characteristics of each locality. The analyses also help improve decision-making and strengthen intersectoral coordination across territories, bringing together information and capacities from different sectors to foster climate adaptation in the health system in the face of climate change impacts.

The identification of priority populations and territories is guided by equity, taking into

account differences in exposure, health conditions, socioeconomic vulnerability, access to healthcare services, and adaptive capacity. In this way, the CISCs seek to inform the prioritization of protection actions and resources for populations facing the greatest risks and barriers to access to healthcare, strengthening the SUS's capacity in the face of climate change impacts and contributing to the reduction of health inequalities.

The Centers are currently being implemented in the municipalities of Belém, Santarém, Fortaleza, Belo Horizonte, Curitiba, Cuiabá, and Porto Alegre, in addition to the implementation of a CISC at the state level in Bahia. The initiative considers different territorial levels of operation, in order to strengthen the capacity to produce and use climate and health information across territories.

BOX 4.10 HEAT PROTOCOL AND HEAT OBSERVATORY – RIO DE JANEIRO[90]

The city of Rio de Janeiro has established an integrated system for managing extreme heat that combines the Heat Protocol and the *Favelas* Heat Observatory, both linked to the Operations and Resilience Center (COR, Centro de Operações e Resiliência). The Protocol establishes five alert levels based on the heat index, which combines temperature and humidity, and sets out progressive measures for preparedness, monitoring and warning, risk communication, and response, with a particular focus on public health impacts. The Heat Observatory, in turn, serves as a complementary territorial monitoring tool, collecting data on temperature, humidity and air quality in vulnerable areas, particularly in *favelas*, to assess the intensity of urban heat islands and inform targeted, evidence-based interventions. Together, these tools make it possible to anticipate risks, issue warnings, and coordinate intersectoral actions to protect the population during extreme heat events.

Key advances include the establishment of a tiered alert system integrated with the health sector, which improves response capacity to extreme events and informs decisions such as intensifying communication, mobilizing the healthcare network, and, where necessary, adapting urban activities. In the case of the Heat Observatory, the data have already revealed significant thermal inequalities, with temperatures recorded in *favelas* being up to approximately 10ºC higher than the city's official measurements, highlighting the unequal impacts of heat and the need for targeted policies. In terms of lessons learned, this experience demonstrates the importance of integrating climate data with health systems, of monitoring at the local level to identify intra-urban inequalities, and of community participation in data collection. In addition, it demonstrates that heat adaptation strategies need to combine technology, integrated governance, and urban planning interventions (such as increasing tree coverage and improving housing conditions) to reduce risks and promote climate justice.

90 Available at: https://saude.prefeitura.rio/protocolo-de-calor. Accessed on: Sep. 08, 2026.

BOX 4.11 CLIMATE RISK OBSERVATORY – FORTALEZA[91]

The Climate Risk Observatory of the municipality of Fortaleza is a public georeferenced platform that integrates environmental, territorial, and event data to continuously monitor and analyze the impacts of climate change across the municipality, informing the development of public policies for adaptation and prevention. Developed by the Fortaleza Research and Planning Institute (IPPLAN, Instituto de Pesquisa e Planejamento de Fortaleza) in coordination with several municipal agencies, the system brings together information on apparent temperature, territorial vulnerability, and Civil Defense records, as well as real-time data collected through a network of ten weather stations installed at strategic locations across the city. The Observatory was launched during COP30 as part of the municipality's strategy for addressing extreme events, such as heat waves, fluvial floods, and droughts, and aims to strengthen the response capacity of public authorities, particularly in the most vulnerable areas, while promoting climate justice and evidence-based urban planning.

Key advances made by the project include the establishment of a real-time climate monitoring network, with frequently updated data on temperature, rainfall, and atmospheric variables, enabling greater accuracy in identifying heat islands and managing risks; the strengthening of Civil Defense response capacity, with approximately 1,500 incidents handled in the first half of 2025 alone; and greater integration of information and actions, including progress in the coverage and management of urban drainage channels, which reached approximately 90% in 2025. In terms of lessons learned, the project highlights the importance of interinstitutional coordination and the use of georeferenced data for more effective decision-making, real-time monitoring for rapid disaster response, and the need to prioritize the most vulnerable territories, where climate impacts are more severe. It also emphasizes that solutions based on data and technology, combined with urban planning and international cooperation, are essential for increasing cities' climate resilience.

4.6. Monitoring and evaluation of adaptation actions and processes

This section provides information on the arrangements, approaches, and systems currently being developed in Brazil to monitor and evaluate the implementation of adaptation actions, in accordance with paragraphs 112 to 114 of the MPGs. The information reported reflects progress already made, existing gaps, and next steps for generating evidence on results, effectiveness, increased resilience, and the reduction of climate impacts.

In response to one of the main gaps identified in national climate governance, the Climate Plan includes a Cross-Cutting Strategy for Monitoring, Management, Evaluation, and Transparency (ET-MGAT, Estratégia Transversal de Monitoramento, Gestão, Avaliação e Transparência). The ET-MGAT aims to establish a system for tracking the implementation of the Climate Plan, contributing to intersectoral consistency, climate justice, and greater effectiveness of

91 Available at: https://observatorio.fortaleza.ce.gov.br/riscos-climaticos. Accessed on: Sep. 08, 2026.

adaptation and mitigation actions. The main definitions and guidelines established by the ET-MGAT are described below. The Strategy established processes for governance, frequency, and transparency, in line with other Federal Government planning mechanisms.

4.6.1. Approaches and systems for monitoring and evaluation

Development of the ET-MGAT began in March 2025 with the creation of the Technical Monitoring and Transparency Working Group (TWG) by the CIM Executive Subcommittee (SUBEX, Subcomitê Executivo), and it was approved in March 2026. The drafting process involved the participation of the federal agencies that are members of the Technical Working Group, guests from the scientific community, and specialized technical support, all of which contributed to the technical quality and diversity of perspectives incorporated into the document.

With regard to governance, sectoral ministries are responsible for the monitoring and self-evaluation of the actions under their purview; they are also responsible for establishing their own arrangements for coordination with civil society and the private sector. The Monitoring and Evaluation Subcommittee, in turn, is responsible for facilitating communication among the various stakeholders, supporting the planning and implementation of the Climate Plan's monitoring and evaluation processes, and compiling reports in a standardized format using language that is easily understood. Finally, the Adaptation Subcommittee will monitor the implementation of the Climate Adaptation Plan, providing technical and strategic input for the preparation of the monitoring and evaluation reports.

Another important actor in the monitoring and evaluation of the Climate Plan is the Scientific Advisory Chamber (CAC), whose structure is detailed in **Chapter 1, National context.** The CAC will be responsible for preparing and presenting the Climate Plan Scientific Evaluation Report, which will serve as an input to the CIM and its bodies for the evaluation of the impact of the Climate Plan, while promoting coordination with academic actors to develop proposals concerning the evaluation of the Plan and the need for its updating. The Interfederative Coordination and Social Participation Chambers may also collaborate with representative organizations to develop proposals.

The ET-MGAT establishes three interconnected cycles for tracking the Climate Plan, integrated with government planning instruments, as shown in Dataframe 4.7 (Brasil, 2026e):

Dataframe 4.7 Climate Plan tracking cycles

Annual Monitoring Cycle	Linked to the methodology and processes of the PPA - Multi-year Plan (Plano Plurianual), it involves monitoring, self-evaluation, and review of sectoral actions. Self-evaluation refers to the identification of areas for improvement in the design, governance, and implementation process of sectoral actions, carried out by the sectoral ministries, within the framework of the Adaptation Subcommittee and with support from the CIM's Monitoring and Evaluation Subcommittee. The review will include adjustments to the actions, indicators, and specific targets associated with the actions, with a view to improving them and ensuring they are consistent with the reality of their implementation. At the end of each cycle, the "Annual Climate Plan Monitoring Report" will be prepared.
Biennial Impact Evaluation Cycle	Scheduled to be conducted every two years, this Cycle focuses on the evaluation of sectoral and national adaptation targets and sectoral and national adaptation goals. The causal relationships between the interventions and observed impacts will be investigated through an analytical process to measure and analyze effects and impacts. The evaluation will include the identification of externalities, co-benefits, efficiency, efficacy, and effectiveness from a cross-cutting and multisectoral perspective, with the participation of the CIM chambers. At the end of each Cycle, the "Biennial Climate Plan Impact Evaluation Report" will be prepared.
Four-Year Update Cycle	It will take place every four years, in alignment with the PPA cycles and Brazil's international commitments, such as reporting under the Paris Agreement and updates to the Nationally Determined Contributions (NDCs). This cycle will enable strategic reviews of the Climate Plan based on the evidence generated by monitoring and evaluation. The update is a systemic review aimed at improving the Plan and aligning it with the reality of its implementation, as well as with other government plans and international reports. According to CIM Resolution No. 03/2023, this process shall take place every four years. At the end of each Cycle, the "Climate Plan Update Synthesis Report" will be prepared.

Source: Compiled by the authors.

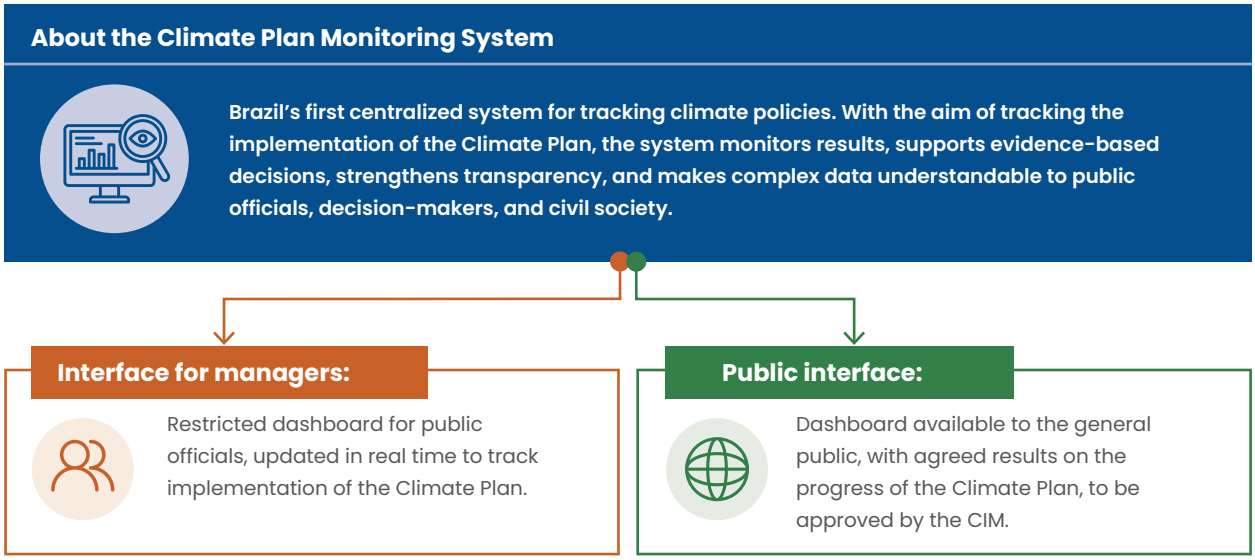
Thus, the **annual monitoring** of the Sectoral and Thematic Plans will inform the sectors' operational decisions; the **biennial impact evaluation** will present cross-sectoral, joint, and cross-cutting analyses, highlighting the plan's progress and areas requiring attention; and the **four-year update** will promote the refinement of the Climate Plan, strengthening its implementation.

The Strategy provides for the development of the *IndicaClima* System — the Climate Plan monitoring and evaluation system (Figure 4.71), which is being developed by the MMA with the goal of establishing a platform for tracking the implementation of the Climate Plan. The system will contain the information collected during the monitoring and evaluation cycles, with data provided by the coordinating bodies for each Sectoral and Thematic Plan. In addition, IndicaClima is expected to integrate with various systems and databases maintained by institutions that generate data, enabling the sharing of data relevant to the monitoring and evaluation of the Climate Plan. The development of this System is integrated with the DataClima+ initiative led by the MCTI.

The system will include a technological tool with an internal interface for managers and an external interface for the general public. It will serve as the Climate Plan's data repository, encompassing the processing, analysis, and dissemination of data and information through

interactive dashboards. The development stages include an initial design, a prototype, a Minimum Viable Product (MVP), followed by further development and interoperability with systems such as DataClima+, AdaptaBrasil, SIRENE - National Emissions Registry System (Sistema de Registro Nacional de Emissões), Sinapse - National Simulator of Sectoral Policies and Emissions (Simulador Nacional de Políticas Setoriais e Emissões, MCTI), and the Integrated Planning and Budget System (SIOP, Sistema Integrado de Planejamento e Orçamento) of the MPO - Ministry of Planning and Budget (Ministério do Planejamento e Orçamento). Climate Plan data are, therefore, expected to be made available in a standardized, interoperable, and periodic manner, thereby facilitating monitoring by society as a whole.

Figure 4.71 Development of the *IndicaClima* System



Source: Brasil, 2026e.

The first "Annual Climate Plan Monitoring Report" will include the collection of baseline and historical data for the indicators associated with the 312 targets and 810 actions set out in the 16 Sectoral and Thematic Plans, considering that several actions included in the Plan relate to public policies already established in Brazil. This initial stage is essential for defining benchmarks and indicators that will make it possible to evaluate the progress of the actions in subsequent years. Data will be collected annually through standardized forms made available to the sectoral ministries, while also seeking to explore integration with the Multi-year Plan (PPA) and make use of information already collected through that process.

In terms of the timeline, the first annual monitoring cycle, including the collection of baseline data, began in July 2026 and will include the preparation of the first monitoring report by the Subcommittees by December 2026.

4.6.2. Definition of indicators

The preparation of the Climate Adaptation Plan was accompanied by capacity-building activities and discussion forums aimed at guiding the sectoral and thematic ministries in defining indicators for their 312 targets and 810 actions. In addition, the process of developing the 12 national adaptation targets (Dataframe 4.8) and their respective indicators included discussions with sectoral government stakeholders and institutions with expertise in working with indicators at the national level, such as the Brazilian Institute of Geography and Statistics (IBGE) and INPE, contributing to a better understanding of the options for tracking progress toward the targets.

Given the broad scope of adaptation, which involves multiple sectors, efforts were made, whenever possible, to use indicators already established in other instruments and supported by well-established data collection systems. The following are the indicators associated with the national adaptation targets included in the National Adaptation Strategy of the Climate Adaptation Plan (Brasil, 2025t). When available, the baselines and measurement criteria are indicated in a footnote. The baselines for the sectoral actions and targets of the Climate Adaptation Plan are expected to be established during the first annual Climate Plan monitoring cycle.

Dataframe 4.8 National adaptation targets and their respective indicators

National Targets	Indicators
By 2035, ensure that all states and at least 35% of Brazilian municipalities have Adaptation Plans.	Number of states and percentage of municipalities with published Adaptation Plans.
By 2035, provide disaster risk prevention infrastructure to at least 4 million people exposed to geohydrological disaster risk.	Number of people benefiting from disaster risk prevention infrastructure and urban drainage and slope stabilization infrastructure.
By 2035, expand vegetation cover in urban areas by 180,000 hectares, prioritizing municipalities at greater climate risk.	Number of hectares of vegetation cover expanded in urban census sectors.
By 2035, reduce to 7.5% the total number of municipalities with the minimum level of water security.	Percentage of municipalities with a minimum level of water security[92].
By 2035, ensure that 100% of the projects for infrastructure works to be supported by the Federal Government consider climate risks.	Percentage of the projects for infrastructure works supported by the Federal Government that consider climate risks[93].
By 2035, reduce, by at least 30%, operational interruptions in federal transport infrastructure caused by climate events.	Percentage of operational interruptions in federal transport infrastructure caused by climate events.

92 Baseline: 13% (2025)

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

National Targets	Indicators
By 2030, expand the extension of Marine Protected Areas to 30%, with specific strategies for climate change included in the management plans.	Percentage of the extension of Marine Protected Areas in the Exclusive Economic Zone (EEZ), including specific strategies for climate change[94].
By 2035, connect 30% of the national territory through ecological corridors between protected areas and Other Effective Area-Based Conservation Measures - OECMs, prioritizing territories at greater climate risk and climate refugia.	Percentage of the national territory connected by ecological corridors[95].
By 2030, expand the adoption of diversified, sustainable and resilient agricultural production systems by 72.68 million hectares.	Number of hectares adopting Sustainable Production Systems, Practices, Products, and Processes (SPSabc, Sistemas, Práticas, Produtos e Processos de Produção Sustentáveis), with the exception of intensive finishing (number of animals) and animal manure management. Number of hectares of family farming units engaged in agroecological farming[96].
By 2035, eradicate severe food and nutrition insecurity.	Number of households with severe food insecurity.
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 to climate change.	Percentage of state departments of health mobilized to adapt the SUS to climate change. Percentage of priority municipal departments of health mobilized and with an assessment of impacts, vulnerabilities and adaptation to climate change in the SUS. Percentage of DSEIs - Special Indigenous Health Districts (Distrito Sanitário Especial Indígena) included in the assessments made by the State Departments of Health.
By 2035, ensure that 100% of power expansion planning takes climate risks into account.	Percentage of power expansion studies and plans that incorporate risk analysis and climate resilience[97].

Source: Brasil, 2025t.

94 Baseline: 26.39% of the Exclusive Economic Zone (EEZ)

95 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).

96 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.

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

4.6.3. Transparency in planning and implementation

Transparency in the planning and implementation of adaptation actions is a key element in ensuring the legitimacy, effectiveness, and democratic governance of the Climate Plan. In the Brazilian context, this principle is supported by a regulatory framework that includes the Federal Constitution, the Access to Information Law (LAI, Lei de Acesso à Informação), the National Policy on Climate Change (PNMC, Política Nacional sobre Mudança do Clima), and international commitments undertaken by the country. Article 225 of the Constitution establishes everyone's right to an ecologically balanced environment, reinforcing the government's duty to promote its protection and ensure access to environmental information. In addition, the Access to Information Law (Law No. 12,527/2011) establishes active and passive transparency obligations, implemented through mechanisms such as the Citizen Information Service (SIC, Serviço de Informação ao Cidadão) and the *Fala.Br* platform, which allow any interested party to request and access public data (Brasil, 2026e).

Within the framework of climate policies, the PNMC reinforces the importance of social participation and the broad dissemination of information as essential conditions for its effectiveness. In line with this national framework, the Paris Agreement, by establishing the Enhanced Transparency Framework (ETF), emphasizes the need for monitoring, reporting, and verification of the progress made in achieving Nationally Determined Contributions (NDCs). The adoption of national and international quality standards, including harmonization with the ETF's Modalities, Procedures, and Guidelines, enables national data to be aligned with the Biennial Transparency Reports (BTRs) and other international obligations. Thus, transparency is strategically incorporated in the national climate planning process, ensuring consistency between international commitments and the implementation of adaptation actions in the country.

In the context of the Climate Plan, transparency is understood in a broader sense, extending beyond the availability of data to encompass the proactive and regular disclosure, in accessible formats, of information on the implementation, results, and impacts of actions. This approach aims to facilitate the tracking and evaluation of the Plan by different stakeholders, including civil society, academia, the private sector, and subnational governments. At the same time, public communication plays an essential role in translating technical content into understandable language, promoting democratic access to information and highlighting shared responsibility for the climate agenda (Brasil, 2026e).

To enable this strategy, the Climate Plan provides for the adoption of structured metadata standards to allow information to be cross-referenced and integrated. Interoperability with existing systems, such as DataClima+, AdaptaBrasil, SIRENE, and SIOP - Integrated Planning and Budget System (Sistema Integrado de Planejamento e Orçamento), is a key element of this effort, contributing to the consolidation of various databases and the enhancement of the analytical robustness of the monitoring and evaluation system. In addition, communication will take place through analytical reports, graphical dashboards, and interactive visualizations, accompanied by explanatory boxes and glossaries of technical terms, fostering climate literacy among the population and seeking to address users' different information needs and levels of knowledge (Brasil, 2026e).

As detailed above, the *IndicaClima* System will bring together information on the monitoring and evaluation of the Climate Plan, with plans for a publicly accessible interface and the publication

of information on the Brazilian Open Data Portal (*Portal Brasileiro de Dados Abertos*)[98], expanding opportunities for access, reuse, and analysis by society. It will also be integrated into DataClima+, a platform developed to strengthen climate transparency in Brazil, in line with compliance with the Paris Agreement. DataClima+, Brazil's National Climate Transparency System, aims to bring together in one place all information related to the climate in the country, such as data on climate risks, public policies, committed targets, and mobilized resources. With a view toward continuous improvement, the platform includes professional training and institutional strengthening, along with increased civil society participation. In addition, there are concerns about data governance and security, with the aim of establishing a reliable and sustainable foundation over time[99].

4.6.4. How adaptation actions influence other development goals

The Climate Adaptation Plan is aligned with national development agendas as part of its strategic framework. Among its guidelines, particular emphasis is placed on promoting sustainable development in its multiple dimensions, considering sectors and themes of strategic importance to the country, with a focus on reducing inequalities, promoting equity, and ensuring just transitions.

Throughout its development process, the Climate Adaptation Plan was aligned with other current development targets and goals in the country, including those defined under the Sustainable Development Goals (SDGs). In this regard, the national adaptation targets (Dataframe 4.8) are directly related to strategic themes present in other government policies and plans, such as the promotion of water and food security, highlighting the cross-cutting nature of the adaptation agenda.

In addition, for each sectoral and thematic action outlined in the Plan, the corresponding targets of the SDGs were identified, thereby establishing an explicit link between the development and adaptation agendas. This approach helps strengthen the consistency of public policies and suggests that progress in implementing the Climate Plan's actions and targets tends to have a positive impact on the achievement of other national development goals.

At the same time, the Climate Plan establishes alignment between public policies, sectoral plans, and budget planning instruments as a strategic pillar, particularly with regard to transparency and communication. To ensure greater effectiveness, this alignment takes into account the Multi-year Plan (PPA) and public and private funding guidelines, strengthening the coordination between climate actions and national development priorities.

In this context, the link between the Climate Plan's targets, the PPA programs, and the financial implementation recorded in the Integrated Planning and Budget System (SIOP) plays a key role. This integration helps ensure the traceability of funds, improve monitoring of the budget allocated to mitigation and adaptation initiatives, and enhance transparency in the management of public investments. Thus, climate adaptation is established not only as an environmental agenda, but also as a foundational component of the country's sustainable development strategies.

98 Available at: https://dados.gov.br/home. Accessed on: Sep. 08, 2026.

99 Available at: https://dataclima.mcti.gov.br/home. Accessed on: Sep. 08, 2026.

4.6.5. Good practices, experiences, and lessons learned from regulatory changes, actions, and coordination mechanisms

In the context of monitoring and evaluation, the development of a specific cross-cutting strategy directly linked to the Climate Plan stands out as a good practice, integrating both adaptation and mitigation. This approach fosters coordination between agendas that have traditionally been addressed separately, promoting greater consistency and effectiveness in the implementation of climate actions.

The establishment of a subcommittee dedicated to monitoring and evaluation enhances intersectoral coordination by involving strategic, cross-cutting agencies, such as the Ministry of Planning and Budget, the Ministry of Science, Technology and Innovation, and the Office of the Chief of Staff, which are responsible for promoting coordination, methodological alignment, and the integration of the tracking of the Climate Plan with other government planning and management instruments. This Monitoring and Evaluation Subcommittee works in conjunction with the Adaptation and Mitigation Subcommittees, which bring together the sectoral agencies responsible for the implementation and tracking of their respective plans. This arrangement strengthens the governance of the Climate Plan, promotes shared responsibility, and contributes to greater consistency in tracking results.

Another aspect considered a good practice is alignment with well-established planning instruments, such as the Multi-year Plan (PPA), which defines targets, priorities, and budget allocation within the Federal Government. Considering that several Climate Plan targets and actions derive from pre-existing policies and plans, it is essential to ensure methodological and indicator alignment with these instruments, thereby ensuring greater consistency, comparability, and efficiency in the evaluation of results.

The pursuit of this alignment from the early stages of the Climate Plan is strategic for promoting the integration of adaptation into foundational public policies. This integration helps reduce redundancies, optimize the use of public resources, and strengthen mechanisms that ensure the sustainability and continuous tracking of adaptation actions.

Finally, the implementation of platforms focused on transparency and tracking of actions, such as *IndicaClima* and *DataClima+,* stands out as a good practice. These tools broaden access to information, strengthen social oversight, and contribute to accountability, while aligning with international commitments and guidelines related to climate change adaptation.

Other elements related to good practices, cooperation, and lessons learned will be presented in section **4.8. Cooperation, good practices, experiences, and lessons learned** of this report.

4.6.6. Effectiveness and sustainability of adaptation measures

Brazil has made progress in establishing the conditions needed to evaluate the effectiveness and sustainability of adaptation actions implemented in its territory. However, there is still limited availability of consolidated and systematized evidence to provide a more robust basis for decision-making. To address this gap, the monitoring and evaluation system being developed under the Climate Plan provides for strengthening structured evaluation processes, with responsibilities and timelines defined for the preparation of analyses.

Unlike the self-evaluation inherent in monitoring, the Climate Plan's biennial evaluation is an analytical process aimed at examining the results and impacts of the policy. In essence, the aim is to determine the extent to which the public policy contributes to addressing the environmental or social issue that prompted its development. Thus, the evaluation focuses directly on the issues of public interest that the Climate Plan seeks to address and is to be conducted in biennial cycles.

In this context, impact assessment plays a central role, as it requires an analysis of the effects produced by the Plan's actions. The guiding question for this process is whether the public policy has been able to solve the problem that gave rise to it. To this end, the effects in relation to the established goals are taken into account, including social and environmental impacts. Given the complexity of this process, the impact assessment will involve additional stakeholders, in addition to the Subcommittees on Adaptation, Mitigation, and Monitoring and Evaluation of the Interministerial Committee on Climate Change (CIM).

Thus, the Scientific Advisory Chamber (CAC) plays a key role in this process, as it is responsible for preparing the "Climate Plan Scientific Evaluation Report." This report will be prepared independently, in accordance with national and international good practices, including those adopted by the IPCC, ensuring that the best available scientific knowledge is incorporated into the analysis of mitigation and adaptation actions. Its results will inform the preparation of the "Climate Plan Government Evaluation Report," helping to improve the evaluation of policy implementation and strengthen the integration of scientific evidence into the decision-making process.

Impact assessment will, therefore, seek, whenever possible, to incorporate socio-environmental analyses guided by the principles of just transition, climate justice, and the fight against environmental racism. To this end, data will be disaggregated by color/race, ethnicity, gender, socioeconomic vulnerability, among other cross-cutting themes, in order to improve our understanding of the impacts and promote greater equity in public policies. One example is the ongoing development of the Gender and Climate Data Initiative, which seeks to develop indicators to evaluate the mainstreaming of gender in Brazilian climate policy, contributing to the implementation of the Climate Plan and the Cross-Cutting Strategy on Women and Climate.

The biennial impact assessment cycle will also make it possible to analyze the Climate Plan from the perspectives of efficiency, efficacy, and effectiveness. With regard to efficiency, the goal is to evaluate whether the resources mobilized were used optimally, with the help of tools such as cost-benefit analysis. Efficacy, in turn, relates to the achievement of the established general and specific goals and is measured through results indicators. Effectiveness, on the other hand, involves a more comprehensive analysis aimed at understanding to what extent the social issue that prompted the Plan was actually addressed, taking into account long-term impacts and more complex causal relationships.

The impact assessment cycle will be structured through a process of methodological agreement between the Adaptation and Mitigation Subcommittees, based on an initial proposal from the Monitoring and Evaluation Subcommittee. In this process, the Scientific Advisory Chamber may submit technical and scientific proposals, while the Social Participation Chamber and the Interfederative Coordination Chamber may make recommendations and proposals aimed at improving the evaluation, taking into account the perspectives of society and of the federative entities. This approach strengthens the legitimacy, technical quality, and comprehensiveness of the evaluation process.

Under the Climate Adaptation Plan, the sectoral and thematic goals, the national adaptation goals, and the national adaptation targets are central elements of the impact assessment, guiding the analysis of the achieved results and impacts.

Finally, the Plan's cross-cutting strategy acknowledges significant limitations associated with the evaluation process. Among these is the difficulty of attributing causality to adaptation actions, as their effects are influenced by multiple external factors. The evaluation of results also presents additional challenges when considering the effectiveness of actions for priority population groups, such as women, Indigenous Peoples, and traditional peoples and communities, requiring approaches capable of capturing not only the aggregate results of adaptation but also its effects on reducing inequalities and strengthening climate justice. The time dimension also poses a significant challenge, given that the desired social and environmental changes may take decades to be fully realized. This is compounded by the fragmentation of available data, resulting from the diversity of topics covered and the existence of multiple systems that are not yet fully interoperable. These challenges underscore the need for continuous improvement of monitoring and evaluation tools in order to strengthen the effectiveness and sustainability of adaptation actions over the long term.

BOX 4.12 STUDIES ON THE IMPACT OF THE CISTERNS PROGRAM

The Cisterns Program is a public policy that has been in place since 2003 with the goal of expanding access to water for human consumption and food production through low-cost social technologies. Its importance is particularly evident in Brazil's Semi-Arid Region, an area historically marked by recurring droughts, high climate vulnerability, and high rates of rural poverty. Given its long history of implementation and availability of data, the program has been the subject of numerous evaluations, serving as an important reference for the development of adaptation actions aimed at addressing the increasing frequency and duration of droughts in different regions of the country.

The available evidence points to significant results in reducing water vulnerability among the beneficiary families. The One Million Cisterns Program (P1MC) had built 1,146,210 cisterns by 2022, enabling families to store enough water for consumption during periods of drought. The impacts on access to water are evident, for example, in the reduction in the time people spend collecting water. Analyses indicate that the proportion of families spending less than 15 minutes per day collecting water increased from 7% to 93% following the installation of cisterns, substantially reducing the time devoted to this activity and increasing the time available for other productive activities (Barreto *et al.*, 2025).

Studies also show consistent results in the health and well-being of the populations served. Based on hospital records, modeling indicates a reduction of between 16% and 34% in hospitalizations due to waterborne diseases among adults and a 37% reduction among children. In addition, evidence indicates a reduction in episodes of diarrhea, improved birth weight, and progress in food security. These benefits were accompanied by greater compliance with the health and education requirements associated with cash transfer programs, demonstrating that safe access to water generates positive impacts that go beyond the water dimension (Gonçalves, 2026; Barreto *et al.*, 2025).

From a socioeconomic perspective, the observed effects indicate a high degree of adaptive effectiveness and the sustainability of the results over time. Over a ten-year

horizon, the families' dependence on cash transfers was reduced by up to 34%, while income from formal employment increased by 20%. The studies also highlight that these effects persist for several years, showing no signs of weakening even after a decade of implementation, which reinforces the policy's foundational role in strengthening resilience to droughts (Barreto *et al.*, 2025).

Another key aspect for the program's effectiveness is its participatory approach (Costa *et al.*, 2026; Gonçalves, 2026): community mobilization and the involvement of families in all stages of cistern construction and management strengthen local leadership, community bonds, and a sense of belonging. This factor of engagement, together with the training of beneficiaries in water management, contributed substantially to the program's success (Gonçalves, 2026). In conjunction with social protection policies, particularly the *Bolsa Família* (Family Allowance) program, the cisterns have increased families' capacity to manage water shortages, helping to keep the populations in their territories and strengthening local socioeconomic resilience. In this context, high rates of immobility were observed among beneficiaries, with no migration occurring in 86% of the households analyzed over a one-year period, reinforcing the program's contribution to adaptation to the adverse conditions of the Semi-Arid Region (Costa *et al.*, 2026).

4.7. Information related to averting, minimizing and addressing loss and damage associated with climate change impacts

Under the United Nations Framework Convention on Climate Change (UNFCCC), the Loss and Damage (with capitalized initials) agenda relates to the adverse impacts of climate change that are not averted through mitigation or fully managed through adaptation. The agenda has become firmly established internationally since the Warsaw International Mechanism (2013) and the Santiago Network (2019), as well as through Article 8 of the Paris Agreement under the UNFCCC (2015), making progress with regard to responses related to averting, minimizing, and addressing these impacts. From an analytical perspective, loss and damage (with lowercase initials) refers to the observed or projected impacts of climate change on human and natural systems and is associated, among other aspects, with residual impacts and limits to adaptation (Mechler *et al.*, 2020; Birkmann *et al.*, 2022).

For the purposes of this report, losses are understood as impacts that are permanent, irreversible, or difficult to recover, while damage refers to significant negative impacts that are potentially repairable, restorable, or recoverable (Lusk, 2017; Möller *et al.*, 2022). This distinction is related to the irreversibility of impacts and the limits to adaptation. Thus, impacts that are initially repairable may, over time, evolve into irreversible losses, especially when they are recurrent or cumulative, produce cascading effects, or exceed the response and adaptation capacity of the affected social and ecological systems (Birkmann *et al.*, 2022; Möller *et al.*, 2022).

Loss and damage may be of an economic or non-economic nature. The economic dimensions encompass impacts on resources, income, goods, and services that are normally traded in markets, including infrastructure, physical assets, agricultural production, fisheries, energy, housing, and other economic flows. Non-economic loss and damage, on the other hand, encompasses dimensions that are not easily quantifiable in monetary terms, such as human lives, physical and mental health, territory, culture, ways of life, Indigenous and traditional knowledge, biodiversity, and ecosystem services (Birkmann *et al.*, 2022). These dimensions are interconnected, and impacts on a given system can trigger indirect, cumulative, and cascading effects on other systems, populations, and territories (Möller *et al.*, 2022).

Such impacts may result from both extreme events and slow-onset processes. Slow-onset processes recognized under the UNFCCC include sea level rise, gradual increase in temperatures, ocean acidification, glacial retreat and its related impacts, salinization, land and forest degradation, biodiversity loss, and desertification. Due to their gradual and cumulative nature, these processes can produce impacts that are difficult to detect, but potentially long-lasting or irreversible, particularly when the limits to adaptation are exceeded[100] (Birkmann *et al.*, 2022; UNFCCC, 2026).

In Brazil, a significant portion of the information available to characterize the effects of extreme events and disasters is produced within the framework of risk and disaster management, based on its own concepts, recording systems, and methodologies. In this context, national records of human and material damage and of public and private losses associated with disasters constitute an important source of evidence for the analysis of loss and damage associated with the impacts of climate change. These records are made available through the S2ID - Integrated Disaster Information System (Sistema Integrado de Informações sobre Desastres) and systematized in the Digital Atlas of Disasters in Brazil (Brasil, 2026a).

The information presented in this section is derived from different methodologies, including administrative disaster records, post-disaster assessments, and prospective modeling-based studies. As these instruments capture different dimensions of the impacts of climate change, their results are not directly comparable. This section provides evidence on observed and potential impacts, as well as information on activities and institutional arrangements related to averting, minimizing, and addressing loss and damage. The understanding of these impacts should be considered together with the assessment of impacts, risks, and vulnerabilities presented in section **4.2.2. Impacts, risks, and vulnerabilities for sectors and themes of strategic importance to Brazil**, organized according to the National Adaptation Goals (NG1 to NG9), which provide the basis for planning measures aimed at reducing climate risks and associated loss and damage.

100 Limits to adaptation: Although adaptation helps reduce climate risks, there are situations in which impacts cannot be completely averted, resulting in residual risks. These limits may be hard (hard limits), when no adaptation actions are capable of averting the impacts, or soft (soft limits), when adaptation solutions exist but are not yet available (UNFCCC, 2026).

4.7.1. Observed and potential impacts of climate change

4.7.1.1. Summary of the main observed impacts recorded in Brazil

Among climate-related extreme events and disasters, those associated with extreme heat and those related to water scarcity or excess affect a significant portion of Brazil's territory.

Heat waves also cause loss and damage to human health, reflected in mortality, the worsening of health conditions, and increased demand for healthcare services. From 2000 to 2019, a national study conducted across 5,566 municipalities estimated approximately 120,000 deaths associated with extreme heat, equivalent to 0.6% of total mortality over the period, excluding deaths from external causes (see section **4.2.2, Impacts, risks, and vulnerabilities for sectors and themes of strategic importance to Brazil**). Of this total, **more than 97,000 deaths occurred among people aged 65 years or older, while approximately 34,000 and 24,000 deaths were attributed to cardiovascular and respiratory diseases, respectively.** The effects were more pronounced among older people and for respiratory causes, and also differed by sex and education level, demonstrating that losses associated with heat waves are influenced by demographic and social vulnerabilities (Brasil, 2026c).

Regarding damage to health and public services, the study analyzed hospital admissions through the Brazilian National Health System in 680 municipalities between 2010 and 2019, identifying an increased risk of hospitalization associated with heat waves for different groups and causes. In the general population, consistent increases were observed for respiratory and genitourinary diseases, while among children under 10 years of age, gastroenteritis had the strongest association across all macro-regions. Among older people, respiratory, renal, and metabolic causes were particularly prominent. These results indicate that **heat waves can worsen health conditions and increase demand for healthcare services, placing pressure on the response capacity of the Brazilian National Health System (SUS) and constituting a dimension of the damage associated with extreme heat** (Brasil, 2026c).

Between 1991 and 2024[101], 4,332 municipalities (77.8%) recorded at least one fluvial flooding event, and 3,662 (65.8%) recorded at least one drought event. Over the same period, 18,006 fluvial flooding events, 31,984 drought events, 7,983 storms, and 1,685 mass movement events were recorded (Escobar-Silva *et al.*, 2026).

Records from the Digital Atlas of Disasters in Brazil for the 2014-2024 period show significant impacts on the population, property, and economic activities associated with hydrological events (surface water flooding events, flash floods, and fluvial flooding events) and mass movements[102]. **Approximately 2.5 million records of human damage were reported,** 95% of which were associated with hydrological events (Figure 4.72). Most involved **displaced people, with approximately 1.75 million records**, and homeless people, with 471,000 records, in addition to 383 confirmed deaths. The figures are cumulative over the period and correspond

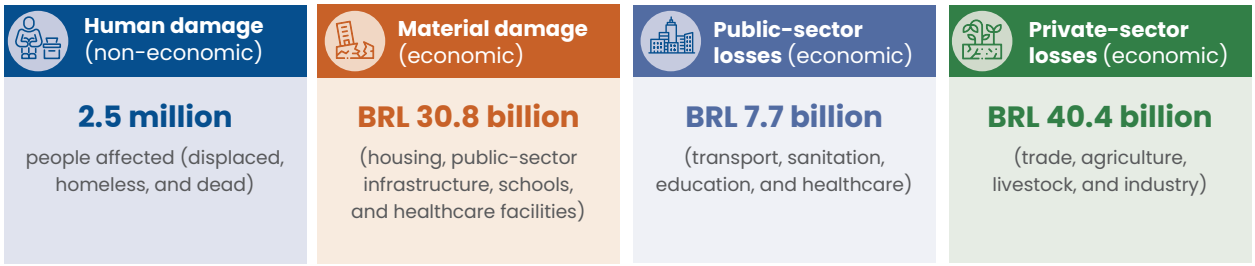
101 These results are based on records from the Integrated Disaster Information System (S2ID) and the Digital Atlas of Disasters in Brazil and should be interpreted taking into account the characteristics of and changes in record coverage over the time series.

102 The recorded and officially recognized events included in the Digital Atlas of Disasters in Brazil that occurred between 2014 and 2024 were considered, encompassing mass movements and hydrological events (surface water flooding events, flash floods, and fluvial flooding events). The Atlas classifies impacts into human damage (HD), material damage (MD), and economic losses (EL), the latter encompassing public and private losses, with aggregations by year, month, status, and type.

to the human damage categories recorded in the database, and, therefore, do not necessarily represent single individuals affected.

Material damage associated with these events totaled approximately BRL 30.8 billion, concentrated mainly in housing units (58%) and public infrastructure facilities (37%). **Economic losses totaled approximately BRL 48 billion**, of which 84% were incurred by the private sector. Within the private sector, losses were highest in trade, at BRL 25.8 billion, and agriculture, at BRL 8.8 billion; among public losses, which totaled approximately BRL 7.7 billion, losses were highest in transport, at BRL 3.7 billion, and sanitation, at BRL 1.8 billion. These results show that the impacts of disasters extend across different dimensions and systems, simultaneously affecting populations, the built environment, infrastructure, and productive activities.

Figure 4.72 Human damage, material damage, and economic losses associated with hydrological events and mass movements in Brazil, 2014-2024



Source: Brasil, 2026a (Atlas).

The administrative disaster records used in this section follow the categories adopted by the Integrated Disaster Information System (S2ID) and the Digital Atlas of Disasters in Brazil. In these systems, human damage refers to people affected, while material damage refers to losses involving buildings, infrastructure, and public facilities; economic losses encompass losses recorded in the public and private sectors. These categories make it possible to characterize the main effects of disasters, but do not fully encompass the dimensions of loss and damage considered in this report, particularly those related to non-economic losses and indirect and long-term impacts.

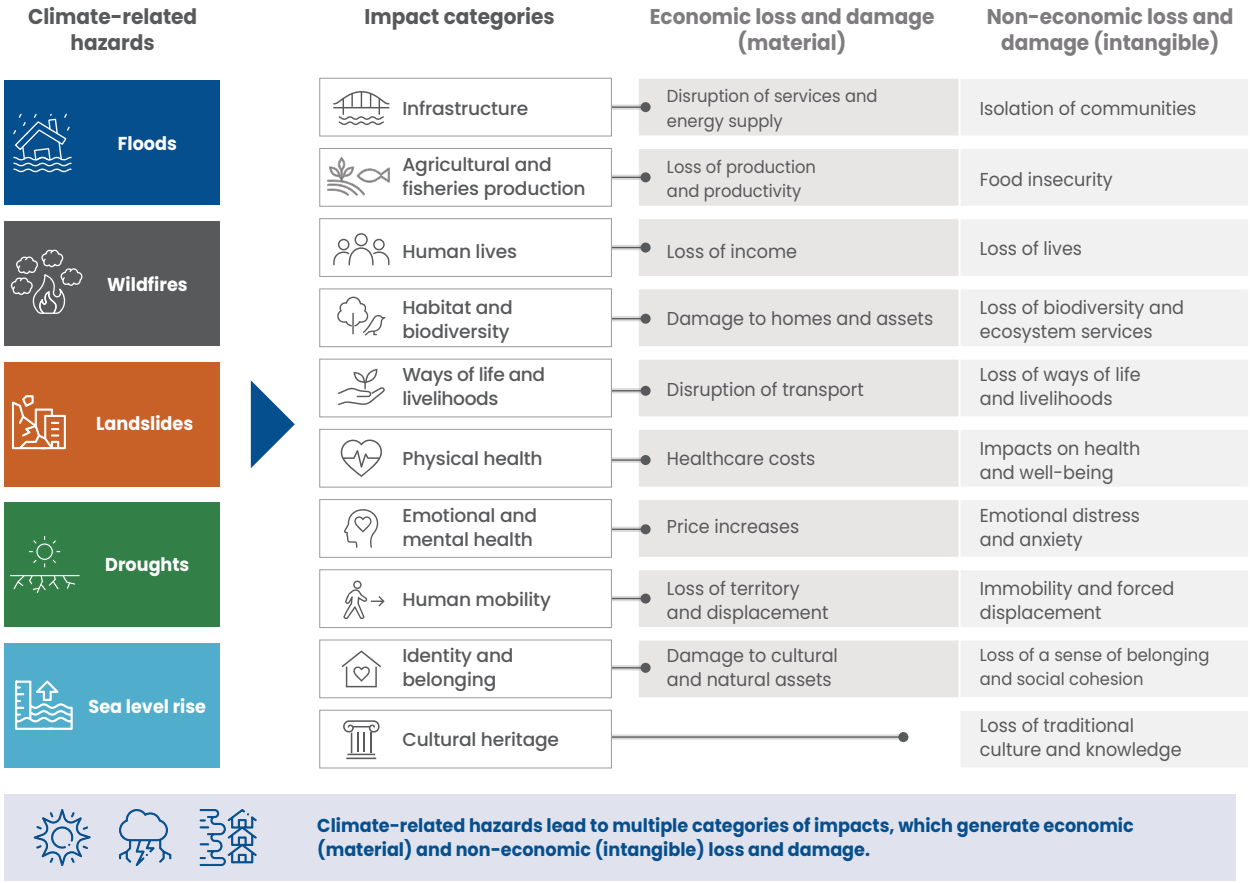
The evidence presented demonstrates that loss and damage associated with climate change in Brazil extends beyond those directly recorded in administrative disaster systems. Although these records provide an important basis for estimating the scale of human and material damage and economic losses, non-economic losses remain less well documented, as do indirect, cumulative, and cascading impacts and those associated with slow-onset processes. The following sections illustrate this multidimensionality through the analysis of the Amazon and the 2024 fluvial flooding events in the state of Rio Grande do Sul.

4.7.1.2. Observed impacts: loss and damage in the Amazon

The Amazon exemplifies the multidimensional nature of the loss and damage associated with climate change. The impacts presented here complement the information on climate risks and vulnerabilities of Amazonian ecosystems discussed in section **4.2.2. Impacts, risks, and vulnerabilities for sectors and themes of strategic importance to Brazil** (**Box 4.5** and **Box 4.7**).

In the region, extreme events such as fluvial flooding events, droughts, and heat waves interact with slow-onset processes and pre-existing socio-environmental pressures, producing impacts on ecosystems, infrastructure, productive activities, health, water and food security, and ways of life (Figure 4.73). These interactions can compromise the adaptive capacity of socioecological systems and result in losses that are difficult to reverse (Birkmann *et al.*, 2022; Pinho *et al.*, 2025a).

Figure 4.73 Loss and damage associated with climate change in the Legal Amazon



Source: Compiled by the authors and adapted from Pinho *et al.*, 2015; Lima et al., 2024; Pinho *et al.*, 2025a; Birkmann et al., 2022; Lapola *et al.*, 2018; Marengo et al., 2024; IOM, 2025.

Fluvial flooding is part of the natural dynamics of Amazonian systems and has historically shaped the productive, economic, and cultural activities and ways of life of the region's populations. However, changes in the frequency and intensity of rainfall have increased the impacts on populations and territories. Evidence gathered indicates an increase in the recurrence of extreme flooding events in recent decades, with effects on housing, infrastructure, production, mobility, and access to essential services, as well as consequences for health, food security, and ways of life (Marengo *et al.*, 2024).

Extreme droughts have also had far-reaching and interdependent impacts. Severe events recorded in 2005, 2010, 2015-2016, and 2023-2024 affected hydrological regimes, river navigability, supply to communities, and various economic activities, while also creating conditions conducive to fires and ecosystem degradation. During the 2023-2024 drought, for example,

the exceptional decline in river levels affected river transport and contributed to the isolation of communities, restrictions on access to water and food, and impacts on aquatic and terrestrial ecosystems (Marengo *et al.*, 2024; Clarke *et al.*, 2024).

The simultaneous or successive occurrence of different extremes amplifies the impacts on the region. Heat waves, droughts, fires, and changes in hydrological regimes can jointly affect human health, food production, water availability and quality, biodiversity, and ecosystem services. Rising water temperatures and reduced oxygen availability can alter community composition and jeopardize species that are sensitive to heat stress, with potential repercussions for fisheries, food security, and ways of life that depend on these systems (Val and Wood, 2022).

In the Amazon, forest degradation, biodiversity loss, fish mortality, the reduced availability of species used for food and medicinal purposes, and the disruption of ecosystem services can have repercussions on income, health, food security, autonomy, cultural and spiritual practices, and the relationship with the territory. For Indigenous Peoples and traditional communities, these interdependencies make the non-economic dimensions of loss and damage particularly relevant, including the loss of knowledge, cultural identity, places of cultural and spiritual value, ways of life, and autonomy, dimensions that are still insufficiently captured by conventional information systems (Birkmann *et al.*, 2022; Pinho *et al.*, 2025a).

4.7.1.3. The 2024 fluvial flooding events in the state of Rio Grande do Sul

Between late April and May 2024, the state of Rio Grande do Sul was hit by heavy, persistent rainfall and widespread fluvial flooding. In some areas, precipitation volumes of up to 300 mm were recorded in a single day (Suárez *et al.*, 2024). The magnitude of the event had an impact on the population, social services, infrastructure, productive activities, and the environment, with repercussions that extended beyond the period during which the flooding events occurred.

The effects and impacts of the disaster were assessed using the *Damage and Loss Assessment* (DaLA) methodology in a study conducted by the Inter-American Development Bank (IDB), the World Bank (WB), and the Economic Commission for Latin America and the Caribbean (ECLAC), in collaboration with national institutions and other United Nations agencies. The DaLA methodology estimates the economic effects of disasters by quantifying damage, losses, and additional costs[103].

The assessment estimated the impact of the fluvial flooding events at approximately BRL 88.9 billion, taking into account damage, losses, and additional costs. Of this total, 46% were attributable to damage, 38% to losses, and 15% to additional costs (Table 4.8). The effects were assessed across four major sectors: social (housing, health, education, culture, and entertainment); infrastructure (transport, electricity, water, and sanitation); production (agriculture, livestock, trade, industry, food, and lodging); and the environment (Suárez *et al.*, 2024).

103 The Damage and Loss Assessment (DaLA) methodology was developed by the Economic Commission for Latin America and the Caribbean (ECLAC) and is widely used by international organizations to estimate the economic effects of disasters. Under the DaLA approach, **damage** corresponds to the monetary value of assets that are totally or partially destroyed or damaged; **losses** refer to the reduction in economic flows resulting from the interruption of the production of goods and provision of services during the recovery period; and **additional costs** comprise extraordinary expenditures required to maintain or restore the provision of goods and services and meet the population's emergency needs. The methodology also estimates impacts on macroeconomic variables. These categories are specific to the DaLA methodology and do not directly correspond to the conceptual categories of loss and damage adopted in this report, which also encompass non-economic dimensions and long-term effects.

Table 4.8 Breakdown of the effects of the 2024 fluvial flooding events in the state of Rio Grande do Sul by damage, losses, and additional costs, and by sector (BRL thousand)

Sector	Damage	Losses	Additional costs	Total
Social	11,605,088	1,033,007	6,405,756	19,043,851
Infrastructure	4,449,312	1,013,196	1,538,109	7,000,617
Productive	25,222,141	30,474,606	5,537,702	61,234,449
Environment	11,836	1,585,882	—	1,597,718
Total	**41,288,377**	**34,106,691**	**13,481,567**	**88,876,635**

Source: Suárez *et al.*, 2024.

The results show that the effects of the disaster went beyond the immediate physical damage, simultaneously affecting assets, economic activities, service provision, and the population's living conditions.

In addition to the economic impacts, the disaster had significant consequences for the population, including displacement, disruption of essential services, and a deterioration in living conditions across much of the state. The breakdown of the effects highlights the extent of the disaster's consequences and the interdependencies among the affected systems. The productive sector experienced a significant share of the estimated effects, while damage to infrastructure compromised services and flows essential to economic and social recovery. In the transport sector, for example, the effects were estimated at BRL 4 billion, of which approximately BRL 3 billion corresponded to damage to assets, BRL 378 million to losses, and BRL 764 million to additional costs (Suárez *et al.*, 2024).

Although the DaLA assessment provides a comprehensive estimate of the economic effects and their macroeconomic repercussions, its results represent an important, but not exhaustive, dimension of the loss and damage associated with the event. Aspects related to non-economic losses, distributional impacts, and long-term effects remain less well documented, highlighting the importance of strengthening information systems, methodologies, and indicators for monitoring these dimensions. The event also illustrates the importance of integration among adaptation, risk management, and disaster response, as discussed in sections **4.7.2. Activities related to averting, minimizing and addressing loss and damage** and **4.7.3. Institutional arrangements related to averting, minimizing and addressing loss and damage**.

4.7.1.4. Potential impacts

Climate projections indicate that the intensification of global warming tends to increase the frequency, intensity, and duration of various extreme events and slow-onset processes, thereby increasing the potential for the occurrence of loss and damage in Brazil. The magnitude of these impacts will depend, among other factors, on future greenhouse gas emissions pathways, the exposure and vulnerability characteristics of natural and human systems, and the effectiveness of the adaptation measures implemented (IPCC, 2022).

In the Amazon, projections indicate an increase in the frequency and intensity of extreme droughts, heat waves, wildfires, and changes in hydrological regimes, with potential

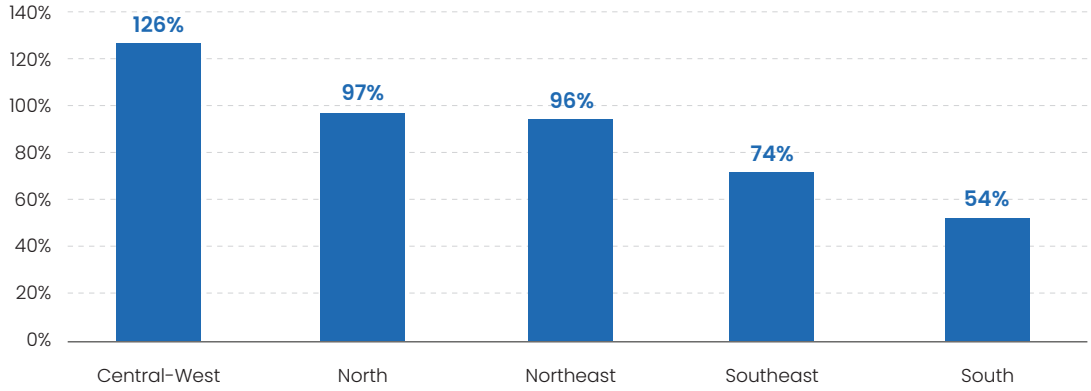
repercussions on ecosystem stability, water availability, biodiversity, food security, human health, and the ways of life of local populations (Marengo *et al.*, 2024; Brondizio, 2025; Pinho *et al.*, 2025a). These processes can simultaneously compromise different dimensions of the Amazon's socioecological systems.

In addition to the directly observable economic impacts, these processes have the potential to exacerbate non-economic losses that are difficult to reverse, including ecosystem degradation, biodiversity loss, changes in ecosystem services, reduced availability of fishery resources, the erosion of traditional knowledge, changes in cultural and spiritual practices, and impacts on the territorial identity of Indigenous Peoples and traditional communities. In situations where extreme events recur or environmental degradation processes persist, such impacts may exceed the limits to adaptation and become permanent or irreversible (Birkmann *et al.*, 2022; Möller *et al.*, 2022; Pinho *et al.*, 2025a, 2025b).

These projected physical impacts also tend to have significant economic repercussions at the national level. The "Strategic Study of the Economic Impacts of Climate Change in Brazil (Brazil 2050 Strategy)" assessed the economic effects associated with different climate scenarios by integrating climate projections, biophysical models, and a computable general equilibrium model, making it possible to estimate the macroeconomic impacts of climate change under different global warming pathways (Brasil, 2025v).

The results indicate that, if global warming reaches approximately 4°C by the end of the century, the cumulative impact of global climate inaction on Brazil's GDP could range from BRL 10.3 trillion to BRL 17.1 trillion by 2050, compared to scenarios consistent with the 2°C and 1.5°C warming thresholds set forth in the Paris Agreement (Brasil, 2025v). The projections also point to a decline in economic activity, impacts on the labor market, rising food prices, a decline in agricultural productivity, restrictions on access to water, and widening regional inequalities in the distribution of the economic impacts of climate change. The Central-West, North, and Northeast regions are more sensitive to scenarios involving greater warming (Figure 4.74), reflecting relatively more significant impacts on their economies and productive sectors (Brasil, 2025v).

Figure 4.74 Impact of the cumulative cost of inaction (4°C vs. 1.5°C) on projected 2050 GDP by macro-region (%)



Source: Brasil, 2025v.

The study emphasizes, however, that these estimates represent modeling results dependent on the climate scenarios and assumptions adopted, as impacts associated with higher-warming scenarios, nonlinear processes, and various non-economic losses may be underestimated or not fully represented (Brasil, 2025v).

Taken together, this evidence indicates that intensifying climate change is likely to increase not only the magnitude of economic losses but also the occurrence of non-economic loss and damage, which is often irreversible and insufficiently captured by conventional monitoring systems. The projections reinforce the importance of incorporating prospective assessments of loss and damage into adaptation planning, as well as of strengthening national monitoring and evaluation systems to inform public policies aimed at averting, minimizing, and addressing their impacts.

4.7.2. Activities related to averting, minimizing and addressing loss and damage

As previously outlined, the Climate Adaptation Plan brings together actions aimed at strengthening the resilience of the various human and natural systems. Although loss and damage has not been explicitly addressed in the Sectoral and Thematic Climate Plans, several actions outlined in these instruments contribute to averting, minimizing, or addressing loss and damage associated with the impacts of climate change.

To that end, a preliminary survey of the targets and actions outlined in the Sectoral and Thematic Climate Plans that have the potential to contribute to averting, minimizing and addressing loss and damage was conducted. This analysis refers to the actions planned or currently being implemented which are set forth in these instruments and does not constitute an assessment of their implementation or effectiveness.

The survey was conducted in accordance with Article 8 of the Paris Agreement and item 115(b) of the Modalities, Procedures, and Guidelines (MPGs) for the Enhanced Transparency Framework. As a complementary methodological reference, the conceptual frameworks of the international loss and damage agenda were considered, including Decision 1/CP.16, the Warsaw International Mechanism for Loss and Damage (WIM), established by Decision 2/CP.19, and the document *Compendium on Comprehensive Risk Management Approaches*, prepared by the WIM Executive Committee. These frameworks informed the organization of the Plan's actions according to their main contribution to averting, minimizing, and addressing loss and damage associated with the impacts of climate change.

Based on this framework, the actions were grouped into six analytical categories:

i. knowledge, assessment, and monitoring of loss and damage;
ii. reduction of loss and damage through adaptation and risk management;
iii. financial protection and risk transfer;
iv. financing and risk retention mechanisms;
v. resilient recovery and transformational approaches; and
vi. governance and an enabling institutional environment.

This framework demonstrates how different sectoral policies contribute, in complementary ways, to strengthening national capacity to avert, minimize, and address loss and damage

associated with the impacts of climate change, without implying that each action is limited to a single category or that this classification is officially adopted by the respective Plans (Dataframe 4.9) (see section **4.4. Adaptation strategies, policies, plans, goals and actions to integrate adaptation into national policies and strategies**).

Dataframe 4.9 Preliminary survey of actions in the Sectoral and Thematic Climate Plans related to averting, minimizing, and addressing loss and damage, organized according to analytical categories inspired by the Warsaw International Mechanism (WIM)

Sectoral/thematic plan	PLAN'S ACTION	Analytical categories inspired by the Warsaw International Mechanism					
		(i)	(ii)	(iii)	(iv)	(v)	(vi)
Cities	Securitization strategy and financial compensation mechanisms for urban infrastructure		●	●		●	
Risk and Disaster Reduction and Management	Improve the provision of resources for response				●	●	●
	Integration of S2iD[104] with *TransfereGov*[105]	●			●		●
	Improve the S2iD Federal Recognition module	●			●		●
	Provision of resources for recovery				●	●	●
	Transfer of funds for reconstruction, environmental restoration and economic recovery		●		●	●	●
	Networks for cultural heritage recovery		●			●	●
	Capacity-building for survey of damage	●					●
Transport	Restoration of waterway infrastructure		●			●	
	Restoration, maintenance, and operation of IP4[106]		●			●	

104 S2iD: Integrated Disaster Information System.

105 *TransfereGov*: An integrated and centralized tool with open data, designed to support the digital processing and operational management of transfers of funds from the Federal Government's Fiscal and Social Security Budgets to bodies or entities of state, Federal District, or municipal public administrations, whether direct or indirect, as well as to public consortia and private nonprofit entities.

106 IP4: Small Public Port Facilities (IP4) are strategic facilities intended for the movement of passengers, cargo, or both, and are characterized by being exclusively dedicated to inland navigation (rivers, lakes, and other inland waterways).

Sectoral/thematic plan	PLAN'S ACTION	Analytical categories inspired by the Warsaw International Mechanism					
		(i)	(ii)	(iii)	(iv)	(v)	(vi)
Agriculture and livestock	Rural Insurance Premium Subsidy Program[107]		●	●			
Family farming	Restoration of settlement infrastructure		●			●	
	Garantia-Safra[108]		●	●	●	●	
Water resources	Assessment of loss and damage resulting from extreme events	●	●				●
Health	Tool for recording impacts and assessing damage	●					●
	Estimates of the costs of non-adaptation	●	●		●		
Traditional peoples and communities	Climate Emergency Insurance/ Climate Support Allowance[109]		●	●	●	●	

Source: Prepared by the authors, based on the Sectoral and Thematic Plans for Cities, Risk and Disaster Reduction and Management, Transport, Agriculture and Livestock, Family Farming, Water Resources, Health, and Traditional Peoples and Communities[110].

The analysis shows that the Sectoral and Thematic Climate Plans contain a comprehensive set of actions that contribute to averting, minimizing, and addressing loss and damage associated with the impacts of climate change, even though this agenda is not explicitly structured within these instruments.

The survey indicates a greater concentration of actions aimed at strengthening response and recovery, producing information on damage and losses, and enhancing financial protection mechanisms, while instruments related to risk retention and transformational approaches are less prevalent. This pattern suggests that national adaptation instruments contribute to the loss and damage agenda primarily by strengthening adaptation, risk management, and civil protection and defense policies.

The survey focused on the actions set out in the Sectoral and Thematic Climate Plans and, therefore, does not cover other national policies, programs, and instruments related to averting, minimizing, and addressing loss and damage. Nevertheless, the results show that the Climate

107 Rural Insurance Premium Subsidy Program (PSR): A federal government instrument designed to subsidize rural insurance premiums, with the aim of expanding producers' access to agricultural insurance.

108 Garantia-Safra: A federal government social program linked to Pronaf - National Program for Strengthening Family Farming (Programa Nacional de Fortalecimento da Agricultura Familiar, a Brazilian federal government program that provides low-interest rural credit), which guarantees a minimum income to family farmers who lose their crops due to drought or excessive rainfall.

109 Climate Emergency Insurance/Climate Support Allowance: to be created.

110 The survey presented here is preliminary and non-exhaustive, and is based on the actions outlined in the Sectoral and Thematic Climate Plans. The classification of the actions was developed specifically for analytical purposes in this BTR2, and the respective Plans did not present these actions as contributing to averting, minimizing, and addressing loss and damage. A single action can contribute to more than one analytical category at the same time.

Plan brings together a set of actions capable of strengthening this agenda, highlighting the contribution of national adaptation instruments to reducing the impacts of climate change.

4.7.3. Institutional arrangements related to averting, minimizing and addressing loss and damage

Building on the previous sections, efforts to avert, minimize, and address loss and damage associated with the impacts of climate change in Brazil are supported by public policies, institutions, information systems, planning instruments, and coordination mechanisms that operate in complementary ways across sectors and levels of government. National action is not centered on a specific loss and damage system, but rather on an institutional architecture that brings together climate policy, adaptation, risk and disaster management, sectoral systems, and technical and scientific knowledge. This approach is consistent with the evolution of the international agenda, which emphasizes strengthening governance, risk management, and coordination to address these impacts (Hasse and Serra, 2025).

For analytical purposes, the main institutional mechanisms related to averting, minimizing, and addressing loss and damage can be organized into four complementary components: (i) governance and intersectoral coordination; (ii) risk management, knowledge production, and monitoring systems; (iii) implementation of sectoral adaptation instruments; and (iv) response, recovery, and financial protection mechanisms. This organizational framework was developed specifically for this report, based on an integrated analysis of the Sectoral and Thematic Climate Plans and on technical literature on loss and damage, and does not correspond to the formal structure of these instruments (Brasil, 2025a, 2025j; Hasse and Serra, 2025).

Governance and intersectoral coordination

Climate change adaptation governance is supported by interministerial coordination mechanisms, participatory processes, and instruments for coordinating public policies, such as the National Civil Protection and Defense Policy (PNPDEC, Política Nacional de Proteção e Defesa Civil) and the National System for Civil Protection and Defense (SINPDEC). The National Adaptation Strategy (ENA, Estratégia Nacional de Adaptação) establishes the reduction of climate risks and the minimization of loss and damage as one of its premises, while the National Plan for Civil Protection and Defense (PN-PDC, Plano Nacional de Proteção e Defesa Civil) guides prevention, mitigation, preparedness, response, and recovery actions in the face of emergency climate impacts (Brasil, 2025c, 2025t). Efforts were also made to mainstream gender through the development of the Women and Climate Emergencies Protocol: Guidelines and recommendations for the protection of rights in risk management and disaster response, a guidance instrument intended to integrate a gender perspective into policies and actions for risk management and disaster response associated with climate emergencies.

The Sectoral Plan for Risk and Disaster Reduction and Management reinforces this institutional framework by integrating civil protection and defense actions into the Climate Adaptation Plan and recognizing their cross-cutting nature in relation to the other sectoral plans. The planned measures include strengthening the institutional capacity of the National Secretariat for Civil Protection and Defense, establishing permanent technical and scientific bodies, and expanding partnerships among public agencies, research institutions, civil society, and international organizations. The National Plan for Civil Protection and Defense (PN-PDC 2025-

2035) complements this framework by guiding the coordinated action of SINPDEC across the areas of prevention, mitigation, preparedness, response, and recovery (Brasil, 2025c, 2025u).

Risk management, knowledge production, and monitoring systems

Climate risk management in Brazil is supported by institutional arrangements that link monitoring and early warning systems for ongoing events with instruments for knowledge production and the assessment of future climate risks.

Under the National Civil Protection and Defense Policy, SINPDEC coordinates the agencies responsible for risk and disaster management across different levels of government. The PN-PDC 2025-2035 and the Sectoral Plan for Risk and Disaster Reduction and Management strengthen this arrangement through the National Disaster Information and Monitoring System, the integration of the Integrated Disaster Information System (S2iD), and other monitoring systems.

The standardization of warning protocols and coordination among institutions responsible for hydrological, meteorological, geological, and environmental monitoring are also essential to this system. In this context, the National Center for Monitoring and Early Warnings of Natural Disasters (Cemaden/MCTI) plays a strategic role in monitoring geological, hydrological, and drought risks and issuing early warnings to support prevention, preparedness, and response actions (Brasil, 2025c, 2025u).

To support adaptation planning, the National Adaptation Strategy establishes mechanisms for knowledge management, monitoring, evaluation, and transparency. In this context, the AdaptaBrasil MCTI platform (see **section 4.2.3.4, AdaptaBrasil MCTI: *methodology adopted in risk assessment by strategic sector***) is a national instrument for assessing current and future climate risks, providing information on hazards, exposure, and vulnerability for all Brazilian municipalities, and supporting the formulation, implementation, and monitoring of public adaptation policies (Brasil, 2025t).

Implementation of sectoral adaptation instruments

The Sectoral and Thematic Plans of the Climate Adaptation Plan establish goals, targets, actions, institutional responsibilities, and monitoring and evaluation mechanisms, promoting the integration of adaptation into national public policy planning (Brasil, 2025t).

Although they were not designed specifically for the loss and damage agenda, sectoral adaptation instruments contribute directly to averting and minimizing loss and damage by reducing exposure and vulnerability and strengthening the adaptive capacity of natural, productive, and social systems. The measures include, among others, actions related to water security, agriculture and food security, health, infrastructure, cities, biodiversity, the ocean and coastal zone, energy, transport, industry and mining, and Indigenous Peoples and traditional peoples and communities, thus reflecting the cross-cutting nature of adaptation and its integration into sustainable development policies (Brasil, 2025s, 2025t).

The monitoring and evaluation provided for in these instruments make it possible to track the progress of actions, incorporate new scientific evidence and lessons learned into the iterative adaptation cycle, and support the continuous improvement of public policies aimed at reducing climate risks and the associated loss and damage.

Response, recovery, and financial protection mechanisms

In the financial sphere, Brazilian law provides for instruments to support prevention, response, and recovery actions in disaster-affected areas, including mechanisms for the mandatory transfer of funds from the Federal government to state and local governments and the National Fund for Public Disasters, Civil Protection and Defense (Funcap, Fundo Nacional para Calamidades Públicas, Proteção e Defesa Civil), in accordance with current legislation. The Sectoral Plan for Risk and Disaster Reduction and Management also provides for strengthening the financing framework for risk reduction and management by expanding public and private financing mechanisms and establishing national and international partnerships aimed at strengthening climate resilience (Brasil, 2025u).

Although the country does not yet have a specific financial mechanism dedicated to loss and damage, existing instruments are aimed at financing prevention, preparedness, response, and recovery actions, being part of Brazil's institutional framework for addressing the impacts of climate change. These include, among others, the National Fund for Public Disasters, Civil Protection and Defense (Funcap), intended to support disaster-related prevention, response, and recovery actions; the National Climate Change Fund (Climate Fund), which supports mitigation and adaptation projects, including disaster risk reduction initiatives; and agricultural risk management mechanisms, such as the Rural Insurance Premium Subsidy Program (PSR, Programa de Subvenção ao Prêmio do Seguro Rural), *Proagro* - Agricultural Activity Guarantee Program (Programa de Garantia da Atividade Agropecuária), and *Garantia-Safra*. These instruments contribute to reducing exposure, supporting responses to extreme events, and enabling the recovery of affected populations, territories, and activities.

The response to the fluvial flooding events in Rio Grande do Sul in 2024 also highlighted the importance of mechanisms to protect income and employment in the face of extreme weather events. At the time, resources and instruments were mobilized for affected workers, including disaster withdrawals (*saque calamidade*) from the Severance Pay Fund (FGTS, Fundo de Garantia do Tempo de Serviço), additional unemployment insurance installments, and early payment of the salary bonus, using resources from the Workers' Support Fund (FAT, Fundo de Amparo ao Trabalhador) and the FGTS. These measures helped expand financial protection for those affected and support the maintenance of living conditions during the emergency and recovery period.

4.8. Cooperation, good practices, experiences, and lessons learned

Various initiatives, partnerships, and institutional mechanisms have recently been strengthened, improved, or developed to support Brazil's climate change adaptation agenda, complementing and updating those reported in the First Biennial Transparency Report (BTR1). Compared with BTR1, which reported nine initiatives related to scientific networks, information systems, international cooperation, science and technology, and early warning, BTR2 updates these initiatives and incorporates new ones focused on data governance, land-use planning, climate justice, food systems, communities of practice, and the integration of adaptation into sectoral and subnational public policies. These initiatives range from scientific networks and

knowledge synthesis initiatives to public planning instruments, capacity-building mechanisms, communities of practice, and private-sector initiatives (Dataframe 4.10, Dataframe 4.11, Dataframe 4.12, Dataframe 4.13). Together, they contribute to increasing the availability of information, strengthening institutional capacities, and supporting the implementation of adaptation actions across different levels and sectors.

The initiatives presented below constitute non-exhaustive examples of initiatives that have been contributing to advancing adaptation in the country. Many of these initiatives also support the implementation of the Climate Adaptation Plan and the strengthening of the capacities needed for planning, implementation, monitoring, and learning in the area of adaptation. In addition to promoting the development of tools, systems, networks, and projects, these measures provide relevant lessons on institutional cooperation, knowledge production and integration, social participation, and the adoption of solutions aimed at reducing vulnerabilities and increasing climate resilience.

Initiatives related to the production, integration, synthesis, and dissemination of knowledge demonstrate that adaptation is strengthened when research, evidence generation, and decision-making processes are developed in an integrated manner. In addition to increasing the availability of and access to relevant information, these initiatives demonstrate the value of institutional cooperation, knowledge co-production, and capacity-building as essential elements for supporting the planning, implementation, and continuous improvement of adaptation actions (Dataframe 4.10).

Dataframe 4.10 Scientific networks, research, knowledge co-production, and synthesis

Initiative	Brief description	Good practice or lesson learned
Brazilian Research Network on Global Climate Change (Rede Clima, Rede Brasileira de Pesquisas sobre Mudanças Climáticas Globais)[111]	The Brazilian Research Network on Global Climate Change (*Rede Clima*), established under the National Policy on Climate Change (PNMC), brings together research institutions and experts from various fields to produce and integrate scientific evidence on climate change. *Rede Clima* conducts analyses of the state of knowledge on climate change in Brazil and thematic and sectoral studies that inform public policymaking and contribute to national and international processes related to climate change adaptation and mitigation (see section **7.2.6. Research, technological development, innovation, and technical and scientific cooperation**).	The initiative demonstrates the importance of collaborative research networks for integrating knowledge from different fields, strengthening scientific capacities, and supporting evidence-based decision-making processes. Coordination among researchers, institutions, and policymakers helps increase the relevance and applicability of scientific knowledge to the climate agenda.

111 Available at: https://redeclima.cemaden.gov.br. Accessed on: Sep. 04, 2024.

Initiative	Brief description	Good practice or lesson learned
Synthesis Center on Environmental and Climate Change (SIMAClim, Centro de Síntese em Mudanças Ambientais e Climáticas)[112]	Launched in 2024, SIMAClim integrates data, evidence, and scientific information to contribute more rapidly to the formulation of public policies related to climate change in Brazil. Its outputs include synthesis reports designed to consolidate scientific knowledge and support decision-making processes on strategic themes related to climate change and its impacts (see section **7.2.6, Research, technological development, innovation, and technical and scientific cooperation**).	Research focused on knowledge synthesis has a strong co-production component, involving a wide range of actors from academic and non-academic communities, as well as decision-makers from the public and private sectors. Synthesis reports represent a good practice by translating complex scientific knowledge into more accessible and applicable outputs, strengthening the science-policy interface and supporting evidence-based decision-making processes. Reports have been published on the tipping point of the Amazon rainforest system; coral bleaching and climate change; the potential of mangrove forests for climate action; and resilient green-blue cities, which provided input for the development of section **4.2. Impacts, risks, and vulnerabilities** of this Report.
MONAN Mathematical Model[113]	MONAN (Model for Ocean-laNd-Atmosphere PredictioN) is a community-based Unified Earth System model developed collaboratively by universities, research centers, operational institutions, and other national and international organizations. The initiative seeks to improve weather, climate, and environmental forecasting for the tropical and subtropical conditions of Brazil and South America, strengthening integration across different fields of knowledge and promoting the joint development of scientific and technological capacities. The MONAN Model is managed by a scientific committee appointed by the director of INPE.	The name "MONAN" was also inspired by ancestral heritage, as in Tupi-Guarani culture it means "land without evil." The initiative demonstrates the importance of scientific cooperation and collaborative capacity-building for the development of tools to support climate adaptation. Coordination among different institutions and fields of knowledge contributes to the continuous improvement of models and forecasts, strengthening the production of information that supports risk identification and decision-making.

112 Available at: https://simaclim.com.br. Accessed on: Sep. 04, 2024.

113 Available at: https://monanadmin.github.io. Accessed on: Sep. 04, 2024.

Initiative	Brief description	Good practice or lesson learned
Investment in Science and Technology[114]	The Ministry of Science, Technology and Innovation (MCTI), primarily through the National Fund for Scientific and Technological Development (FNDCT, Fundo Nacional de Desenvolvimento Científico e Tecnológico), the Agency for the Financing of Studies and Projects (Finep, Financiadora de Estudos e Projetos), and the National Council for Scientific and Technological Development (CNPq), promotes scientific and technological development related to climate change adaptation. This support fosters the development of technologies, methodologies, resilience strategies, and inputs for public policies, particularly through collaboration among the scientific community, governments, and society. A similar role is played by the State Research Support Foundations, particularly the investments made by FAPESP – São Paulo State Research Foundation (Fundação de Amparo à Pesquisa do Estado de São Paulo) in the state of São Paulo.	Targeted funding mechanisms can stimulate the production of applied knowledge, strengthen scientific capacities in historically underfunded regions, and promote greater alignment between research, national priorities, and adaptation needs. The practices adopted include the allocation of FNDCT resources to women researchers and institutions in the North and Northeast regions, support for the National Institutes of Science and Technology (INCTs, Institutos Nacionais de Ciência e Tecnologia), international cooperation initiatives such as the BRICS-STI partnership, and thematic calls for proposals focused on strategic themes, such as health and climate change and the *Pró-Amazônia* Program (see section **7.1.1 Institutional arrangement for meteorological research and observation in Brazil**).
AdaptAÇÃO Project – Ministry of Cities (MCID), Federal University of Rio de Janeiro (UFRJ), and *Observatório das Metrópoles*[115]	The *AdaptAÇÃO* Project is the result of a partnership between the Ministry of Cities (MCID) and the Federal University of Rio de Janeiro (UFRJ), through the Institute for Research and Urban and Regional Planning (IPPUR, Instituto de Pesquisa e Planejamento Urbano e Regional) and *Observatório das Metrópoles* (the latter being an INCT). The initiative seeks to integrate climate change adaptation strategies into urban policies by supporting municipal technical teams, civil society, and the academic community through the development of methodologies, indicators, tools, and capacity-building processes focused on resilient urban planning (see section **7.2.5 Vocational training and institutional capacity-building**).	This initiative demonstrates the importance of knowledge co-production among universities, technical institutions, public officials, and civil society in strengthening climate adaptation. The integration of research, capacity-building, and practical application in urban policies helps bring science and decision-making closer together, strengthen local capacities, and expand the use of evidence in land use planning. Key results include the establishment of the Network for the Evaluation of Urban Policy and Climate Adaptation Instruments (AIPUAC, Rede de Avaliação dos Instrumentos de Política Urbana e Adaptação Climática), the organization of local workshops, and the creation of forums for exchange between researchers and public policymakers.

114 CNPq – National Council for Scientific and Technological Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico) – calls for proposals. Available at: http://memoria2.cnpq.br/web/guest/chamadas-publicas. Accessed on: May 28, 2026.

115 Available at: https://www.gov.br/cidades/pt-br/acesso-a-informacao/acoes-e-programas/desenvolvimento-urbano-e-metropolitano/projeto-adaptacao. Accessed on Jun. 03, 2026.

Initiative	Brief description	Good practice or lesson learned
MetaFavela – Center for *Favela* Studies (CEFAVELA, Centro de Estudos da Favela/UFABC - Federal University of ABC (Universidade Federal do ABC))[116]	A platform developed by the Center for *Favela* Studies (CEFAVELA) of FAPESP's Center for Research, Innovation, and Dissemination (CEPID, Centro de Pesquisa, Inovação e Difusão), located at the Federal University of ABC (UFABC), aimed at expanding access to data and knowledge about Brazilian *favelas*. The initiative compiles and organizes metadata on open data produced by different institutions and organizations, making them available through a catalog and interactive map and facilitating their identification, understanding, and use.	The initiative demonstrates the potential of integrating and democratizing data produced by different stakeholders to expand knowledge about territories historically marked by gaps and fragmentation in information. By compiling and increasing the visibility of data produced by public institutions, universities, civil society organizations, and territorial organizations, the platform broadens access to information and facilitates its use in research and public policies. The opportunity for different data producers to contribute also helps build a more diverse knowledge base about Brazilian *favelas*.
Health Synthesis Center (Centro de Síntese em Saúde): Climate Change, Biodiversity, and Pollution – Fiocruz[117]	An initiative of the Oswaldo Cruz Foundation (Fiocruz) aimed at systematizing and synthesizing scientific evidence on the interactions between climate change, biodiversity loss, pollution, and health. The Center seeks to strengthen the production of integrated knowledge and provide relevant evidence to inform public policy and decision-making processes.	The initiative highlights the importance of knowledge synthesis in integrating evidence produced across different fields and making it more understandable and applicable to decision-making. The integrated approach to climate, biodiversity, pollution, and health helps overcome fragmented analyses and strengthen understanding of the multiple interactions between environmental changes and their effects on health.
Community-Based Sanitation and Health Surveillance Network (RVPSS, Rede de Vigilância Popular em Saneamento e Saúde) – Fiocruz and partner institutions[118]	The Community-Based Sanitation and Health Surveillance Network (RVPSS) brings together research institutions, social movements, community organizations, and other actors working to strengthen the human right to water and sanitation. The initiative undertakes activities involving community mobilization, active listening, training, data production and analysis, participation in governance bodies, and monitoring of sanitation services. Among the strategies used are public consultations, participatory processes, capacity-building activities, and engagement with monitoring committees and other social participation forums.	The initiative demonstrates the importance of knowledge co-production, community-based surveillance, and social participation in strengthening public policies and enhancing the transparency and monitoring of services. The use of participatory mechanisms for data production and use represents a good practice by bringing technical knowledge and local experience closer together, strengthening more inclusive and territory-oriented decision-making processes.

116 Available at: https://metafavela.pesquisa.ufabc.edu.br/catalogo/. Accessed on Jul. 16, 2026.

117 Available at: https://fiocruz.br/programa/centro-de-sintese-em-saude-mudanca-do-clima-biodiversidade-e-poluicao. Accessed on: Jul. 16, 2026.

118 Available at: https://informe.ensp.fiocruz.br/secoes/secao/45098. Accessed on: May 29, 2026.

Initiative	Brief description	Good practice or lesson learned
Climate and Health Observatory[119] (Observatório de Clima e Saúde)	The Climate and Health Observatory is an initiative of the Oswaldo Cruz Foundation (Fiocruz), under the Ministry of Health (MS), which integrates and provides environmental, climate, epidemiological, and socioeconomic data to support analyses of climate impacts on health. Since 2009, the platform has compiled indicators, studies, methodologies, and information on topics such as air quality, extreme events, and vector-borne diseases, contributing to the production and dissemination of evidence on the impacts of climate change on health.	In recent years, the Observatory has expanded its activities to produce and disseminate information aimed at understanding the impacts of climate change on health, including the preparation of technical notes as a rapid response to extreme events and the ongoing monitoring, collection, and analysis of data. The initiative demonstrates the importance of integrating different databases and coordinating research and health surveillance to produce timely information that is easy to understand. Making data, studies, and methodologies publicly available strengthens research networks and enhances the capacity to use evidence on climate and health in planning and decision-making.
Center for Synthesis on Biodiversity and Ecosystem Services (SinBiose, Centro de Síntese em Biodiversidade e Serviços Ecossistêmicos) – CNPq[120]	SinBiose is an initiative of the National Council for Scientific and Technological Development (CNPq) aimed at promoting synthesis science in the fields of biodiversity and ecosystem services. The first synthesis center of the Global South, officially established in 2020, supports working groups that integrate existing data, information, and knowledge to address scientific questions and complex socio-environmental challenges, fostering the generation of new knowledge through collaboration among researchers from different fields and institutions.	The initiative demonstrates the potential of synthesis science to integrate dispersed knowledge and data and generate new evidence applicable to complex socio-environmental challenges. Collaborative and interdisciplinary work fosters the development of integrated analyses and enhances the use of existing scientific knowledge, helping to strengthen a relevant evidence base for public policies, including those related to biodiversity conservation and climate change adaptation.
Biota Synthesis – Center for the Analysis and Synthesis of Nature-Based Solutions[121] (Biota Síntese – Núcleo de Análise e Síntese de Soluções Baseadas na Natureza)	An initiative focused on generating interdisciplinary knowledge and synthesis to support the development and implementation of nature-based solutions. Established in 2022, it brings together researchers and partner institutions and integrates data and knowledge from different fields to address socio-environmental challenges and inform public policy, aligning scientific research with the needs of managers and decision-makers.	The initiative demonstrates the potential of knowledge co-production and synthesis science geared toward specific public policy needs. Collaboration among researchers, managers, and different fields of knowledge promotes the integration of evidence and the development of solutions applicable to complex socio-environmental problems. This approach also demonstrates how scientific production can be organized based on users' needs, thereby increasing its relevance and potential for application to decision-making.

Source: Compiled by the authors.

119 Available at: https://climaesaude.icict.fiocruz.br. Accessed on: Sep. 04, 2024.

120 Available at: https://www.gov.br/cnpq/pt-br/acesso-a-informacao/acoes-e-programas/programas/sinbiose-1. Accessed on Jul. 16, 2026.

121 Available at: https://biotasintese.iea.usp.br/pt/. Accessed on Jul. 16, 2026.

In addition to scientific production and knowledge integration, strengthening adaptation requires instruments that support planning, management, and implementation processes at different levels. In this context, public initiatives have helped expand institutional capacities, provide tools, and strengthen processes related to prevention, land-use planning, and support to decision-making processes (Dataframe 4.11).

Dataframe 4.11 Federal Government and public planning and management tools

Initiative	Brief description	Good practice or lesson learned
AdaptaBrasil MCTI[122]	AdaptaBrasil is developed in partnership with the Ministry of Science, Technology and Innovation (MCTI), the National Institute for Space Research (INPE), and the National Education and Research Network (RNP) (see section **7.2.5 Vocational training and institutional capacity-building**). Launched in 2020, it is a platform that provides climate risk indices across various themes for all municipalities in Brazil. The platform is being continuously improved through the incorporation of new forms of representation, new sectors, and updates to methodologies and indicators.	AdaptaBrasil MCTI relies on the collaboration of various partner institutions. The initiative shows that the collaborative development of integrated platforms, combined with the continuous updating of data, indicators, and methodologies, strengthens the production of more robust analyses and enhances the capacity to inform decision-making processes related to climate adaptation. New strategic themes are incorporated through integrated and intersectoral approaches to climate risks and their impacts across various social, environmental, and economic dimensions. The Cities Dashboard (Painel Cidades) was recently launched, which is a new feature that compiles information on 12 strategic sectors and subsectors, with a focus on the municipal level[123].
DataClima+ National Climate Transparency System[124] (DataClima+ Sistema Nacional de Transparência Climática)	An initiative aimed at strengthening Brazil's climate transparency system to meet the requirements of the Enhanced Transparency Framework (ETF) under the Paris Agreement. DataClima+ aims to improve the governance and management of climate data by strengthening the processes involved in planning, collecting, processing, analyzing, sharing, and preserving the information needed to prepare transparency reports and inform decision-making. The project also promotes institutional arrangements, standardization of procedures, and capacity building for stakeholders involved in the production and use of climate information. The initiative aims to integrate systems such as AdaptaBrasil and IndicaClima (see **Box 1.3. Strengthening the National Climate Transparency System (DataClima+)**).	This initiative highlights the importance of data governance, knowledge management, and the strengthening of institutional capacity to improve the quality, consistency, and availability of climate information. The development of standardized processes, data-sharing mechanisms, and permanent institutional arrangements helps strengthen climate transparency and support evidence-based planning and decision-making processes.

122 Available at: https://sistema.adaptabrasil.mcti.gov.br. Accessed on: May 04, 2026.

123 Available at: https://painelcidades.adaptabrasil.mcti.gov.br/. Accessed on Jul. 17, 2026.

124 Available at: https://dataclima.mcti.gov.br/home. Accessed on Jul. 17, 2026.

Initiative	Brief description	Good practice or lesson learned
IndicaClima	The IndicaClima System is Brazil's first centralized system for tracking climate policies. Initially developed to support the monitoring of the implementation of the Climate Plan, the system was designed with a modular structure, allowing for its future expansion to track other climate policies. The platform will provide a dashboard with restricted access for public officials, featuring real-time updates on the implementation of the Climate Plan, thereby supporting government planning and evidence-based decision-making. In addition, there will be a dashboard open to the public that will show the results agreed upon and approved by the Interministerial Committee on Climate Change (CIM), thereby enhancing transparency and society's access to information on the progress of Brazil's climate policy.	The establishment of the IndicaClima System represents progress in institutionalizing the monitoring of climate policies in Brazil. Among the main lessons learned is that the effectiveness of a monitoring system depends on clearly defined roles and responsibilities, the standardization of the information collected, and the integration of governance, indicators, and digital tools. This approach helps strengthen evidence-based management, increase transparency, and support the continuous improvement of climate policies.
Civil Defense Warning[125] (Defesa Civil Alerta)	The Civil Defense Warning is an initiative of the National Civil Defense, developed in partnership with the National Telecommunications Agency (Anatel, Agência Nacional de Telecomunicações) and mobile network operators to enhance the capacity to communicate with and warn the population in situations of risk. The initiative uses mobile communication technologies to support the rapid dissemination of information and strengthen preventive strategies in the face of extreme events.	The gradual implementation of the Civil Defense Warning demonstrates the importance of testing and evaluating new solutions before scaling them up. The tool was launched as a pilot project in 11 municipalities in the South and Southeast regions in August 2024, followed by implementation in those two regions and a gradual expansion to the Northeast, North, and Central-West, accompanied by testing and training for Civil Defense teams. In October 2025, the system became operational throughout the country, marking the nationwide expansion of a solution initially tested at the local level. The initiative demonstrates the potential of pilot approaches to generate lessons, improve processes, and support the replication and expansion of solutions across different territorial contexts.

125 Available at: https://www.gov.br/mdr/pt-br/assuntos/protecao-e-defesa-civil/defesa-civil-alerta/mas-o-que-e-defesa-civil-alerta. Accessed on Jul. 16, 2026.

Initiative	Brief description	Good practice or lesson learned
GeoRisk – Cemaden[126]	A platform developed by the National Center for Monitoring and Early Warnings of Natural Disasters (Cemaden) that integrates and provides geospatial information related to disaster risks throughout Brazil. The tool brings together data and products that support the identification and analysis of areas exposed to different types of risks, contributing to access to territory-tailored information and to risk planning and management.	This initiative demonstrates the importance of transforming data and technical-scientific knowledge into accessible tools to support decision-making. The integration and availability of geospatial information on a public platform help expand access to risk data and strengthen its use in territorial planning and management processes.
Risk-free Urban Peripheries (*Periferia sem Risco*) – Ministry of Cities (MCID)[127]	The Risk-free Urban Peripheries is an initiative aimed at reducing socio-environmental risks in urban peripheries by supporting prevention actions, land use planning, urban improvement, and the strengthening of resilience in the most vulnerable areas. The initiative operates across different integrated areas: (i) Infrastructure, including slope stabilization works and nature-based solutions aimed at disaster risk reduction and inclusive climate adaptation in urban peripheries; (ii) Mapping and Planning, supporting instruments such as Municipal Risk Reduction Plans (PMRRs, Planos Municipais de Redução de Riscos), Community Disaster Risk Management Plans, and the use of tools such as the Urban Peripheries Map to guide investments and prioritize actions; and (iii) Communication and Participation, through the preparation of booklets, guides, and technical publications, coordination with universities and local governments, as well as socio-technical visits to vulnerable territories under the Urban Peripheries Caravan - Risk-free Urban Peripheries Initiative (*Caravana das Periferias – Periferia sem Risco*).	The initiative demonstrates the importance of integrating infrastructure, land-use planning, and social participation to reduce urban vulnerabilities and strengthen climate adaptation strategies. The combination of structural investments, the use of data and planning instruments, and the strengthening of local capacities represents a good practice for targeting resources, increasing social participation, and promoting more effective and inclusive responses in territories that are more exposed to climate risks. In addition, through this initiative, the Federal government engages directly with local communities, connecting resources and knowledge developed at the national level with the needs and solutions identified at the community level.

126 Available at: https://georisk.cemaden.gov.br/. Accessed on Jul. 16, 2026.

127 Available at: https://www.gov.br/cidades/pt-br/acesso-a-informacao/acoes-e-programas/periferias/periferia-sem-risco. Accessed on: May 21, 2026.

Initiative	Brief description	Good practice or lesson learned
#AprenderPara-Prevenir (Learning to Prevent) National Campaign – *Cemaden Educação)*	Conducted since 2016 by the Cemaden Education Program, the National #LearningToPrevent Campaign (see section 7.1 for further information) mobilizes schools, universities, Civil Protection and Defense agencies, public institutions, organizations, and communities around education for disaster risk reduction. Each edition of the campaign addresses a specific theme and promotes engagement, training, and participation activities aimed at strengthening a culture of prevention. In 2026, the campaign's theme was "Risk-Free Cities," with a focus on engaging communities and developing local initiatives related to risk prevention and the creation of safer, more resilient territories.	The continuity of the campaign since 2016 demonstrates the importance of ongoing education and social engagement processes that can be updated in response to emerging issues and challenges. Defining specific themes for each edition makes it possible to adapt a long-term initiative to different contexts and priorities, while the engagement of schools, communities, and institutions promotes the dissemination of knowledge and the strengthening of local capacities for risk prevention and adaptation (see section **7.2.4 Non-formal climate education and educational initiatives**).
AdaptaCidades – Ministry of the Environment and Climate Change (MMA)[128]	*AdaptaCidades* is an initiative coordinated by the Ministry of the Environment and Climate Change (MMA), with support from the Ministry of Cities (MCID) and the Ministry of Science, Technology and Innovation (MCTI). This initiative is aimed at strengthening the capacity of states and municipalities to incorporate climate change adaptation into land use planning and management instruments. The initiative offers capacity-building, guidance materials, technical support, and tools to assist in the development and implementation of local adaptation strategies, taking into account specific territorial and sectoral characteristics.	The initiative, launched in 2024, highlights the importance of strengthening institutional capacity and providing ongoing technical support to expand the implementation of adaptation measures at the local level. The development of practical tools, capacity-building programs, and support mechanisms represents a good practice in bridging the gap between technical knowledge and planning processes, thereby contributing to the integration of adaptation into public management instruments. With progressive targets, in 2026 approximately 40 Brazilian cities are receiving support to develop their adaptation plans (see sections **4.5. Progress in implementation** and section **7.2.5 Vocational training and institutional capacity-building**).
Reference Framework on Food Systems and Climate for Public Policies – Ministry of Development and Social Assistance, Family and Fight against Hunger (MDS)[129]	The Reference Framework on Food Systems and Climate for Public Policies was developed through a participatory process involving government and society to guide the integration of food, food and nutrition security, and climate change policies. The document recognizes that food systems are both affected by and contribute to climate change, and proposes guidelines, strategies, and pathways for strengthening healthier, more sustainable, equitable, and resilient food systems. It also promotes coordination with planning instruments and policies related to climate adaptation and mitigation.	The initiative highlights the importance of guiding instruments capable of incorporating the climate agenda into food security policies. The participatory process used to develop the framework, involving government, academia, and civil society, represents a good practice in knowledge co-production and the strengthening of governance, helping to guide more coordinated public policies and promote the transition to resilient and socially just food systems.

128 Available at: https://www.gov.br/mma/pt-br/composicao/smc/adaptacidades. Accessed on: Jun. 02, 2026.

129 Available at: https://www.gov.br/mds/pt-br/acoes-e-programas/promocao-da-alimentacao-adequada-e-saudavel/marco-de-referencia-sobre-sistemas-alimentares-e-clima-para-politicas-publicas. Accessed on: May 29, 2026.

Initiative	Brief description	Good practice or lesson learned
Adapting Conservation Units Project (*Projeto Adaptando Unidades de Conservação*) – UFPR - Federal University of Paraná (Universidade Federal do Paraná), Boticário Group Foundation (Fundação Grupo Boticário), and partner institutions[130]	An initiative coordinated by the Geoprocessing and Environmental Studies Laboratory of the Federal University of Paraná (Lageamb/UFPR, Laboratório de Geoprocessamento e Estudos Ambientais da Universidade Federal do Paraná), in partnership with the Boticário Group Foundation for the Protection of Nature (Fundação Grupo Boticário de Proteção à Natureza) and with the participation of partner institutions, including ICMBio – Chico Mendes Biodiversity Conservation Institute (Instituto Chico Mendes de Conservação da Biodiversidade). The project aims to incorporate the climate change perspective into the management of Conservation Units, initially by developing Climate Adaptation Plans for the Salto Morato Nature Reserve (Reserva Natural Salto Morato) in the Atlantic Forest and the Serra do Tombador Nature Reserve (Reserva Natural Serra do Tombador) in the Cerrado. Based on the experience with these initiatives, a methodological roadmap is being developed to support the development of adaptation plans for other Conservation Units.	The initiative combines applied science, local knowledge, and the participation of various stakeholders in the development of responses tailored to the characteristics of each territory. The development of pilot plans for Conservation Units located in different biomes makes it possible to test and systematize a methodological approach that may be replicated in other protected areas. Developing the roadmap with the participation of public institutions, civil society organizations, academia, and communities is an important practice for integrating different types of knowledge and broadening the applicability of the results to the management of Conservation Units.
National Committee for Addressing Environmental and Climate Racism[131]	The National Committee for Addressing Environmental and Climate Racism was established in the context of COP30 as a body for interministerial and multisectoral coordination, jointly coordinated by the Ministry of Racial Equality (MIR), the Ministry of the Environment and Climate Change (MMA), the Ministry of Indigenous Peoples (MPI), and the Ministry of Agrarian Development and Family Farming (MDA). The initiative aims to expand social participation, develop guidelines, and promote actions designed to address the inequalities exacerbated by the impacts of climate change, particularly those affecting Black, Indigenous, and Quilombola populations, as well as traditional communities.	The initiative highlights the importance of incorporating principles of climate justice, social participation, and equity into adaptation policies. Coordination among different ministries and the inclusion of civil society organizations represent a good practice for strengthening integrated approaches and ensuring that adaptation strategies take into account the differing vulnerabilities of various population groups and territories.

Source: Compiled by the authors.

130 Available at: https://lageamb.ufpr.br/elementor-14562. Accessed on Jul. 16, 2026.

131 Available at: https://www.in.gov.br/en/web/dou/-/portaria-interministerial-mir/mma/mda/mpi-n-12-de-9-de-setembro-de-2025-660424698

The implementation of adaptation actions also depends on continuous processes of capacity-building and cooperation among national and international institutions. Cooperation initiatives have supported the development of methodologies, tools, and strategies aimed at incorporating adaptation into public policies and planning processes (Dataframe 4.12).

Dataframe 4.12 Cooperation and capacity building

Initiative	Brief description	Good practice or lesson learned
Ciência&Clima – MCTI, UNDP and GEF[132]	The Science&Climate (*Ciência&Clima*) project (BRA/23/G31 - Brazil's Fifth National Communication, Biennial Update Report, and Biennial Transparency Reports to the UNFCCC) is executed by the Ministry of Science, Technology and Innovation (MCTI), with support from the United Nations Development Programme (UNDP) in its implementation and funding from the Global Environment Facility (GEF). The initiative aims to strengthen national capacities related to climate science and the integration of scientific research with public policy, by supporting the development of tools, knowledge syntheses, and mechanisms designed to inform decision-making on climate change.	This initiative highlights the importance of cooperation between national institutions and international organizations in strengthening technical capacities and bridging the gap between scientific research and public policy-making. The joint development of tools, studies, synthesis mechanisms, and strategies for disseminating knowledge represents a good practice for expanding the use of scientific evidence in adaptation and decision-making processes.
ProAdapta[133]	Launched in 2017, the initiative is the result of a partnership between the MMA and the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV), within the framework of the International Climate Initiative (IKI), and is implemented by the German Agency for International Cooperation (GIZ). *ProAdapta* aims to support the Brazilian government in implementing the national climate change adaptation agenda, involving stakeholders from different levels of government, the private sector, and civil society.	Through projects with subnational governments, the private sector, and the Federal Government, the initiative supports the development of climate risk analyses, coordination across different sectors, and the provision of training, guides, and action plans in the area of adaptation.

132 Available at: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/cgcl/paginas/ciencia-clima. Accessed on Jun. 01, 2026.

133 Available at: https://www.adaptacao.eco.br. Accessed on: Sep. 04, 2024.

Initiative	Brief description	Good practice or lesson learned
Water Resilience Tracker (WRT)[134]	Water Resilience Tracker (WRT) is an international methodology developed by the Alliance for Global Water Adaptation (AGWA) and implemented in Brazil through a partnership between the National Water and Basic Sanitation Agency (ANA) and the Ministry of the Environment and Climate Change (MMA). The initiative was applied to the sectoral and thematic plans of the Climate Adaptation Plan to assess how water resilience and water resources are incorporated into adaptation strategies, identifying strengths, gaps, and opportunities for improvement.	This initiative highlights the potential of international cooperation to adapt and apply global methodologies to the national context. The use of a common approach across different sectors made it possible to generate comparable assessments, identify opportunities to integrate water resources into climate policies, and strengthen processes for learning, monitoring, and the continuous improvement of adaptation instruments.
Children and Environment Dashboard – UNICEF and Vital Strategies[135]	Developed through a partnership between the United Nations Children's Fund (UNICEF) and Vital Strategies, the Children and Environment Dashboard is a tool aimed at supporting decision-making that brings together 14 environmental exposure indicators organized into four thematic areas, covering 53 million children and adolescents across Brazil's 5,571 municipalities. The tool provides assessments and recommendations based on municipal performance across the different indicators, seeking to support more preventive decision-making and contribute to ensuring the right of children and adolescents to a clean, healthy, and safe environment.	The initiative demonstrates the potential of transforming territory-tailored data into practical information and recommendations to support the work of local public officials. Focusing specifically on children and adolescents helps shed light on distinct vulnerabilities and identify territorial inequalities that may be less apparent in analyses of the general population. The nationwide coverage and public availability of the information facilitate the use of evidence to prioritize preventive actions and formulate responses that are more responsive to the needs of children and adolescents.

Source: Compiled by the authors.

Collaborative networks and communities of practice also play an important role by promoting the exchange of experiences, peer learning, and the dissemination of solutions applied across different territorial and institutional contexts (Dataframe 4.13).

134 Available at: https://www.gov.br/ana/pt-br/assuntos/noticias-e-eventos/noticias/ana-mma-e-agwa-firmam-parceria-para-implementacao-da-ferramenta-internacional-water-resilience-tracker-no-brasil. Accessed on Jun. 09, 2026.

135 Available at: https://www.criancasemeioambiente.org.br. Accessed on Jul. 23, 2026.

Dataframe 4.13 Private sector and communities of practice

Initiative	Brief description	Good practice or lesson learned
UN Global Compact	Cooperation between the Ministry of Science, Technology and Innovation (MCTI) and the UN Global Compact Network Brazil aimed at sharing data and information and conducting studies, training, research, and events related to climate change adaptation with business applications. The initiative also promotes the integration of biodiversity into adaptation strategies, the dissemination of information through *AdaptaBrasil*, and actions aimed at climate transparency and private-sector engagement.	This initiative demonstrates the potential of collaborative platforms to bring scientific information, public tools, and end users closer together. The collaboration between *AdaptaBrasil* and the Nature and Climate HUB demonstrates how information on climate risks and impacts can be translated and incorporated into decision-making processes in the business sector.
Sustainable Urban Development Network (ReDUS, Rede de Desenvolvimento Urbano Sustentável)[136]	ReDUS is an initiative developed under the Support Project for the National Sustainable Urban Development Agenda (ANDUS, Projeto de Apoio à Agenda Nacional de Desenvolvimento Urbano Sustentável), in partnership with the National Front of Mayors (FNP, Frente Nacional de Prefeitos), aimed at bringing together stakeholders and disseminating knowledge, practices, and solutions related to sustainable urban development. The network brings together initiatives, communities of practice, courses, tools, experiences, and forums for exchange aimed at strengthening local capacities and implementing sustainable urban policies.	This initiative highlights the importance of collaborative networks in strengthening technical and institutional capacities, promoting peer learning, and expanding access to tools, methodologies, and good practices. Collaboration among governments, academia, organizations, and other stakeholders promotes integrated approaches and accelerates the dissemination of solutions to complex urban challenges.
Businesses for Climate Adaptation (*Empresas pelo Clima - EPC Adapta)* (FGVces – Center of Studies in Sustainability - Getúlio Vargas Foundation (Centro de Estudos em Sustentabilidade da Fundação Getúlio Vargas))[137]	An initiative aimed at strengthening the adaptation agenda in the private sector by promoting training programs, communities of practice, the exchange of experiences, and the development of strategies for climate risk management in companies. The training program aims to support the development of corporate adaptation plans based on real-world challenges and applied knowledge.	Climate adaptation can be strengthened through collaborative mechanisms that bring different sectors together, promote peer learning, and encourage the incorporation of climate risks into the private sector's decision-making and institutional planning processes.

Source: Compiled by the authors.

136 Available at: https://www.redus.org.br/redus. Accessed on: May 21, 2026.

137 Available at: https://eaesp.fgv.br/sites/default/files/legacy/u1087/fgvces_ciclo_2026_epc_adapta.pdf. Accessed on: May 21, 2026.

The initiatives presented demonstrate that climate adaptation can be strengthened through integrated approaches that combine land use planning, knowledge generation and synthesis, innovation, institutional strengthening, social participation, and multisectoral cooperation. The implementation of tools, pilot projects, collaborative mechanisms, and cooperation networks helps foster learning, expand institutional capacity, and strengthen decision-making processes in different contexts and territories.

Among the common elements observed in these initiatives, the strengthening of collaborative arrangements between the government, research institutions, civil society, the private sector, and cooperation agencies stands out. This lesson is consistent with the findings from the monitoring and evaluation of the National Adaptation Plan (NAP), conducted in 2017 and 2021, which helped shape the process of developing the Climate Adaptation Plan. The lessons identified include the need to ensure coordination at strategic levels of the Federal Government, further develop governance structures, and strengthen integration across sectors and different levels of government, with clearly defined responsibilities. Also highlighted are the importance of establishing national targets linked to the country's priorities and to indicators that can be monitored throughout the Plan's effective implementation period, as well as expanding capacity-building actions linked to the generation and dissemination of evidence to address the new climate reality (Brasil, 2025t).

The complexity of climate risks and adaptation processes requires integrated approaches capable of bringing together different types of knowledge, promoting interoperability and integrated interaccessibility across data and systems, and expanding access to relevant information to support decision-making at multiple levels. Another recurring theme concerns the development of solutions tailored to specific demands and needs identified by different stakeholders and territories. Bringing knowledge production, user needs, and implementation processes closer together contributes to the development of more effective solutions that are applicable to local contexts. Finally, the experience gained with the initiatives presented also demonstrates that the integration of different types of knowledge - scientific, technical, local, and traditional - strengthens our understanding of climate risks and vulnerabilities and facilitates the development of solutions that are more context-specific, inclusive, and socially relevant.

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Annexes

Annex 1 Structural and methodological aspects of strategic sectors of the AdaptaBrasil MCTI Information System.

Strategic Sector	Subsectors	Level	Thematic indicators of exposure and vulnerability (sensitivity + adaptive capacity)
Water resources	Risk of water stress	Municipal (analysis conducted by hydrographic basins (Ottobasins) – when data on hydrological aspects are available, with results organized at the municipal scale).	Exposure: Water resources users who require water use, and the population. Vulnerability: Sensitivity: Pressures on water availability associated with land use, water supply for human consumption, and sectoral demands. Adaptive capacity: Water infrastructure, water resources management, and water governance instruments.
Food security	Food availability; Food access and consumption	Municipal	Exposure: Territorial conditions of agricultural production and socioeconomic factors that influence access to and consumption of food. Vulnerability: Sensitivity: Productive characteristics of agriculture and socioeconomic conditions of the population that affect food production and access to food. Adaptive capacity: Infrastructure, public policies, and institutional conditions that strengthen the resilience of food systems.
Energy security	Access; Availability* (hydropower, solar, wind, and cooling demand) ** Availability is a final indicator developed through modeling and, therefore, does not include thematic indices or indicators.*	Access: Municipal (analyses based on the national electricity system/ generation areas).	Exposure: Population density and percentage of energy-intensive industries. Vulnerability: Sensitivity: Indicators that provide information on demand and supply. Adaptive capacity: Indicators of the economic capacity and of the capacity for diversification of the energy matrix. *Note: The sector does not use thematic indicators. The individual indicators directly comprise the exposure, sensitivity, and adaptive capacity indices.*

Climate-related hazards	Scenarios
Hydrological modeling based on changes in the hydrological regime associated with changes in evapotranspiration and precipitation, which affect water availability.	Reference period: 1980-2014; 2015-2040 for 2030; and 2041-2070 for 2050, considering the SSP4.5 and SSP8.5 scenarios.
Drought, represented by the number of consecutive dry days and the Standardized Precipitation-Evapotranspiration Index (SPEI).	Present 1986-2005; projections for 2030 and 2050 under the RCP 4.5 and RCP 8.5 scenarios.
Changes in renewable energy supply (hydropower, wind, and solar) and increased cooling demand, resulting in greater dispatch of fossil-fuel-fired thermal power plants. Natural inflow energy (ENA) data are provided by the National Electric System Operator (ONS, Operador Nacional do Sistema Elétrico).	The Climate Hazard Index for the Electricity System is represented by the dispatch of fossil-fuel-fired thermal power plants as a function of changes in hydropower potential and wind and solar resources between the Present (2010-2021) and a future scenario based on RCP 8.5, with a global warming level of 2ºC (2040-2070). It is calculated as the percentage of thermal power generation from fossil-fuel sources relative to the maximum possible generation from these sources, taking into account their installed capacity and a maximum utilization limit of 95% of the year, with the remaining 5% corresponding to technical outages such as maintenance.

Strategic Sector	Subsectors	Level	Thematic indicators of exposure and vulnerability (sensitivity + adaptive capacity)
Health	Malaria; American cutaneous leishmaniasis; visceral leishmaniasis; arboviral diseases: Dengue, Zika, and chikungunya	Municipal	Exposure: Socio-environmental factors that favor disease vectors. Vulnerability: Sensitivity: Socioeconomic and environmental factors. Adaptive capacity: Access to health services and primary healthcare.
Geo-hydrological disasters	Landslides; fluvial flooding events, flash floods, and surface water flooding events	Municipal	Exposure: Population in risk areas and population density. Vulnerability: Sensitivity: Population characteristics (special needs, education, income, and housing) and deficiencies in municipal infrastructure (mobility, roads, and basic sanitation). Adaptive capacity: Municipal economic capacity, disaster risk management (institutional and governance structures), and urban policy.
Port infrastructure	Storms; extreme winds; sea level rise.	Port facilities	Exposure: Location and characteristics of port infrastructure. Vulnerability: Sensitivity of the infrastructure and coastal environment. Adaptive capacity: Not considered in the index.
Road infrastructure	Impacts from surface water flooding and fluvial flooding events; landslides; erosion; fires; high temperatures	Sections of the national road network	Exposure: Location and length of road sections and physical characteristics of road infrastructure. Vulnerability: Susceptibility of the biophysical environment and road infrastructure to climate impacts. Adaptive capacity: Not considered in the index.

Climate-related hazards	Scenarios
Climate variables associated with the dynamics of vector-borne diseases (temperature, precipitation, humidity, and heat waves), used in statistical modeling of disease occurrence.	Present (1986-2005), 2030, and 2050 – RCP 4.5 and RCP 8.5.
Modeling based on extreme precipitation events (maximum 1-day precipitation – Rx1day, and maximum 5-day precipitation – Rx5day) associated with extreme hydrological events, such as landslides and fluvial flooding events, as well as topographic characteristics and human factors.	Present (1970-2005); projections for 2030 and 2050 under the RCP 4.5 (optimistic) and RCP 8.5 (pessimistic) scenarios.
Sea level rise, storms, waves, and heavy rainfall.	Present, 2030 and 2050 – RCP 4.5 and RCP 8.5.
Heavy rainfall, high temperatures, droughts, and conditions associated with fires.	Base period: 1981-2000; projections for 2030 and 2050 under SSP2-4.5 and SSP5-8.5.

Strategic Sector	Subsectors	Level	Thematic indicators of exposure and vulnerability (sensitivity + adaptive capacity)
Railway infrastructure	Impacts from landslides; impacts from erosion; impacts from high temperatures	Sections of the national railway network	Exposure: Location and length of railway sections and physical characteristics of the infrastructure along the railway network. Vulnerability: Sensitivity of the biophysical environment (susceptibility to landslides and erosion) and sensitivity of the railway infrastructure to landslides, erosion, and high temperatures. Adaptive capacity: Not considered in the index.
Biodiversity	Biome integrity	Municipal (analyses conducted by biome and organized at the municipal level)	Exposure: Natural vegetation cover, protected areas, and priority areas for conservation. Vulnerability: Agricultural pressures, pressures on vegetation cover, demographic and economic pressures. Adaptive capacity: Environmental governance, management of conservation units, technical assistance, and sustainable management.

Source: AdaptaBrasil.

Climate-related hazards	Scenarios
Heavy rainfall, landslides, erosion, and high temperatures.	Base period 1981-2000; projections for 2026-2045 (2030) and 2046-2065 (2050) under the SSP2-4.5 (optimistic) and SSP5-8.5 (pessimistic) scenarios.
Changes in the climate regimes of the biomes represented by climate variables (annual cumulative precipitation, precipitation seasonality, mean annual temperature, and annual temperature range).	Present (1960-1990); future scenarios based on RCP 8.5 with the following global warming levels: 1.5°C (2011-2040) and 2°C (2041-2070).



CHAPTER 5

Information on Financial, Technology Development and Transfer and Capacity-Building Support Needed and Received under Articles 9–11 of the Paris Agreement

5.1 National circumstances, institutional arrangements and country-driven strategies

International climate finance has proven to be essential for Brazil to expand its capacity to mitigate greenhouse gas emissions, address the impacts of climate change, and strengthen its climate governance. This approach is directly in line with the National Policy on Climate Change (PNMC, Política Nacional sobre Mudança do Clima), which includes, among its guidelines, the promotion of international cooperation focused on financing, capacity building, and technology transfer.

Under the United Nations Framework Convention on Climate Change (UNFCCC), Brazil has accessed resources from the Green Climate Fund (GCF) and the Global Environment Facility (GEF). In addition, the Brazilian government, through the Ministry of the Environment and Climate Change (MMA, Ministério do Meio Ambiente e Mudança do Clima), has been working to have national entities accredited by the Adaptation Fund (AF) with a view to financing climate resilience projects. Another potential source of funding is the Loss and Damage Fund, established at COP27, held in Egypt in 2022, with the aim of supporting vulnerable developing countries in addressing the irreversible losses caused by climate change. The fund began operations at COP30, held in 2025 in Belém, and has not made any disbursements to date.

It is also worth mentioning that at COP29, held in 2024 in Baku, the New Collective Quantified Goal on Climate Finance (NCQG) was adopted, which has been in effect since 2025. This goal replaced the previous goal of USD 100 billion with a new goal of mobilizing USD 300 billion annually for climate finance, under the leadership of developed countries, in addition to calling for these amounts to reach at least USD 1.3 trillion in mobilized funds annually by 2035 (Brasil, 2026c).

Outside the scope of the UNFCCC, but inspired by the discussions held under the Convention, other international financial instruments have been created to accelerate climate investments in developing countries, such as the Climate Investment Funds (CIF). The CIF continues to receive donations and is fully operational, having even benefited Brazil through two recently approved investment plans: the Renewable Energy Integration Program (CIF REI), in 2023, with an estimated USD 70 million in concessional resources from the fund and the expected mobilization of USD 173.5 million in co-financing; and the Nature, People, and Climate Program (CIF NPC), in 2025, with an estimated USD 47 million in concessional resources from the CIF, combined with USD 100 million from the Climate Fund, via the Brazilian Development Bank (BNDES, Banco Nacional de Desenvolvimento Econômico e Social), and USD 100 million from the World Bank, with these funds directed to the private sector to finance restoration projects in the Amazon and in the Cerrado. In addition, in 2025, the CIF approved two programs dedicated to the private sector for industrial decarbonization and energy transition, totaling USD 90 million in concessional resources from the fund, and is expected to mobilize an additional amount of nearly USD 2.7 billion.

It is also worth noting that, in November 2025, Brazil's new Country Programme was published with the GCF, featuring an indicative portfolio of nine projects through 2027, the potential to raise up to USD 1 billion in resources from the fund, an expected USD 3.8 billion in co-financing, an estimated 665 million tons of CO_2e in avoided emissions, and direct benefits to approximately 53 million people, in line with the main national policies on climate and sustainable development. Between 2023 and 2025, Brazil had nine projects approved by the GCF, totaling nearly USD 285 million. These elements point to an important pipeline of new resources to be monitored in upcoming reporting cycles (GCF, 2025).

Under the GEF, the eighth replenishment cycle (GEF-8) resulted in the approval of 18 projects by December 2025, totaling more than USD 100 million for Brazil with the potential to mobilize approximately USD 826 million in co-financing. In addition to the expansion of Brazil's portfolio, the country's role in implementing the Global Biodiversity Framework Fund (GBFF) is noteworthy, with two projects approved since its creation, including the Fund's first financial mechanism structured under the direct leadership of Indigenous Peoples.

In light of the foregoing, it is noteworthy that multilateral and bilateral climate finance plays a key role in advancing climate action in Brazil. This financing contributes significantly to the implementation of public policies and programs, in addition to mobilizing private resources for investments aimed at low carbon emissions and at increasing climate resilience, including to support initiatives by civil society organizations (Brasil, 2024d).

There are also some relevant instruments at the national level. The Amazon Fund (Fundo Amazônia), which was established in 2008 and has been operational since 2009, has been an important mechanism for reducing deforestation, by financing environmental policies through results-based compensation. In 2024, the Fund reached the milestone of BRL 1.76 billion disbursed, BRL 2.99 billion approved, BRL 4.5 billion in received donations, and 119 projects approved (BNDES, 2025).

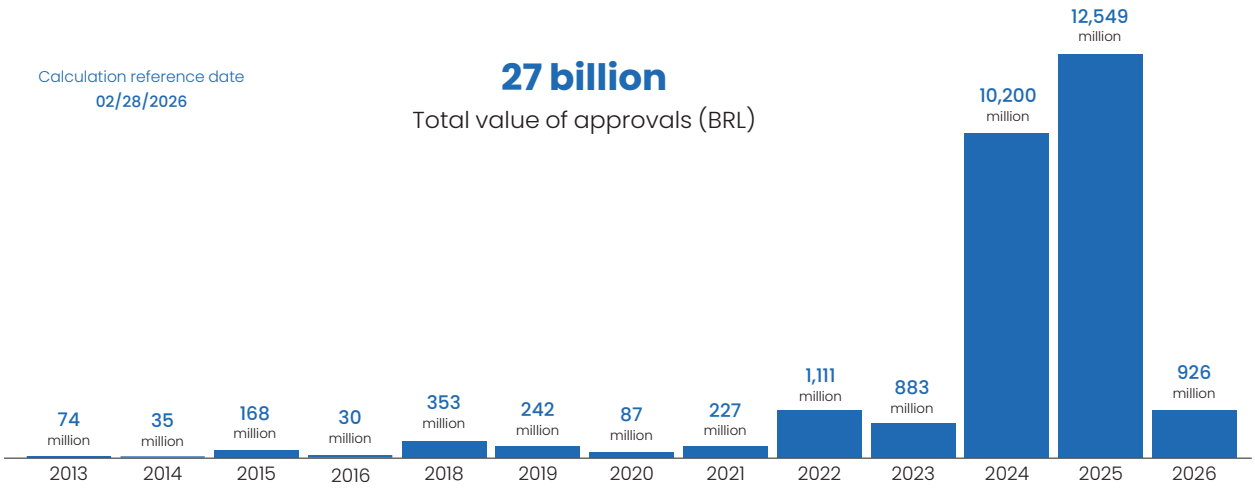
The most recent data indicate further progress by the Amazon Fund over the following two-year period: between 2023 and 2025, the Fund approved and contracted BRL 3.7 billion in projects, equivalent to 56% of the total amount supported since its creation in 2008, having reached, in 2025 alone, approximately BRL 2 billion in new approvals, the highest annual amount in its history. During this period, the Fund gained new donors - the United Kingdom, the European Union, the United States, Switzerland, Japan, Denmark, and Ireland - in addition to Norway and Germany, and expanded its portfolio to include more than 650 supported institutions and approximately 260,000 people benefitted throughout the Legal Amazon (Brasil, 2025c).

The National Climate Change Fund (FNMC, Fundo Nacional sobre Mudança do Clima), an instrument of the National Policy on Climate Change, aims to finance projects, studies, and initiatives focused on reducing greenhouse gas emissions and adapting to the effects of climate change. Under the Ministry of the Environment and Climate Change (MMA), the Climate Fund provides resources through two modalities: reimbursable, managed by the BNDES, and non-reimbursable, managed by the MMA.

Since 2023, the Climate Fund has been undergoing significant changes, such as the expansion of civil society's participation on the Management Committee and a substantial increase in available resources. Until 2023, the Fund's main source of revenue was the MMA's share of special participation revenues from oil and natural gas production. As of 2024, however, sustainable government bonds issued by the National Treasury became the Fund's main source of resources (Brasil, 2024d). In this context, the Climate Fund, which had received a cumulative BRL 3.1 billion in reimbursable resources through 2023, recorded a substantial increase, with BRL 10.2 billion in 2024 and BRL 12.55 billion in 2025, bringing the current cumulative total to approximately BRL 27 billion (Figure 5.1). Regarding the purpose of the projects, as shown in Figure 5.2, the largest volume of investments has historically been concentrated in initiatives focused on the energy transition, totaling BRL 14.21 billion. However, in recent years, the Climate Fund has been expanding its activities to diversify its investments, achieving significant results in resource allocation to Green Industry (BRL 3.056 billion), Green Logistics and Mobility (BRL 2.730 billion), Sustainable Urban Development (BRL 2.448 billion), and Native Forests and Water Resources (BRL 1.673 billion). Furthermore, the

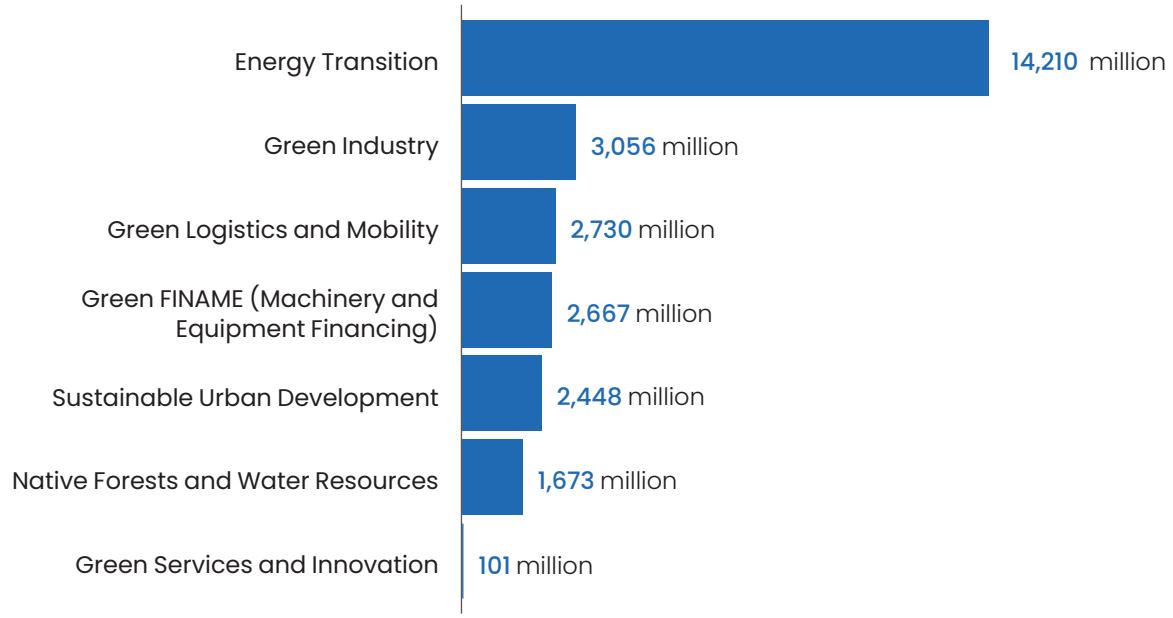
Climate Fund has also made progress in reducing the spatial and thematic concentration of credit through the establishment of aspirational targets. The 2026 Annual Resource Allocation Plan (PAAR, Plano Anual de Aplicação de Recursos), for example, establishes a target of allocating 25% of its financing portfolio to the North and Northeast regions, thereby mitigating regional disparities in resource allocation, as well as 20% to climate adaptation projects.

Figure 5.1 Cumulative resources of the Climate Fund under the reimbursable modality



Source: Climate Fund Dashboard, reimbursable modality (BNDES, 2026).

Figure 5.2 Allocation of resources by purpose (BRL)



Source: Climate Fund Dashboard, reimbursable modality (BNDES, 2026).

In addition to the Climate Fund, another noteworthy source of domestic resources provided by the Brazilian government to finance agricultural production is the Harvest Plan (PS, Plano Safra). The Harvest Plan includes the Sectoral Plan for Adaptation and Low Carbon Emission in Agriculture (ABC+ Plan), which is a policy focused on adaptation and mitigation of greenhouse gas (GHG) emissions in agriculture. Starting with the 2023/2024 Harvest Plan, the credit line allocated to the ABC+ Plan was renamed as the Financing Program for Sustainable Agricultural Production Systems (RenovAgro), with the following credit goals: (i) reducing greenhouse gas emissions from agricultural activities; (ii) reducing deforestation; (iii) increasing agricultural production on a sustainable basis; (iv) making rural properties compliant with environmental legislation; (v) expanding the area of planted forests; and (vi) encouraging the restoration of degraded areas (Brasil, 2023). The beneficiaries are rural producers and their cooperatives, including for on-lending to cooperative members (Brasil, 2025a). Table 5.1 below presents the resources allocated under the most recent Harvest Plans and the amounts allocated to the ABC+/RenovAgro Program, which ranged from 1.5% to 1.9% of the total over this period (Brasil, 2024a). The 2025/2026 Harvest Plan was the largest in history in terms of resources, totaling BRL 516 billion (Brasil, 2025a).

Table 5.1 Resources allocated under the Harvest Plans (BRL billion)

Purpose	22/23 Harvest**	23/24 Harvest	24/25 Harvest	25/26 Harvest
Production costs, marketing, and industrialization	246.28	272.12	401.3	414.7
Investment	94.6	92.1	107.3	101.5
*ABC+/RenovAgro**	6.19	6.93	7.68	8.15
Share of ABC+/RenovAgro in the total	1.82%	1.90%	1.51%	1.58%
Total	**340.88**	**364.22**	**508.6**	**516.2**

*Starting with the 2023/2024 Harvest Plan (launched on June 27, 2023), the former ABC Program - Low Carbon Emission Agriculture (Agricultura de Baixa Emissão de Carbono), linked to the ABC+ Plan, began operating under the name RenovAgro (Financing Program for Sustainable Agricultural Production Systems). The ABC+ Plan (2020–2030) remains the public policy framework for low-carbon agriculture. What changed was the name of the credit line/finance program linked to it under the Harvest Plan, which was renamed from "ABC Program" to "RenovAgro."
**The originally planned amount, which included the amount allocated to ABC+, was used (Brasil, 2022). The 2023/2024 Harvest Plan presents the implementation of the 2022/2023 Plan, but without ABC+.

The Program for Mobilizing Foreign Private Capital and Foreign Exchange Risk Protection – Eco Invest Brasil Program was established in 2024 under the Ecological Transformation Plan, with the aim of mobilizing domestic and foreign private capital for long-term sustainable projects. The initiative aims to expand access by Brazilian companies and projects to international capital markets, reduce risks associated with exchange rate volatility, and support the structuring of investments. To this end, the Program has four sub-lines: partial financing (blended finance), liquidity and mitigation of the effects of exchange rate volatility, promotion of foreign exchange hedging, and project structuring.

The first four Eco Invest Brasil auctions together achieved the potential to mobilize approximately BRL 140 billion in public and private resources for sustainable investments. The first one provided for approximately BRL 44.6 billion in investments to be allocated to projects related to the energy transition, the bioeconomy, the circular economy, and green infrastructure (Brasil, 2024f).

Subsequently, the second auction obtained approximately BRL 30.2 billion in investments aimed at restoring the productive capacity of approximately 1.4 million hectares of degraded land (Brasil, 2025b). The third one, in turn, totaled approximately BRL 52.8 billion in equity investments, with a particular focus on startups and small and medium-sized enterprises (Brasil, 2026a). The fourth auction obtained BRL 13.2 billion in investments to be allocated to the bioeconomy, sustainable tourism, and enabling infrastructure, with a focus on the Legal Amazon (Brasil, 2026b). More recently, the fifth auction was launched, but its results have not yet been published. It focuses on technological innovation in six strategic chains, combining Innovation Funds, corporate credit, and non-reimbursable support, with the aim of bringing together companies, universities, research centers, startups, and investors.

Finally, it is worth emphasizing that, despite Brazil's efforts, the available resources, both domestic and international, are insufficient to meet the complex demands posed by climate change. Additionally, most funds are directed toward mitigation, leaving adaptation actions underfunded. The inequitable allocation of resources perpetuates inequalities, as the most vulnerable populations often lack the financial means needed to address climate challenges. It is, therefore, imperative to increase the availability of resources and rebalance investments, allocating a significant share to adaptation strategies (Brasil, 2024e).

5.1.1 Institutional arrangements for climate finance information management in Brazil

Climate finance information management in Brazil involves various entities and mechanisms. Some of the collegiate bodies, instruments, and entities relevant to this management process are highlighted below.

Interministerial Committee on Climate Change (CIM, Comitê Interministerial sobre Mudança do Clima): The committee is comprised of 23 ministries and plays a key role in coordinating climate policies and overseeing finance strategies. It is the country's main permanent climate governance body. Its duties include ensuring that climate policies are aligned with financing objectives and that there is effective integration among different areas of government.

National Climate Change Fund (Climate Fund): The Climate Fund is a central financing mechanism under the National Policy on Climate Change (PNMC), designed to support climate change mitigation and adaptation projects. Under the Ministry of the Environment and Climate Change (MMA), the Climate Fund provides resources under two modalities: reimbursable and non-reimbursable. Reimbursable resources are managed by the BNDES, while non-reimbursable resources are managed by the MMA. The Fund, under both modalities, has the primary objective of financing actions and initiatives that contribute to reducing GHG emissions and strengthening the resilience of Brazilian communities and ecosystems.

Secretariat for International Affairs (SAIN, Secretaria de Assuntos Internacionais) of the Ministry of Finance (MF, Ministério da Fazenda): SAIN, through the General Coordination for Sustainable Finance, under the Undersecretariat for Sustainable Development Financing, serves as the MF's focal point for discussions on international climate finance, seeking to develop strategies to help obtain resources for projects that address the effects of climate change in the country. Specifically, SAIN serves as the National Designated Authority for the Green Climate Fund (GCF), the Operational Focal Point (OFP) for the Global Environment Facility (GEF), and represents Brazil in the Climate Investment Funds (CIF).

Commission on External Financing (Cofiex, Comissão de Financiamentos Externos): Cofiex, a collegiate body within the organizational structure of the Ministry of Planning and Budget (MPO, Ministério do Planejamento e Orçamento), is responsible for reviewing and authorizing the preparation of public-sector programs/projects financed by external sources at the federal, state, and municipal levels, when backed by a federal government guarantee or financed by an international organization or a foreign government agency. It is comprised of the Ministries of Planning and Budget, Finance, and Foreign Affairs. Under the Cofiex framework, information on public-sector projects and programs that receive external financing from multilateral and bilateral organizations is available on the COFIEX Dashboard (Brasil, 2026f).

National Secretariat for Climate Change of the Ministry of the Environment and Climate Change, SMC, Secretaria Nacional de Mudança do Clima/MMA): The SMC serves as the National Designated Authority (NDA) for the Adaptation Fund (AF) and is responsible for endorsing project proposals and designating the national entities authorized to manage these resources. The actual submission and implementation of national projects are contingent upon the final completion of the accreditation process for national entities, which is still underway.

Brazilian Development Bank (BNDES): The BNDES has adopted a policy aimed at integrating the economic, social, environmental, and climate agendas, with the aim of helping the country achieve the UN's Sustainable Development Goals (SDGs), make a just transition to a carbon-neutral economy, and attain economic prosperity. This translates into financing for initiatives that help reduce GHG emissions and achieve Brazil's NDC targets, as established under the Paris Agreement. As a developing country, Brazil relies on international cooperation and receives financial resources, especially from developed countries and international financial institutions, to support and/or complement BNDES' actions.

National Planning Secretariat (Seplan, Secretaria Nacional de Planejamento): Seplan, a body under the Ministry of Planning and Budget (MPO), is responsible for coordinating the process of preparation of the Federal Government's Multi-Year Plan (PPA, Plano Plurianual), in collaboration with the sectoral bodies responsible for their respective public policies. These programs include elements financed both by budgetary resources and by non-budgetary modalities, including tax-related instruments. Among these instruments, tax expenditures and tax relief measures stand out, encompassing modalities such as exemptions, amnesties, and subsidies. Although they do not constitute direct budgetary expenditures, they represent forms of government intervention and indirect financing of public policies. Thus, the development of the PPA programs seeks to take into account, in an integrated manner, the various sources and instruments of financing for public policies, including those related to environmental policy.

General Coordination of Climate Science (CGCL, Coordenação-Geral de Ciência do Clima): The CGCL under the Ministry of Science, Technology and Innovation (MCTI, Ministério da Ciência, Tecnologia e Inovação) serves as the National Designated Entity (NDE) for the Convention's Technology Mechanism in Brazil. Therefore, it is responsible for assessing the technological needs for implementing climate action plans in Brazil and for drawing up Technology Action Plans (TAPs), considering priority sectors and key technologies, with a view to achieving the mitigation targets presented in Brazil's NDC.

Climate Department of the Ministry of Foreign Affairs (MRE, Ministério das Relações Exteriores): The Climate Department (DECLIMA, Departamento de Clima), under the Secretariat for Climate, Energy, and the Environment (SECLIMA, Secretaria de Clima, Energia e Meio Ambiente), serves as the MRE's focal point for representing Brazil on the Boards of the Green Climate Fund (GCF) and

the Fund for Responding to Loss and Damage (FRLD). This entails diplomatic coordination and engagement with members of the other countries represented on these Funds' Boards, particularly those with which Brazil shares Board seats, with a view to developing joint positions that incorporate Brazilian perspectives and contributions into the decisions of these collegiate bodies. DECLIMA is also responsible for ensuring consistency between the operations of these Funds and their mandates as operating entities of the Financial Mechanism of the UNFCCC.

5.2 Underlying assumptions, definitions and methodologies

The collection of information on financial resources received was carried out with the support of SAIN/MF and ABC/MRE. Members of the CIM were also consulted to supplement any information that might not be available in the SAIN or ABC databases. The structure used was that of Table CTF III.7[1], covering the period from 2023 to 2025 for projects with the status "Under Implementation," "Council Approved," "Pending," "CEO Endorsement Cleared," "CEO Endorsement Pending," or "CEO PIF Cleared," and whose focal area includes "climate change."

In order to present the information regarding the financial support received, the following criteria were defined:

- The original amounts of the resources received are presented in U.S. dollars (USD), with the conversion to domestic currency based on the following exchange rate: 1 USD = 5 BRL (Brazilian reais);
- Due to the lack of precise guidance on MRV of support received and the limited availability of information, resources directed to the private sector and external resources received directly by subnational entities were not included in this survey.

Regarding information on technology transfer, the CGCL/MCTI was consulted directly. In addition, in an effort to collect further supplementary information, including information on capacity-building, technology transfer, and needs, an electronic questionnaire was developed and shared with the ministries that are members of the CIM, with a view to broadening the reach of the survey. Finally, an assessment of the entire survey was conducted, excluding repeated information and data that were not directly related to climate change.

Other partners in the promotion of sustainable development in Brazil through bilateral cooperation were not included in the tables due to different approaches used in the accounting of the support and cooperation received, which could not be efficiently assessed or did not meet the established criteria.

During data collection, information from multilateral institutions proved much more accessible than information on bilateral flows. This is because multilateral resources must necessarily be processed through the ABC/MRE or the Ministry of Finance, which facilitates their identification and systematization.

Information on bilateral channels only includes resources that have been internalized through a public entity or implemented under the coordination of a public entity, whether federal, state or

1 Common Tabular Formats (CTFs) for the electronic reporting of information on financial support, technology development and transfer, and capacity-building are set forth in Annex III of Decision 5/CMA.3. The CTFs corresponding to this BTR were structured using the ETF reporting tool and submitted electronically as annexes to the report.

municipal. Access to information on bilateral flows established directly between a donor and a civil society organization, without the involvement of the Federal Government, remains challenging, as already noted in BTR1.

5.3 Information on financial support needed by developing country Parties under Article 9 of the Paris Agreement

The Climate Plan and the estimates of financial needs described here are directly based on the first and second NDCs. The first NDC, submitted in 2016 and last updated in 2023, establishes emission limits of 1.32 Gt CO_2 eq in 2025 and 1.20 Gt CO_2 eq in 2030 (GWP AR5), equivalent to reductions of 49% and 54%, respectively, relative to national GHG emissions in 2005, according to the data published in Brazil's BTR2 (**Chapter 2**). The first NDC also provides for climate neutrality by 2050. The second NDC establishes a 59% to 67% reduction in net GHG emissions by 2035 relative to 2005 levels, corresponding to an emission limit of between 1.05 and 0.85 Gt CO_2 eq (GWP AR5), according to the data published in the NIR 2024 (Brasil, 2024b). Further details can be found in **Chapter 3**.

The 2024–2035 Climate Plan is structured around three main pillars: Mitigation (National Mitigation Strategy and Sectoral Mitigation Plans); Adaptation (National Adaptation Strategy and Sectoral and Thematic Adaptation Plans); and Cross-Cutting Strategies for Climate Action (details in **Chapter 1**). The Sectoral and Thematic Plans comprise a total of 1,051 actions, including 241 Mitigation actions distributed across 8 sectors[2] and 810 Adaptation actions distributed across 16 sectors and themes[3] (Brasil, 2026d).

A further step needed for the Climate Plan is to estimate the total amount of resources required, both public and private, for the effective implementation of all sectoral and thematic actions. Although studies are underway in this regard, the challenges inherent in the complexity and cross-cutting nature of this type of exercise mean that the estimates are still preliminary and will need to be further refined at a later stage (Brasil, 2026c).

As an example, the Sectoral Mitigation Plans provide investment estimates for implementing the high-impact actions under each plan. As shown in Table 5.2, at least USD 11.4 billion would be needed to meet the needs of the sectoral plans.

2 1. Land-use changes in public areas and collective territories; 2. Land-use changes in private rural areas; 3. Agriculture and Livestock; 4. Energy; 5. Transport; 6. Industry; 7. Cities; 8. Solid Waste and Domestic Wastewater.

3 1. Agriculture and Livestock; 2. Family Farming; 3. Biodiversity; 4. Cities; 5. Energy; 6. Racial Equality and Combating Racism; 7. Industry and Mining; 8. Ocean and Coastal Zone; 9. Traditional Peoples and Communities; 10. Indigenous Peoples; 11. Water Resources; 12. Risk and Disaster Reduction and Management; 13. Health; 14. Food and Nutrition Security; 15. Transport; and 16. Tourism.

Table 5.2 Estimated investment in high-impact actions under the Sectoral Mitigation Plans

Sectoral Mitigation Plans	Estimated investment in high-impact actions*
Sectoral Mitigation Plan – Land-Use Changes in Public Areas and Collective Territories	USD 1.8 billion
Sectoral Mitigation Plan – Land-Use Changes in Private Rural Areas	USD 1.4 billion
Sectoral Mitigation Plan – Agriculture and Livestock	USD 2.8 billion
Sectoral Mitigation Plan – Industry	USD 0.8 billion
Sectoral Mitigation Plan – Cities	USD 1.4 billion
Sectoral Mitigation Plan – Transport	USD 0.6 billion
Sectoral Mitigation Plan – Energy	USD 1.8 billion
Sectoral Mitigation Plan – Solid Waste and Domestic Wastewater	USD 0.8 billion
Total	**USD 11.4 billion**

Source: Compiled by the authors.

* Exchange rate used: 1 USD (U.S. dollar) = 5 BRL (Brazilian real).

Some findings from the Climate Plan are as follows:

- The mobilization of public resources will not be sufficient to close the financing gap for sectoral priorities. In this regard, it will be necessary to coordinate different mechanisms capable of encouraging the redirection of financial flows toward the implementation of mitigation actions by leveraging domestic and international private investments, concessional resources from international climate finance funds, and international cooperation (Brasil, 2026e);
- Adaptation actions rely primarily on public and non-reimbursable resources as their main financing mechanism, whereas mitigation actions have more diversified sources of resources and greater access to the private sector, making them more amenable to being structured as projects with more readily demonstrable financial returns (Brasil, 2026c); and
- There remains a need for a broader understanding of how climate change affects infrastructure, cities and human settlements, and energy, food, and water security, among other themes and sectors of strategic importance to the country. The availability of data and risk analyses, for both the present and the future, focusing on vulnerable populations, constitutes another important gap in tracking adaptation progress in the country and ensuring the effectiveness of the actions under the Climate Adaptation Plan (Brasil, 2026c).

The implementation of the actions set out in the sectoral and thematic plans depends on a coordinated set of means of implementation, encompassing normative, regulatory, financial, and technological instruments. The Cross-Cutting Strategy on Means of Implementation lists the main potential sources of finance, as well as the financial instruments identified for implementing the actions under each of the plans (Brasil, 2026c).

Based on the National Mitigation and Adaptation Strategies, the actions established in the Sectoral and Thematic Mitigation and Adaptation Plans, the emissions profile of the Brazilian economy,

and the commitments undertaken by Brazil in its NDC, the Cross-Cutting Strategy on Means of Implementation (ETMI, Estratégia Transversal de Meios de Implementação) identifies five priority areas (Brasil, 2026c):

a. Restoration of native vegetation;
b. Low-carbon agriculture and livestock farming and sustainable food systems;
c. Economic incentives to reduce the authorized removal of native vegetation;
d. Decarbonization in energy production and use and in industrial processes; and
e. Adaptation and strengthening resilience in cities (87% of Brazil's population currently lives in urban areas).

In addition to the actions listed in the Climate Plan, as reported in BTR1, the Technology Action Plans (TAPs), developed by the country under the project "Technology Needs Assessment for the Implementation of Climate Action Plans in Brazil (TNA_BRAZIL)," also constitute a complementary source of information.

Among the contributions made by CIM members, the following needs were highlighted:

- Need to expand gender-sensitive climate finance in Brazil by creating or strengthening dedicated financing lines for women within existing financial instruments. These resources are meant to support women-led initiatives in areas such as the bioeconomy, resilient agriculture, food security, and climate adaptation, as well as strengthen cooperatives and productive organizations, as exemplified by the "Gender Safeguards and Assessment Protocol for Socioenvironmental and Climate Projects – Guidelines, Methodology, and Scorecard," an instrument that establishes a methodology for assessing gender mainstreaming from an intersectional perspective in climate projects, aimed at improving the integration of a gender perspective into climate finance. Such measures contribute to reducing vulnerabilities and strengthening climate resilience in more vulnerable territories;
- In the agriculture and livestock sector, resources to improve data collection and analysis systems for the quantification, categorization, and classification of livestock production systems, including the minimum variables needed to improve the National Inventory; resources for research aimed at reviewing emission factors for the agriculture sector and the Land Use, Land-Use Change and Forestry (LULUCF) sector; expansion and implementation of mitigation measures; and capacity-building for the technical teams responsible for managing and monitoring these measures;
- Institutional and operational structuring of the Brazilian Greenhouse Gas Emissions Trading System (SBCE, Sistema Brasileiro de Comércio de Emissões de gases de efeito estufa), with the potential to mobilize international finance through transfers of mitigation outcomes under Article 6;
- Expanding access to adaptation resources for traditional peoples and communities and racialized groups, with particular attention to Quilombola communities, traditional peoples and communities of *terreiros* and African origin, and Roma peoples, through accessible financing lines, including non-reimbursable resources, for community-based and territory-tailored initiatives related to water and food security, agroecology, environmental protection of territories, preservation of cultural heritage, and strengthening of resilience.

Additional data can be found in Table A.5.1.

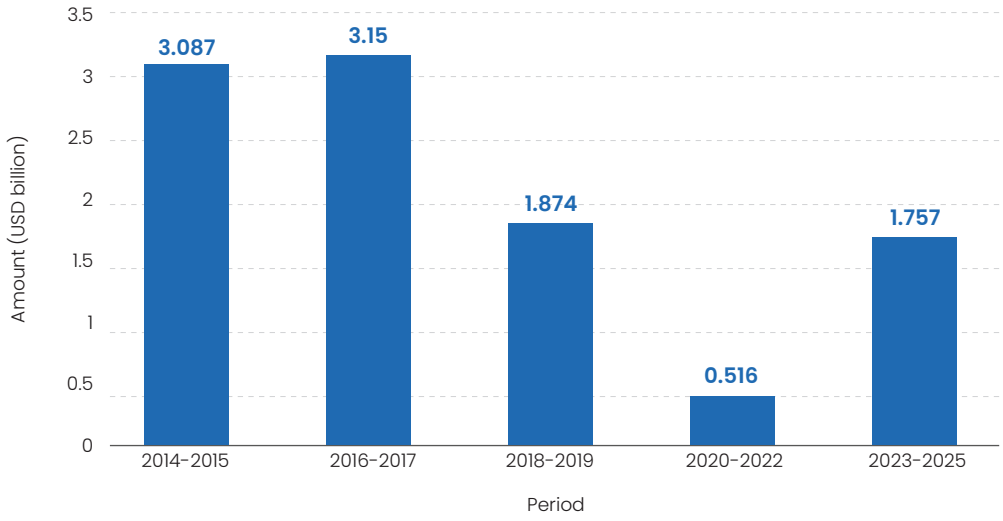
5.4 Information on financial support received by developing country Parties under Article 9 of the Paris Agreement

Information on financial support received was collected through contributions from SAIN/MF, ABC/MRE, and the ministries that are members of the CIM. The data are detailed in **Table CTF III.7**.

According to the survey, resources endorsed/approved for Brazil during the 2023–2025 period totaled approximately USD 1.757 billion (Table 5.3). In BTR1, committed resources had totaled approximately USD 516 million during the 2020–2022 period (Brasil, 2024c). It is worth noting that the survey conducted for BTR1 remained valid for BTR2, as the respective projects are still ongoing or in the planning stage.

According to previous Biennial Update Reports (BURs) (Figure 5.3), committed resources allocated to climate change totaled USD 3.087 billion in 2014–2015 (Brasil, 2017), USD 3.15 billion in the 2016–2017 period (Brasil, 2019), and USD 1.874 billion in the 2018–2019 period (Brasil, 2020). A decline was observed in the 2018–2019 and 2020–2022 periods compared with their respective preceding periods, whereas a new increase occurred in the 2023–2025 period, bringing the amount close to the amount recorded in the 2018–2019 period.

Figure 5.3 Climate-specific resources allocated to Brazil, by period (USD billions)



Source: Compiled by the authors based on data from Brasil (2017, 2019, and 2020).

Table 5.3 below shows that 97% of the approved resources were obtained through multilateral channels and only 3% through bilateral channels. GEF was the main channel, accounting for 49% of the total amount committed, followed by the GCF (29%) and the CIF (14%).[4]

4 The amounts refer to resources endorsed/approved by the respective funds, not necessarily already disbursed to Brazil.

Table 5.3 Resources approved for Brazil through multilateral and bilateral channels

Channel	Details	Amount (USD)	Share	Number of projects
Bilateral	Brazil-Germany	48,487,618.66	3%	5
Multilateral	*Climate Investment Funds*	249,356,534.00	14%	5
Multilateral	*Global Environment Facility*	855,905,104.68	49%	19
Multilateral	*Green Climate Fund*	508,579,147.45	29%	18
Multilateral	Information not available at the time of reporting	95,069,308.84	5%	62
Total		**1,757,397,713.63**	**100%**	**109**

Source: Compiled by the authors.

Regarding the status of the projects, 93 projects are ongoing, accounting for 72.1% of the resources; 14 are planned (26.7% of the resources); and 2 have been completed and are in the financial reporting phase (1.3% of the resources) (Table 5.4).

Table 5.4 Status of the projects

Status of the projects	Amount (USD)	Share	Number of projects
Completed	22,631,006.06	1.3%	2
Ongoing	1,266,340,235.75	72.1%	93
Planned	468,426,471.82	26.7%	14
Total	**1,757,397,713.63**	**100%**	**109**

Source: Compiled by the authors

Regarding the type of approach (Table 5.5), the largest share of resources was allocated to mitigation (52%), while only 5% was allocated to adaptation, reinforcing the argument that most resources remain concentrated on mitigation. A significant share, corresponding to 30%, was identified as cross-cutting (i.e., encompassing both approaches), while the remaining 12% was not disaggregated by the respective approaches considered.

Table 5.5 Allocation of resources by approach

Approach	Amount (USD)	Share	Number of projects
Mitigation	918,935,288.97	52%	14
Adaptation	90,035,064.97	5%	7
Cross-cutting	528,805,168.51	30%	17
Disaggregation unavailable	219,622,191.18	12%	71
Total	**1,757,397,713.63**	**100%**	**109**

Source: Compiled by the authors

5.5 Information on technology development and transfer support needed by developing country Parties under Article 10 of the Paris Agreement

Under the CMA, Decision 15/CMA.1 established the technology framework under the Paris Agreement, highlighting implementation, innovation, an enabling environment, capacity-building, and support among its key themes. The framework explicitly emphasizes the importance of conducting and updating Technology Needs Assessments (TNAs), implementing their outcomes, and aligning them with NDCs, national adaptation plans, and other climate and development strategies. In addition, decisions such as Decision 13/CP.18 reinforce the strategic role of TNAs as instruments for guiding public policies and investments in technology.

In Brazil's case, the update of the first TNA, presented in the first Biennial Transparency Report (BTR1), should ensure that the new version is aligned with Brazil's current NDC under the Paris Agreement, with the structure of the Climate Plan, and its respective sectoral mitigation and adaptation plans and with cross-cutting strategies for climate action. This coordination requires significant institutional effort, particularly given Brazil's complex federal structure and vast territory, which pose additional challenges for coordination, policy integration, and harmonization of regional priorities.

In this context, Brazil's National Designated Entity (NDE) developed a proposal to update the country's first TNA, covering GHG mitigation and including technology needs for adaptation to climate change and alignment with the Climate Plan. Thus, the proposal contributes to ensuring that Brazil's climate commitments are supported by realistic and well-defined technology plans, promoting more effective and coordinated climate action. An estimated USD 5 million is needed for this activity, which aims to update and enhance Brazil's TNA. These resources will be sought from either the GEF or the GCF, depending on their availability.

From a technological perspective, there is a shortage of accessible tools for environmental monitoring, database integration, including to enable traceability and transparency, and the automation of environmental control processes. There is also evidence of the use of mechanisms involving open digital platforms, with appropriate security measures, as well as a lack of local institutional capacity for decentralized implementation, particularly in territories where land tenure conflicts or the absence of the State are more evident (Brasil, 2026e).

Additionally, under the Cross-Cutting Strategy on Women and Climate of the Climate Plan, the need to expand technology transfer initiatives aimed at climate action from a gender perspective is highlighted. This includes the dissemination of methodologies for climate risk analysis, the production and use of gender-disaggregated data, and tools for monitoring climate policies. It is also necessary to expand women's access to sustainable technologies and production practices for climate adaptation and income generation. These actions strengthen institutional and territorial capacities for climate action.

Additional data can be found in Table A.5.1.

5.6 Information on technology development and transfer support received by developing country Parties under Article 10 of the Paris Agreement

With regard to technology development and transfer support, Brazil received:

- **USD 20,000** in technical assistance from the Climate Technology Centre and Network (2016–2018), aimed at supporting the Brazilian Hydrogen Association as a strategic multiplier of hydrogen fuel cell technology (CTCN, 2026);
- **USD 700,000** from the Green Climate Fund's Readiness Programme for the preparation of the first TNA_BRAZIL, entitled "Report on the Technology Needs Assessment for the Implementation of Climate Action Plans in Brazil: Mitigation (2018–2021)," in the context of international support for the implementation of the technology framework under the UNFCCC and the Paris Agreement. It should be noted that the resources obtained from the GCF were insufficient to include technologies aimed at adaptation to climate change, making it necessary to defer this theme to a future opportunity (Brasil, 2021; UNFCCC, 2026).

Although relevant from an institutional perspective, these amounts reveal a significant discrepancy between the recognized central importance of technology development and transfer, repeatedly affirmed in COP and CMA decisions, and the actual amount of resources mobilized.

If technology is, indeed, an essential pillar for developing countries to achieve their mitigation targets, strengthen adaptation, and promote resilient, low-carbon development pathways, financial support must reflect this strategic priority. One-off, small-scale resources, although important for planning and capacity-building, are insufficient to enable structural technological transformation, industrial-scale deployment, systemic innovation, and large-scale implementation.

In the context of the COP and CMA negotiations, this underscores the need to:

- Significantly expand the means for technology implementation;
- Strengthen coherence between the Technology Mechanism and the Financial Mechanism (GEF, GCF, and Adaptation Fund); and
- Ensure predictable, adequate, and scalable support for technology development, demonstration, diffusion, and transfer, in accordance with Article 10 of the Paris Agreement.

The credibility of the climate regime depends on aligning stated political ambition with the actual scale of support mobilized. In this regard, the establishment of the Belém Technology Implementation Programme (BTIP) stands out as the result of a concerted effort by Brazil, in coordination with other developing countries, within the framework of the UNFCCC and the Paris Agreement.

During the preparatory process and throughout COP30, Brazil placed technology implementation at the center of the political agenda, emphasizing that identifying technology needs alone is not enough; it is necessary to create the conditions for transforming technology priorities into concrete actions.

Developing countries, including Brazil, have historically maintained that:

- Technology development and transfer are pillars of the climate regime, alongside mitigation, adaptation, and finance;

- There is a persistent gap between the identification of technological needs and their actual implementation;
- It is necessary to strengthen coherence between the Technology Mechanism and the Financial Mechanism of the Convention;
- It is essential to bridge the financing gap to promote industrial development based on new technologies and the decarbonization of the Brazilian economy, through the mobilization of public and private, domestic and international resources, including through cooperative arrangements under Article 6 of the Paris Agreement.

The BTIP symbolizes a shift in emphasis: from identifying needs to the concrete delivery of solutions. It reflects developing countries' historical demand for greater effectiveness, predictability, and scale in the support for climate technology.

Strengthening the mobilization of means of implementation and accelerating the implementation of climate technologies are crucial to ensuring that technology fully fulfills its role as a strategic driver of climate action in developing countries. This is an essential condition for these countries to achieve their mitigation and adaptation targets, in line with their NDCs and national plans, while promoting sustainable development, systemic innovation, just transitions, and social inclusion.

In this context, it is imperative to move beyond making commitments and toward the actual delivery of support. It is essential to establish clear, structured, and operationally feasible actions, supported by financing at a scale commensurate with climate ambition in order to ensure that support for technology development and transfer to developing countries, as provided for in Article 10 of the Paris Agreement, is effectively implemented in an adequate, predictable, sustainable, and scalable manner. A good example of this was the technical, operational, and methodological support provided by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) to the Ministry of Women under the Climate Plan's Cross-Cutting Strategy on Women and Climate, aimed at the development and transfer of technologies related to climate action from a gender perspective. The activities included the provision of knowledge, participatory methodologies, and analytical tools for developing the strategy, territorial listening sessions involving approximately 250 women across all biomes, and capacity-building activities focused on climate justice and territorial resilience.

Additional data can be found in **Table CTF III.9**.

5.7 Information on capacity-building support needed by developing country Parties under Article 11 of the Paris Agreement

Regarding capacity-building support, needs were identified in coordination with the CIM to expand capacity-building programs on climate action from a gender perspective, particularly those targeting women from rural, forest, and waterside communities; leaders in vulnerable territories; and leaders, organizations, and associations of traditional peoples and communities, with particular attention to traditional peoples and communities of *terreiros* and African origin, Roma peoples, and Quilombola communities. The training programs should cover topics such as climate justice, adaptation, risk management, climate governance, participation in national and UNFCCC processes, and project development to access climate finance, using territory-tailored methodologies and valuing traditional knowledge.

Also from a gender perspective, with a view to increasing women's effective participation in climate action, the need to strengthen capacity-building in sustainable production practices and in the use of technologies for climate adaptation and mitigation was also identified. Another identified need concerns the agriculture sector, for which capacity-building actions were proposed for the technical teams responsible for managing and monitoring sectoral mitigation measures.

In addition, as part of the technical expert review process conducted by the UNFCCC Technical Expert Review Team (TERT), in consultation with Brazil, capacity-building needs were identified in relation to the flexibilities applied by the country in accordance with the Modalities, Procedures and Guidelines (MPGs) for the enhanced transparency framework (ETF), with a view to facilitating the preparation of subsequent Biennial Transparency Reports (BTRs).

The Brazilian government also identified, in its first BTR (Chapter 5), the need for support to strengthen institutional arrangements for preparing national greenhouse gas inventories, particularly in the Land Use, Land-Use Change and Forestry (LULUCF) and Industrial Processes and Product Use (IPPU) sectors, including data collection and management, the application of higher-tier methods, and the training of experts. Part of this support has been provided through enabling activity project BRA/23/G31, implemented with GEF funds (see **section 5.9**), aimed at preparing the Fifth National Communication (5NC) and the BTRs, as well as through the strengthening of the National Transparency System (DataClima+), which supports national policymaking and compliance with ETF requirements.

Similarly, the international technical review identified capacity-building needs of varying priority levels related to improving national reporting. Regarding general aspects, the need to strengthen quality assurance and quality control (QA/QC) processes in the preparation of the BTR and the National Inventory Report (NIR), as well as to improve understanding of the use of ETF reporting tools, including the completion of the Common Reporting Tables (CRTs) and Common Tabular Formats (CTFs), was identified as a medium priority.

Regarding the National Inventory Report (NIR), sector-specific needs were identified. In the Energy sector, medium-priority needs include improving understanding of the national parameters required to convert physical units into energy units for fuel consumption and to allocate fuels to the relevant sectors, as well as identifying sources of activity data for estimating emissions in energy sector categories using data obtained from non-official sources, such as corporations. In the IPPU sector, high-priority needs were identified concerning the estimation of fluorinated gas emissions for subcategory 2.F.1 (refrigeration and air conditioning) and the disaggregation of activity data for estimating nitrogen trifluoride emissions in subcategory 2.E.3 (photovoltaics). In the Agriculture sector, low-priority needs were identified concerning the disaggregation of sewage sludge from wastewater treatment plants applied to soils and the collection of activity data on the use of compost on agricultural soils. In the LULUCF sector, a medium-priority need was identified to complete and update a consistent time series of annual land-use and land-use change data for land representation purposes, along with a low-priority need to apply splicing techniques, in accordance with the 2006 IPCC Guidelines, to obtain annual time series for LULUCF categories from periodically collected data. In the Waste sector, a high-priority need was identified to systematize databases on solid waste generation and treatment to enable the accurate classification of disposal sites throughout the time series, along with a low-priority need to improve the assessment of the statistical consistency of the time series.

Finally, with regard to the information needed to track progress in implementing and achieving the Nationally Determined Contribution (NDC) under Article 4 of the Paris Agreement, three main

needs were identified, all with high priority: i) establishing a permanent system for estimating the GHG emission reductions expected and achieved from policies and measures (PaMs), in order to ensure their periodic reporting; ii) establishing a sustainable system for preparing GHG emission projections, for the same purpose; and iii) developing technical capacity, data collection systems, methodologies, and institutional arrangements to compile, assess, and report information on the interactions between mitigation measures, the costs associated with each policy or measure, how these measures affect long-term trends in greenhouse gas emissions and removals, and the assessment of the economic and social impacts of response measures.

Further information can be found in **Table CTF III.11**. It should be noted that, despite the effort made to conduct this survey, it cannot be considered exhaustive. Other needs, therefore, may be included in the future.

5.8 Information on capacity-building support received by developing country Parties under Article 11 of the Paris Agreement

Regarding the capacity-building support received by Brazil, the ministries comprising the CIM were also consulted and reported on various topics covered by capacity-building activities conducted in different areas.

Regarding broader topics, capacity-building activities were reported on multilevel and multisectoral climate governance, the promotion of transformative climate policies, and the development of climate change-related capacities, as well as technical support in climate finance and climate communication.

In the economic sphere, capacity-building activities were reported on the regulation of sustainable finance markets and sustainable bonds, as well as on the bioeconomy.

Regarding efforts to combat deforestation, capacity-building activities focused on improving the detection and prediction of new deforestation events in the Brazilian Amazon through the use of satellite radar imagery and artificial intelligence techniques.

Another capacity-building activity mentioned aimed to promote integrated and participatory territorial environmental management of terrestrial and marine areas, adopting an approach based on the connections between these areas, with a view to conserving biodiversity. Participants included the state governments of Alagoas, Pernambuco, Bahia, and Espírito Santo, as well as municipal governments, associations, social movements, non-governmental organizations (NGOs), the private sector, and various other stakeholders involved in implementing mitigation and adaptation activities in both terrestrial and marine areas. Capacity-building activities were also conducted on climate risk management, including ecosystem-based adaptation (EbA) solutions.

Finally, under the Cross-Cutting Strategy on Women and Climate (ETMC), capacity-building activities were conducted to strengthen women's engagement in the climate agenda, involving approximately 250 women leaders in territorial listening sessions, with training in climate justice and resilience, as well as 100 women from rural, forest, and waterside communities who received training in climate governance and participation in UNFCCC processes, with a focus on COP30. Between 2024 and 2026, listening, training, mobilization, and social participation activities recorded

a total of 2,877 instances of women's participation in various activities, including targeted listening sessions to inform the development of the ETMC, preparatory meetings and forums of the 5th National Conference on Policies for Women, the National Women and Climate Coordination Initiative, the two editions of the Popular Diplomacy course, women and youth plenary sessions across the biomes, the Women for Climate project (*Projeto Elas pelo Clima*), forums for the participation of Quilombola women, training under the Training Program for Community Health Educators (AgPopSUS, Agentes Educadoras e Educadores Populares de Saúde), and a webinar with women managers at state level. In the state of Pará, specific initiatives have strengthened the capacity of women who are waste collectors and members of Quilombola communities in the management of productive organizations and combating gender-based violence.

Additional data can be found in **Table CTF III.11**.

5.9 Information on support needed and received by developing country Parties for the implementation of Article 13 of the Paris Agreement and transparency-related activities, including for transparency-related capacity-building

The preparation of Brazil's Second Biennial Transparency Report (BTR2) and Fifth National Communication (5NC) was made possible through financial support received from the GEF for the development of project BRA/23/G31, totaling USD 7.5 million, of which approximately USD 1.7 million was allocated to the project component dedicated to preparing the country's first three BTRs. These resources are essential to ensure that the information provided is kept up to date, without which data collection would be compromised. This project is executed by the Ministry of Science, Technology and Innovation (MCTI) and implemented in partnership with the United Nations Development Programme (UNDP). Through this project, it was possible to prepare the Fifth Biennial Update Report (BUR5) and the First Biennial Transparency Report (BTR1), both submitted to the UNFCCC in December 2024.

It should be noted that the resources allocated to the preparation of this document are not limited to those received from the GEF. The institutions involved have significant support and contributions from different bodies and a great deal of engagement from teams from other projects and from the government itself.

The team involved in preparing this BTR would like to acknowledge the support received from the United Nations Framework Convention on Climate Change (UNFCCC) and the Consultative Group of Experts (CGE) through the organization of training sessions and workshops on BTR preparation and capacity-building for experts for the international review of these reports. These initiatives contributed significantly to the development of the team involved in preparing this document.

Regarding support for transparency-related activities, workshops were held by the Monitoring Working Group under the CIM to strengthen capacities in monitoring, evaluation, and transparency. The activities also supported the Ministry of Women in preparing the monitoring chapter of the Cross-Cutting Strategy on Women and Climate (ETMC), including guidance on indicators and the systematization of information, as well as integrating the ETMC into national climate governance monitoring mechanisms, with the first monitoring cycle scheduled to begin in 2026.

Additional information is available in **Table CTF III.13**.

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CHAPTER 5 APPENDIX

Table A.5.1 Information on financial, capacity-building, or technology transfer support needed

Notation keys: NA = not applicable; UA = information not available at the time of reporting; NR = not reported (to indicate the voluntary character of the information)

Activity	Sector	Gap
Support for institutional development to establish and train a qualified technical team to conduct parametric modeling analyses using integrated assessment models (IAMs)	Agriculture, LULUCF, Energy, Industry, Transport, Cities, and Waste	Lack of support and institutional strengthening for the long-term development and retention of a qualified technical team to develop and improve long-term scenarios of greenhouse gas emission pathways and mitigation options using integrated assessment models (IAMs).
Measurement, reporting, and verification of actions to transform and maintain resilient and sustainable production systems.	Agriculture	Lack of more detailed data collected in situ and through imagery to measure and validate efforts and results.
Measurement, reporting, and verification of actions to transform and maintain resilient and sustainable production systems.	Agriculture	Lack of a participatory and integrated system for entering data into the tracking system and of streamlined processes for information input and output.
Measurement, reporting, and verification of actions to transform and maintain resilient and sustainable production systems.	Agriculture	Lack of a participatory process and an integrated system for the validation and verification of results by experts for monitoring and analysis purposes

Barrier	Financial resources needed	Capacity-building needed	Technology transfer needed
Limited resources for retaining a qualified technical team; the absence of mechanisms to retain qualified researchers at Brazilian research centers and universities; and the lack of long-term partnerships between the Federal Government and Brazilian research centers and universities.	Development of research related to mitigation of GHG emissions, adaptation to the adverse effects of climate change, and integrated assessment models (IAMs); long-term support for the development of studies and research projects on IAMs; and measures to establish long-term institutional positions for senior researchers as a means of retaining qualified professionals in Brazil.	Exchanges and sharing of experiences with other countries on the state of the art in integrated assessment models (IAMs) and climate change mitigation and adaptation.	Exchange of technology and knowledge with the world's most advanced nations in this field
Vast territory to cover for verification and validation, and limited resources for purchasing equipment and traveling across the country.	Acquisition of or access to imagery and in situ visits to assess and validate the interpretation.	NA	NA
Wide diversity of systems and stakeholders involved across the various Federative Units; dynamic evolution of actions and knowledge requiring an easily accessible, transparent, and consistent system; and limited resources for hiring national experts in data storage and organization systems with streamlined processes for data input and information output.	Recruitment of the personnel needed to develop and structure a participatory and integrated system for entering data into the monitoring system.	NA	NA
Diversity of stakeholders involved across the various Federative Units; dynamic evolution of activities, technologies, and knowledge; differences in the performance of technologies and systems across the various biomes; and limited resources for hiring national experts and covering stakeholders' travel expenses for consultations, verification, discussion, and data validation.	Development and implementation of an integrated system and a participatory process for validating the results of analyses.	NA	NA

Activity	Sector	Gap
Measurement, reporting, and verification of actions to transform and maintain resilient and sustainable production systems.	Agriculture	Limited availability of harmonized preliminary information for the development of a national traceability and certification system.
Training for technical and financial assistance personnel	Agriculture	Knowledge gaps regarding best practices and technologies and systems suited to the various biomes.
Research and technological development	Agriculture	Increased complexity and uncertainty due to climate change; need for new research in the biological and agricultural fields; statistics and data interpretation; and alternative and innovative solutions.
Cooperation between the Federal Government and the states to improve forest management	LULUCF	Shortcomings in the integration of systems for issuing vegetation removal permits across the various levels of government
Strengthening wildfire prevention and control measures.	LULUCF	Integrated fire management techniques are not yet widely disseminated.

	Barrier	Financial resources needed	Capacity-building needed	Technology transfer needed
	Diversity of data and institutions; lack of a strategy to ensure the necessary transparency and reliability of a national traceability and certification system; limited resources for hiring national experts and for conducting preliminary studies for a traceability and certification system.	Establishment of an effective traceability and certification system	Training of experts in traceability and certification systems	NA
	Limited resources to promote the necessary capacity-building, consolidation, and dissemination of knowledge, taking into account the diversity of stakeholders involved across the various Federative Units; the dynamic evolution of activities, technologies, and knowledge; and differences in the performance of technologies and systems across the various biomes.	Infrastructure development, studies, equipment acquisition, and capacity-building.	Professional training and knowledge dissemination	NA
	Limited resources for data collection, studies, and technological development	Infrastructure, equipment, and studies	Exchange of knowledge and technologies	Exchange of knowledge and technologies
	Limited resources, including budgetary constraints	Technical and institutional cooperation	Raising awareness of the importance of the initiative for the country's reputation and for the formulation of public policies to combat illegal activities and promote compliance with the law.	NA
	Limited resources, including budgetary constraints	Dissemination of techniques for the control and prevention of wildfires	Training in integrated fire management	NA

Activity	Sector	Gap
Promotion of the bioeconomy and payments for environmental services	LULUCF	A favorable business environment and a lack of legal certainty
Development and implementation of new pilot projects in regions not covered by the ongoing project	LULUCF and Industry	Limited availability of financing sources for new pilot projects
Expansion of the results-based payment mechanism to companies not covered by the ongoing project	LULUCF and Industry	Limited availability of financing sources to extend results-based payments to companies not covered by the ongoing project
Promoting gains from scaling up the pilot project	LULUCF and Industry	Limited availability of financing sources to achieve gains from scaling up the ongoing pilot project.
Capacity-building to increase the share of non-conventional renewable energy sources in the national energy matrix	Energy	Need for the consolidation and dissemination of concentrated solar thermal power generation technologies
Capacity-building to increase the deployment of energy storage technologies	Energy	Need for the consolidation and dissemination of energy storage technologies

Barrier	Financial resources needed	Capacity-building needed	Technology transfer needed
Lack of recognition of the importance of the contribution of market mechanisms	NA	Management of streamlined, efficient, and user-oriented administrative processes	Exchange of technologies for process management
Limited financial resources	Development and implementation of new pilot projects	Training for stakeholders in regions not covered by the ongoing project	Technology transfer to stakeholders in regions not covered by the ongoing project
Limited financial resources	Extension of results-based payments to companies not included in the ongoing project	Training for stakeholders not included in the current project (e.g., MRV methodology, MRV platform)	NA
Limited financial resources	Promoting gains from scaling up the pilot project	Training for stakeholders not involved in the pilot project	Technology transfer to stakeholders not involved in the pilot project
Limited financial resources	Technological development, consolidation, and dissemination of knowledge on concentrated solar thermal power plants	Professional training and dissemination of knowledge on concentrated solar thermal power (seminars, workshops, and exchanges of experience on the subject)	Cooperation on technological development in concentrated solar thermal power
Limited financial resources	Technological development, consolidation, and dissemination of knowledge on energy storage	Professional training and dissemination of knowledge on energy storage (seminars, workshops, and exchanges of experience on the subject)	Cooperation on technological development in energy storage

Activity	Sector	Gap
Capacity-building to promote the consolidation of Monitoring, Reporting and Verification (MRV) systems of energy efficiency programs	Energy	Shortcomings in the Monitoring, Reporting and Verification (MRV) processes of energy efficiency programs
Quantification of greenhouse gas emission reductions by supply chain	Agriculture, Energy, LULUCF, and Industry	Methodological challenges in quantifying emission reductions by supply chain
Promotion of research and technological development	Agriculture, Waste, Energy, LULUCF, and Industry	Lack of information and data on activities, and insufficient technical and scientific production based on the country's reality
Improvement of the Monitoring, Reporting and Verification (MRV) System for emissions	Agriculture, Waste, Energy, LULUCF, and Industry	Official information is insufficiently systematized, organized, or available
Strengthening existing institutional arrangements through capacity-building and the generation of information through climate and economic modeling	Agriculture, Waste, Energy, LULUCF, and Industry	Lack of an official information center to inform decision-making on climate change

Barrier	Financial resources needed	Capacity-building needed	Technology transfer needed
Limited financial resources	Development and dissemination of methodologies and procedures for the MRV of energy efficiency programs	Professional training and dissemination of knowledge on MRV in Energy Efficiency (seminars, workshops, and exchanges of experience on the subject).	Cooperation for the development and dissemination of methodologies and procedures for the MRV of energy efficiency programs
Lack of awareness regarding the importance of generating data on emissions and removals by economic activity	NA	Development, implementation, and dissemination of methodologies	Methodologies and technologies for quantifying emission reductions by supply chain
Limited financial resources for climate sciences	Infrastructure, equipment, and promotion of studies and research projects focused on climate change	Exchanges, webinars, sharing of experiences with other countries, and training to enable the transfer of technologies and knowledge	Exchange of technologies and knowledge
Lack of a legal framework defining the responsibilities and operation of a system for the country's national greenhouse gas emissions inventory	Infrastructure and institutions responsible for systematizing information	Training to establish the necessary structures and ensure the availability of information for proper Monitoring, reporting and verification (MRV) of emissions	Exchange of technologies and knowledge
Limited financial resources	Development of a platform and promotion of targeted studies and research projects to inform a long-term climate change strategy	Exchanges, *webinars*, and sharing of experiences with other countries regarding modeling and information networks to inform decision-making	Exchange of technologies and knowledge

Activity	Sector	Gap
Improvement of data collection and analysis systems for the quantification, categorization, and classification of livestock production systems, including the minimum variables necessary to improve the National Inventory	Agriculture	Disaggregated input data and lack of information on the characteristics of production systems
Research for the review of emission factors for the agriculture sector and for the agriculture-related LULUCF sector.	Land Use, LULUCF	Lack of experimental studies and analyses of national data
Expansion of mitigation measures in the Agriculture Sector	Agriculture	Methodological inconsistencies between mitigation measures and the inventory
Training of technical teams responsible for managing and monitoring mitigation measures	Agriculture	Limitations in incorporating the effects of improvements in production systems into the National Inventory

Barrier	Financial resources needed	Capacity-building needed	Technology transfer needed
Lack of adequate coordination among the Ministries of Agriculture and the Environment, statistical agencies, state agriculture agencies, and private sector associations.	Increased adoption of mitigation measures	Training of technical teams responsible for managing and monitoring mitigation measures	NA
Limited financial resources	Improvement and organization of information and data collection systems	NA	NA
	Research and periodic updating of parameters	NA	NA
	NA	Training of technical teams responsible for managing and monitoring mitigation measures	NA



CHAPTER 6

Information on flexibilities

With a view to promoting universal participation, the ETF and its MPGs include an inherent flexibility that takes into account the different capacities of the Parties and is based on the collective experience of developed and developing countries. The MPGs specify the flexibility provisions available to those developing country Parties that need it in the light of their capacities, pursuant to Article 13, paragraph 2.

The application of the flexibility provided for in the provisions of the MPGs for developing country Parties shall be self-determined, i.e., the country will determine when the flexibility can be applied in the light of its capacity constraint(s) and always in relation to a specific reporting requirement to which such flexibility can be applied.

In doing so, developing country Parties shall clearly indicate the provision to which flexibility is applied, concisely clarify the capacity constraints, noting that some constraints may be relevant to several provisions, and provide estimated and self-determined time frames for improvements in relation to these capacity constraints.

Therefore, the flexibility provision under the Paris Agreement is essential to ensure the effective participation of all countries, taking into account their different circumstances and capacities. These provisions allow developing countries to adapt their commitments to their specific circumstances, ensuring progress in a sustainable and equitable manner, while receiving the international support necessary to strengthen their capacities over time.

Dataframes 6.1 and 6.2 present a general overview of the flexibility provisions of the MPGs for preparing the GHG inventory and tracking the progress of the NDC, respectively. In addition, an assessment is made as to whether or not Brazil has used these provisions, in the light of its national capacities.

Dataframe 6.1 Flexibility provision used by Brazil to prepare the National Inventory

MPG Reference (Annex to Decision 18/ CMA.1)	Provisions in the MPGs	Indication of the flexibility provision used by Brazil in the light of its capacities
Paragraph 25 *Key category analysis*	Each Party shall implement the key category analysis consistent with the IPCC guidelines (i.e., apply the 95% threshold defined in the IPCC Guidelines).	**Flexibility not used by the country**. The 95% threshold was used to identify the categories, in accordance with the IPCC Guidelines.
Paragraph 29 *Uncertainty assessment*	Each Party shall quantitatively estimate and qualitatively discuss the uncertainty of emission and removal estimates for all categories, including the inventory totals, for at least the starting year and the latest reporting year of the inventory time series, and shall also estimate the trend uncertainty for these same categories/inventory totals for the entire time series.	**Flexibility not used by the country**. Brazil estimated the uncertainties of the Inventory for all categories for the starting year (1990) and for the latest year of the time series (2024).

MPG Reference (Annex to Decision 18/ CMA.1)	Provisions in the MPGs	Indication of the flexibility provision used by Brazil in the light of its capacities
Paragraph 32 *Use of the notation key "NE" (not estimated)*	A category should only be considered insignificant if the likely level of emissions is below 0.05 per cent of the national total GHG emissions, excluding LULUCF, or 500 kilotonnes of carbon dioxide equivalent (kt CO_2 eq), whichever is lower. The total national aggregate of estimated emissions for all gases from categories considered insignificant shall remain below 0.1 per cent of the national total GHG emissions, excluding LULUCF.	**Flexibility not used by the country**. The country did not use the flexibility for the non-estimation of categories considered to be insignificant. Emissions were estimated and accounted for in the inventory for all categories for which data were available, without considering their degree of significance.
Paragraph 34 *Quality assurance / Quality control*	Each Party shall elaborate an inventory quality assurance and quality control plan in accordance with IPCC guidelines, including information on the inventory agency responsible for implementing QA/QC.	**Flexibility not used by the country**. Brazil has an inventory quality assurance and quality control plan. The MCTI is responsible for implementing this plan.
Paragraph 35 *Quality assurance / Quality control*	Each Party shall implement and provide information on general inventory QC procedures in accordance with its QA/QC plan and the IPCC guidelines.	**Flexibility not used by the country**. Brazil implements the inventory quality assurance and quality control plan.
Paragraph 48 *Gases*	Each Party shall report seven gases: CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3.	**Flexibility not used by the country**. All gases listed in paragraph 48 were accounted for and reported.
Paragraph 57 *Time Series*	Each Party shall report a consistent annual time series starting from 1990.	**Flexibility not used by the country**. The annual time series starts from 1990.
Paragraph 58 *Reporting year*	The latest reporting year shall be no more than two years prior to the submission of its national inventory report.	**Flexibility not used by the country**. The latest reporting year (2024) is no more than two years prior to the submission of the report (2026).

Dataframe 6.2 Flexibility provision used by Brazil with regard to tracking of NDC progress

MPG Reference (Annex to Decision 18/CMA.1)	Provisions in the MPGs	Indication of the flexibility provision used by Brazil, in the light of its capacities
Paragraph 85 *Expected and achieved GHG emission reductions for its actions, policies and measures (PAMs)*	Each Party shall provide, to the extent possible, estimates of expected and achieved GHG emission reductions for its actions, policies and measures (PAMs)	**Flexibility not used by the country**. In Chapter 3, Section 3.4, Brazil reported the estimates of expected and achieved GHG emission reductions for its Climate Mitigation Plan (a national instrument for achieving the NDC targets), at an aggregate level, encompassing the National Mitigation Strategy and its component Sectoral Mitigation Plans.
Paragraph 92 *Projections of greenhouse gas emissions and removals*	Each Party shall report its projections pursuant to paragraphs 93–101 of the MPGs	**Flexibility not used by the country**. Brazil reported projections of GHG emissions and removals in Chapter 3, Section 3.6.
Paragraph 95 *Extent of the projections*	Projections shall begin from the most recent year in the Party's national inventory report and extend at least 15 years beyond the next year ending in zero or five.	**Flexibility not used by the country**. Brazil reports projected GHG emissions and removals for the years 2025, 2030, 2035, and 2040. The scenarios start in 2020, owing to the conditions, data and assumptions available in 2023 and 2024, when the scenarios were developed.
Paragraph 102 *Methodology or coverage of the projections*	Those developing country Parties that need flexibility in the light of their capacities can instead report using a less detailed methodology or coverage.	**Flexibility not used by the country**. Brazil provides a detailed description of the methodology and coverage of the projections of GHG emissions and removals presented in Chapter 3, Section 3.6.



CHAPTER 7

Additional information

7.1 Research and systematic observation

7.1.1 Institutional arrangement for meteorological research and observation in Brazil

Meteorological research and systematic observation are key elements for the implementation of the United Nations Framework Convention on Climate Change (UNFCCC), for the production of national climate information, and for supporting public policies on mitigation, adaptation, and transparency. In this respect, the Convention establishes that the Parties shall support and develop programs and networks for systematic climate observation, including the atmosphere, the ocean, the cryosphere, and the Earth's surface, as well as promote the exchange of scientific, technical, and socioeconomic information relevant to its implementation (UNFCCC, 1992, Articles 4.1(g), 4.1(h), 5, and 12). The guidelines for the preparation of National Communications by Parties not included in Annex I, on the other hand, provide guidance on reporting information regarding measures adopted, observation networks and programs, contributions to regional and international systems, and needs related to systematic observation (Decision 17/CP.8, annex, section VI; UNFCCC, 2002). Under the Paris Agreement, this information is linked to the Enhanced Transparency Framework established by Decision 18/CMA.1 and to the option of jointly submitting National Communications and Biennial Transparency Reports, in accordance with Decision 1/CP.24 and Decision 5/CMA.3.

In Brazil, meteorological research and observation are organized through an institutional arrangement that is broad, decentralized, and inter-institutional and which reflects both the country's vast territory and the diversity of topics related to the climate system. This arrangement involves federal agencies, research institutions, state-level networks, sector-specific operators, and data platforms, spanning fields such as science and technology, meteorology, climatology, hydrology, water resources, oceanography, geosciences, the environment, defense, agriculture, and land management. The description provided in this chapter is based on primary institutional sources (CPTEC/INPE, INMET, DECEA, DHN, ANA, CEMADEN[1] and other network operators), supplemented by regulatory documentation and technical surveys compiled during the reference period of this document.

At the regulatory level, the National Policy on Climate Change (PNMC, Política Nacional sobre Mudança do Clima), established by Law No. 12,187/2009 (Brasil, 2009b), is the primary national legal instrument for climate governance, as described in **Chapter 1 - National context**.

The PNMC establishes the principles, objectives, guidelines, and instruments of Brazil's climate policy, and lists, in Article 7, the institutional instruments that implement it, expressly including the Commission for the Coordination of Meteorological, Climatological, and Hydrological Activities (CMCH, Comissão de Coordenação das Atividades de Meteorologia, Climatologia e Hidrologia), the National Communications to the UNFCCC, and the national inventory of greenhouse gas emissions.

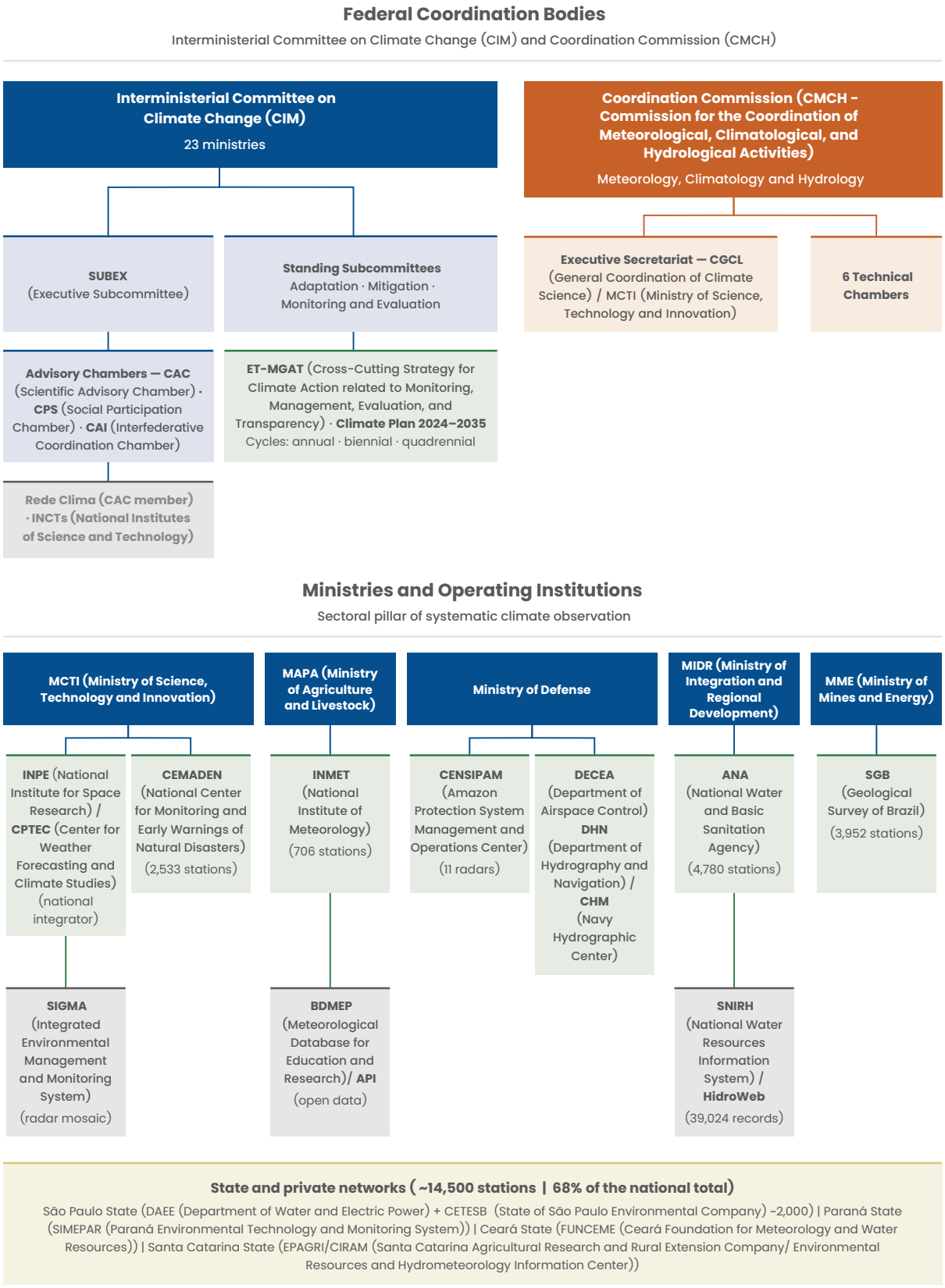
1 Namely: CPTEC/INPE - Center for Weather Forecasting and Climate Studies (Centro de Previsão de Tempo e Estudos Climáticos) of the National Institute for Space Research (Instituto Nacional de Pesquisas Espaciais); INMET - National Institute of Meteorology (Instituto Nacional de Meteorologia); DECEA - Department of Airspace Control (Departamento de Controle do Espaço Aéreo); DHN - Department of Hydrography and Navigation (Diretoria de Hidrografia e Navegação); ANA - National Water and Basic Sanitation Agency (Agência Nacional de Águas e Saneamento Básico); CEMADEN - National Center for Monitoring and Early Warnings of Natural Disasters (Centro Nacional de Monitoramento e Alertas de Desastres Naturais).

The CMCH was initially established by Law No. 10,683, dated May 28, 2003, as part of the basic structure of the Ministry of Science and Technology (MCT, Ministério da Ciência e Tecnologia). The regulations governing this commission were established by Decree No. 6,065, dated March 21, 2007 (Brasil, 2007a), and amended by Decree No. 6,971, dated September 29, 2009 (Brasil, 2009a). The CMCH is the primary federal body responsible for coordinating meteorological, climatological, and hydrological activities, with decision-making authority to coordinate observation networks and strengthen the national climate monitoring infrastructure, in collaboration with the PNMC. Its Executive Office is managed by the General Coordination of Climate Science (CGCL, Coordenação-Geral de Ciência do Clima), and the presidency is held by the Office for Strategic Policies and Programs (SEPPE, Secretaria de Políticas e Programas Estratégicos), both of which are under the MCTI. The Commission is comprised of 22 members, representing ministries, federal agencies, scientific organizations, and the private sector. Its internal structure consists of a Plenary, an Executive Committee, and six permanent Technical Chambers, in accordance with the bylaws approved by SEPED – Office for Research and Development Policies and Programs (Secretaria de Políticas e Programas de Pesquisa e Desenvolvimento/MCT - Ministry of Science and Technology (Ministério da Ciência e Tecnologia)) Ordinance No. 2/2008 (Brasil, 2008).

Specifically with regard to this systematic observation, the relevant institutional arrangement is divided among: (a) the MCTI, which coordinates the CMCH through the CGCL and includes INPE and CEMADEN; (b) MAPA - the Ministry of Agriculture and Livestock (Ministério da Agricultura e Pecuária), to which INMET is linked as the official synoptic meteorological agency; (c) the Ministry of Defense, which includes DECEA, the DHN, CENSIPAM - Amazon Protection System Management and Operations Center (Centro Gestor e Operacional do Sistema de Proteção da Amazônia), and the CHM - the Navy Hydrographic Center (Centro de Hidrografia da Marinha); (d) the MIDR - the Ministry of Integration and Regional Development (Ministério da Integração e do Desenvolvimento Regional), to which ANA is linked; (e) the MME - the Ministry of Mines and Energy (Ministério de Minas e Energia), to which the SGB is linked; and (f) the states of the Federation, through their agencies and departments of the environment and water resources.

The relationship between these institutions is summarized in Figure 7.1.1, which presents a simplified organizational chart of the main institutions and governance bodies for meteorological observation in Brazil, identifying the Commission for the Coordination of Meteorological, Climatological, and Hydrological Activities (CMCH) and the Interministerial Committee on Climate Change (CIM, Comitê Interministerial sobre Mudança do Clima) as the two coordinating bodies at the federal level with responsibilities related to this topic.

Figure 7.1.1 Organizational Chart of the Federal Governance Structure for Systematic Meteorological Observation in Brazil.



Source: Prepared based on Decree No. 11,550/2023, Decree No. 6,065/2007, the 2024-2035 Climate Plan, and ET-MGAT - Cross-Cutting Strategy for Climate Action related to Monitoring, Management, Evaluation, and Transparency (Estratégia Transversal para Ação Climática de Monitoramento, Gestão, Avaliação e Transparência) (Brasil, 2026b).

The national meteorological observation system is extensive and consists of networks with different mandates, scales, and modes of operation. The inter-institutional survey of the meteorological and hydrological monitoring network, compiled in February 2026, based on available primary institutional databases, identified 23,981 operational stations linked to 847 institutions[2]. This system is organized into three institutional tiers: (1) the five institutions that form the core of the CMCH – namely: MCTI, CPTEC/INPE, INMET, DECEA, and DHN; (2) the complementary federal institutions, which include ANA, CEMADEN, SGB - Geological Survey of Brazil (Serviço Geológico do Brasil), CENSIPAM, and EMBRAPA - Brazilian Agricultural Research Corporation (Empresa Brasileira de Pesquisa Agropecuária); and (3) the state, municipal, private, and other institutional networks[3] (ANA, 2026; INMET, 2026; INPE, 2026; CEMADEN, 2026). This arrangement demonstrates the country's extensive climate observation network, while also highlighting the importance of coordination mechanisms capable of harmonizing mandates, metadata standards, data transmission methods, access policies, and data integration procedures.

Despite its extensive reach, the national arrangement still faces significant structural challenges. Among these, the following stand out: the need to improve the interoperability among databases and systems; the standardization of metadata, transmission protocols, quality criteria, and access policies; and the strengthening of the governance of observational data. The lack of a formal, permanent national coordinating body makes it difficult to achieve harmonization among networks with different mandates, scopes, and capabilities. Additionally, there is a need to ensure the long-term maintenance, modernization, and operational sustainability of the networks, including the conventional weather stations, some of which are over a century old. This is essential for preserving the continuity, comparability, and quality of the observational series.

Within the broader context of climate governance, the Interministerial Committee on Climate Change (CIM) plays a central role in the coordination of federal public policies related to climate change, and the Climate Plan has been the country's primary climate planning instrument in recent years. The Climate Plan organizes mitigation and adaptation actions and cross-cutting strategies, including the Cross-Cutting Strategy for Monitoring, Management, Evaluation, and Transparency (ET-MGAT) (Brasil, 2025a; 2026a) (see **Chapter 1. National context**). For systematic observation, ET-MGAT is particularly important because it establishes periodic cycles of monitoring, impact assessment, and updates to the Climate Plan, thereby creating institutional demand for consistent meteorological data, continuous time series, reliable indicators, and mechanisms for integrating science, information, and public policy. The strategy provides for strengthening information systems focused on climate transparency, including DataClima+ (Box 1.3), designed as a national climate transparency system under the Paris Agreement (Brasil, 2026a; UNFCCC, 2018).

The Cross-Cutting Strategy for Education, Training, Research, Development, and Innovation (ET-ECAPI, Estratégia Transversal de Educação, Capacitação, Pesquisa, Desenvolvimento e Inovação) is indirectly linked to systematic observation, in that the training of qualified personnel and the promotion of applied research are prerequisites for the long-term sustainability of monitoring networks (for more information, see **Section 7.2**).

2 The quantitative characterization of the national observation network is based on the consolidation of primary institutional databases, including SNIRH - National Water Resources Information System (Sistema Nacional de Informações sobre Recursos Hídricos)/HidroWeb/ANA, INMET, SIGMA/CPTEC/INPE, and CEMADEN, as detailed in the atmospheric observation section.

3 CMCH, Commission for the Coordination of Meteorological, Climatological, and Hydrological Activities; MCTI, Ministry of Science, Technology and Innovation; CPTEC/INPE, Center for Weather Forecasting and Climate Studies of the National Institute for Space Research; INMET, National Institute of Meteorology; DECEA, Department of Airspace Control; DHN, Department of Hydrography and Navigation; ANA, National Water and Basic Sanitation Agency; CEMADEN – National Center for Monitoring and Early Warnings of Natural Disasters; SGB, Geological Survey of Brazil; CENSIPAM, Amazon Protection System Management and Operations Center; EMBRAPA, Brazilian Agricultural Research Corporation.

The coordination between the CMCH and the CIM is a key element of Brazil's institutional arrangement for systematic observation. The CMCH has a specific mandate related to the coordination of meteorological, climatological, and hydrological activities, while the CIM serves as the coordinating body for climate policy in the broadest sense. The reorganization of the CIM and the consolidation of the 2024-2035 Climate Plan have changed the institutional context of meteorological observation in Brazil, by creating an institutionalized demand for climate data and indicators and by linking national transparency processes to the Enhanced Transparency Framework under the Paris Agreement. In this context, the integration of sectoral coordination mechanisms with climate governance processes tends to strengthen the role of data-producing agencies in the formulation, implementation, and evaluation of national climate policy. This improvement can be seen, for example, in studies attributing extreme events, such as heat waves and geo-hydrological events, to climate change, in which systematic monitoring helps to improve the empirical basis of the analyses and expand the capability to produce quantitative estimates.

In addition to providing inputs for the reports submitted to the UNFCCC, systematic observation serves as critical infrastructure for the development of national climate services. Continuous and consistent observational data that are made available in a timely manner support weather and climate forecasting, early warning systems, the monitoring of extreme events, and activities such as agricultural planning, for example, the Agro-Climate Risk Zoning (ZARC, Zoneamento Agrícola de Risco Climático). They also support water resources management, food security, and disaster prevention. Thus, these data support not only international reporting commitments, but also the country's adaptive capacity and climate resilience.

The effectiveness of these services depends, however, on how the data are integrated and made available. Although the diversity of institutions, platforms, and networks expands the reach of systematic observation, it also poses challenges in terms of coordination, interoperability, and data governance. The lack of common metadata standards, unified data transmission mechanisms, shared quality criteria, and a formally designated national coordination for the cross-cutting integration of observational networks may limit the full use of the existing database. Making progress in standardization, data governance, and interagency coordination is, therefore, essential to transforming Brazil's extensive observational capability into more effective climate services that are useful for public policy planning and aimed at strengthening national resilience.

The research component integrates this arrangement by transforming the data generated by the observation networks into scientific evidence for the formulation, implementation, and evaluation of climate policies.

Rede Clima – Brazilian Research Network on Global Climate Change (Rede Brasileira de Pesquisas sobre Mudanças Climáticas Globais), for example, coordinates research groups at universities and science and technology institutes in different regions of the country and has played a significant role in providing scientific input for the national reports submitted to the UNFCCC. In the context of the Climate Plan, its participation in the CIM's Scientific Advisory Chamber (CAC, Câmara de Assessoramento Científico) strengthens the link between scientific research, climate observation, and decision-making (Brasil, 2026a).

The National Institutes of Science and Technology for Climate Change (INCT-MC, Institutos Nacionais de Ciência e Tecnologia para Mudanças Climáticas) complement this capability by bringing together researchers focused on Earth system modeling, sector-specific climate impacts, and adaptation, thereby providing input for AdaptaBrasil MCTI and for studies on Impacts, Vulnerabilities, and Adaptation (Brasil, 2007b). The INCTs play a prominent role in this arrangement,

as they are key instruments for coordinating the national science and technology system. In addition to the INCTs-MC, which bring together research groups focused on earth system modeling and sector-specific climate impacts, various scientific networks produce data of great relevance for climate observation and monitoring. This is the case with flux tower networks that measure greenhouse gas exchanges between the surface and the atmosphere, such as those operating in the Amazon as part of the Large-Scale Biosphere-Atmosphere Program in the Amazon (LBA) and the Amazon Tall Tower Observatory (ATTO), as well as initiatives aimed at monitoring different biomes, such as Embrapa's Fluxus network and research networks operating in the Caatinga and in the Pampa regions. These initiatives are linked to Rede Clima and expand the country's observation database and strengthen the link between operational monitoring infrastructure and scientific research, one of the distinctive features of Brazil's observation arrangement.

In addition to the federal level, the interfederative level is an important part of meteorological observation in Brazil. State meteorological, hydrological, and environmental monitoring networks operate their own systems and complement the coverage provided by federal networks, together accounting for a significant portion of the operational stations installed in the country. The CIM's Interfederative Coordination Chamber (CAI, Câmara de Articulação Interfederativa) serves as an institutional channel for coordination between the federal government and subnational entities in the implementation of the Climate Plan, and can help align national climate actions with regional and local contexts (Brasil, 2026a). This aspect is particularly important in a country with a vast territory, such as Brazil, where observational coverage, network maintenance, and data integration depend on cooperation among the federal government, states, research institutions, and other operators, which is also reflected in the diverse composition of the CIM and the CMCH.

Thus, Brazil's institutional arrangement for meteorological research and observation combines coordinating bodies, institutions that operate monitoring networks, research centers, data platforms, and mechanisms for federal and scientific coordination. This structure supports the production of information used in national greenhouse gas inventories, impact, vulnerability, and adaptation studies, early warning systems, climate modeling, the monitoring of public policies, and the preparation of national reports submitted to the UNFCCC. By integrating systematic observation, applied research, and climate governance, this arrangement contributes to the transformation of meteorological data into technical and scientific knowledge and into inputs for national climate action.

7.1.2 Atmospheric observation

Atmospheric observation is one of the bases of systematic climate observation in Brazil, as it provides essential information for monitoring climate variability, forecasting weather and climate, issuing warnings, assessing extreme events, and generating inputs for public policies on mitigation and adaptation. In Brazil, this domain encompasses the surface meteorological and hydrological monitoring network, monitoring of the upper atmosphere via radiosoundings, the measurement of greenhouse gases and other atmospheric components, monitoring of stratospheric ozone and air quality, as well as satellite monitoring and the use of remote sensing products, including rainfall and wind estimates. It should be noted that the geostationary satellites used for this monitoring are operated by foreign entities.

To support the quantitative characterization of the Brazilian atmospheric network[4] presented in this section, data from the primary databases maintained by the operating institutions themselves were consolidated in February 2026, namely from: the National Water Resources Information System (SNIRH, Sistema Nacional de Informações sobre Recursos Hídricos)/HidroWeb, maintained by the National Water and Basic Sanitation Agency (ANA); the institutional catalog, the Meteorological Database for Education and Research (BDMEP, Banco de Dados Meteorológicos para Ensino e Pesquisa), and the public application programming interface of the National Institute of Meteorology (INMET); the portal and national mosaic of weather radars of the Integrated Environmental Management and Monitoring System (SIGMA), operated by the Center for Weather Forecasting and Climate Studies of the National Institute for Space Research (CPTEC/INPE); and the data published by the National Center for Monitoring and Early Warnings of Natural Disasters (CEMADEN) regarding its automatic rainfall network.

In the analyzed dataset, 25,102 station records were identified, of which 23,981 corresponded to surface stations operating in the Brazilian territory, 28 corresponded to weather radars, and 915 corresponded to stations in border countries registered in the SNIRH (ANA, 2026; INMET, 2026; INPE, 2026; CEMADEN, 2026). In this dataset, it is important to distinguish between multivariable weather stations and rainfall gauges and stream gauges. The former, the multivariable weather stations, measure temperature, humidity, pressure, radiation, wind, and precipitation, and are concentrated in the INMET network, which has 706 stations installed, of which about 528 are operational. On the other hand, most of the remaining stations are rainfall gauges and stream gauges, used primarily to measure rainfall and hydrological variables: approximately 13,400 stations record precipitation, and more than half of the entire network, about 52.5%, measures only this parameter (as shown in Table 7.1.1).

The surface system can be described in terms of three operational groups of institutions. The main federal agencies included in the quantitative consolidation, INMET, ANA, and CEMADEN, comprise 8,019 stations or monitoring points, equivalent to 33.4% of the national total. The other federal agencies, such as DECEA, DNOCS - National Department of Drought Relief (Departamento Nacional de Obras Contra as Secas), SGB/CPRM - Mineral Resources Research Company (Companhia de Pesquisa de Recursos Minerais), CENSIPAM, CHM, and Embrapa, account for approximately 1,500 stations, that is, 6.3% of the total. On the other hand, state networks and those belonging to other institutions account for 14,462 stations, equivalent to 60.3% of the surface stations in operation in the country (as shown in Table 7.1.1). This composition highlights the combined role of federal and state networks, as well as of other operators, in the generation of atmospheric and hydrometeorological data.

It should be noted, however, that the classification presented in Table 7.1.1 does not correspond to the formal composition of the CMCH, but rather to an operational interpretation of the networks considered in the quantitative consolidation. The Commission's Executive Committee is comprised

4 Methodological procedure adopted: The consolidation considered operational records within Brazilian territory as of February 2026 and used the following primary databases: (i) the ANA's SNIRH/HidroWeb database, as of February 2026, containing records from 847 operating institutions and covering federal, state and concessionaire networks, as well as those in border countries with metadata on coordinates, station type, operational status, transmission method, responsible institution, watershed, municipality, state, and operation period; (ii) INMET's institutional catalog, the BDMEP (time series dating back to 1961), and the public real-time data API, for the set of conventional and automatic multivariable weather stations; (iii) the SIGMA portal and national mosaic of weather radars, operated by CPTEC/INPE, for the S-band Doppler radar infrastructure; and (iv) the data published by CEMADEN regarding its automatic rainfall network designed to support disaster prevention. Due to the coexistence of distinct identification systems, duplicate checks were performed between the SNIRH and the INMET catalog, and records pertaining to stations in border countries integrated into the SNIRH under bilateral water resource management agreements were excluded from the Brazilian total.

of the MCTI, INPE, INMET, DECEA, and DHN. ANA, CEMADEN, and CENSIPAM, on the other hand, operate networks that are relevant to surface observation, although they are not members of this Committee. In addition, a significant portion of the consolidated network consists of rainfall gauges and stream gauges, as is the case of ANA and CEMADEN, rather than multivariable weather stations.

Table 7.1.1 Overview of the inventory of stations and monitoring points by institutional operational group.

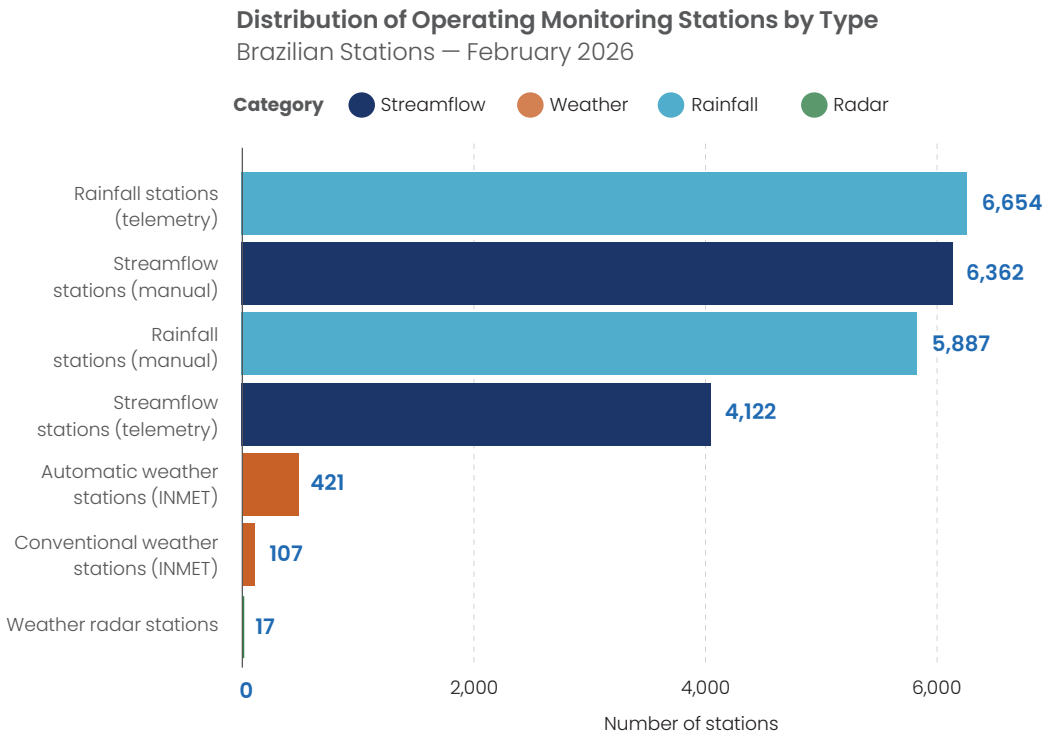
Institutional operational group	Operating stations/ points	% of Total	Main institutions and number of stations/points
Major federal surface networks included in the consolidation	8,019	33.4%	INMET (706 weather stations: 528 operational and 178 out of order), ANA (4,780 rainfall and stream gauges), CEMADEN (2,533 rainfall gauges)
Other federal networks	~1,500	6.3%	DECEA, DNOCS, SGB/CPRM, CENSIPAM, CHM, Embrapa
State networks and networks belonging to other institutions	14,462	60.3%	DAEE-SP - Department of Water and Electric Power - São Paulo (Departamento de Águas e Energia Elétrica - São Paulo) (1,358), IGAM-MG - Minas Gerais Institute of Water Management (Instituto Mineiro de Gestão das Águas - Minas Gerais) (854), FUNCEME-CE - Ceará Foundation for Meteorology and Water Resources (Fundação Cearense de Meteorologia e Recursos Hídricos - Ceará) (769), INEMA-BA - Institute of the Environment and Water Resources (Instituto do Meio Ambiente e Recursos Hídricos - Bahia) (692), CETESB-SP – State of São Paulo Environmental Company (Companhia Ambiental do Estado de São Paulo) (605), IAT-PR - Water and Earth Institute (Instituto Água e Terra) (483)
Brazil surface total	23,981	100%	847 different institutions
Weather radars	28 (17 operational)	Not applicable	DECEA (6), CENSIPAM (11), CEMADEN (9), IPMet - Institute of Meteorological Research (Instituto de Pesquisas Meteorológicas) (2)
Border stations	915	Not applicable	Bolivia (430), Ecuador (182), Argentina (97), Suriname (90), French Guiana (34), Venezuela (33), Guyana (31), Paraguay (18).

Source: Compiled based on consolidated data from SNIRH/HidroWeb/ANA, the INMET station inventory and SIGMA/CPTEC/INPE, dated February 2026, supplemented by data published by CEMADEN on its automatic rainfall network and by records from DNOCS and the concessionaires FURNAS, CHESF – São Francisco Hydroelectric Company (Companhia Hidrelétrica de São Francisco), and CODEVASF - São Francisco and Parnaíba Valleys Development Corporation (Companhia de Desenvolvimento dos Vales do São Francisco e do Parnaíba) in the complementary federal categories.

The main operating institutions have complementary profiles. The Geological Survey of Brazil (SGB) is the largest single operator of stations, with 3,952 stations under its direct operation, of which 3,670 are operated by delegation from ANA under the National Hydrometeorological Network (RHN, Rede Hidrometeorológica Nacional). CEMADEN operates 2,533 automatic rainfall gauge stations, all of which are telemetric, aimed at supporting disaster prevention. INMET operates the national network of multivariable weather stations, including automatic and conventional stations, which measure variables such as air temperature, relative humidity, atmospheric pressure, solar radiation, wind, and precipitation (ANA, 2026; INMET, 2026; CEMADEN, 2026). Together, these networks perform distinct and complementary roles related to meteorological, hydrological, and climatological monitoring, as well as the monitoring of hydrometeorological risks. In the case of CEMADEN, the primary purpose of CEMADEN's automatic rainfall gauges is to support disaster prevention and the monitoring of hydrometeorological risks. For this reason, they should not be used for climatological purposes, especially in analyses that rely on homogeneous and comparable time series.

The composition of the network of stations reflects the historical predominance of hydrological monitoring in Brazil. Since a single station can measure more than one variable, the survey identified approximately 13,415 rainfall measurement records and approximately 10,952 streamflow measurement records, in addition to the 528 operational multivariable weather stations operated by INMET, plus 178 automatic stations reported as out of order at the time of the survey. Figure 7.1.2 shows the distribution of operating stations by type, indicating the predominance of hydrological stations and the proportion of weather stations and radar stations in the analyzed set.

Figure 7.1.2 Distribution of operating monitoring stations by type: Rainfall, Streamflow, Weather, and Radar.

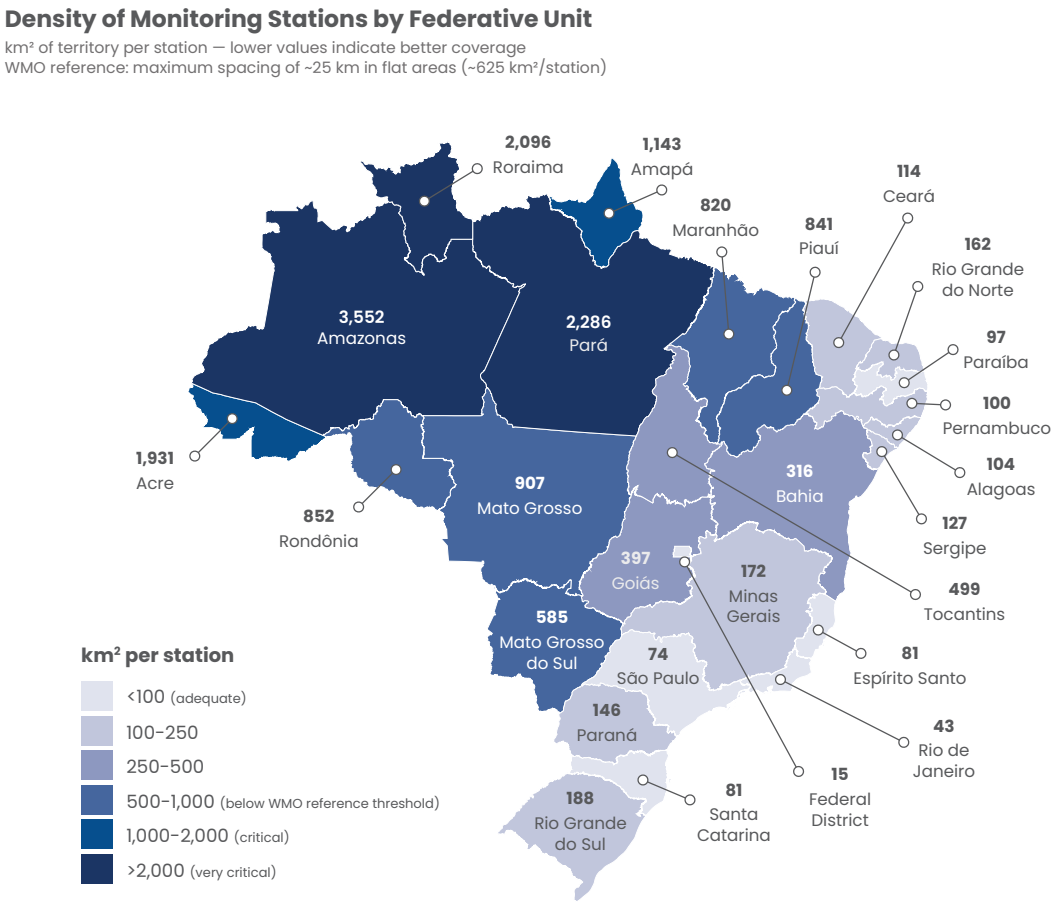


Source: Compiled based on consolidated data from SNIRH/HidroWeb/ANA, the INMET station inventory and SIGMA/CPTEC/INPE, dated February 2026.

Rainfall gauge and stream gauge stations provide comprehensive coverage of variables related to precipitation and water resources, while multivariable weather stations produce time series that are essential for climate characterization, weather forecasting, modeling, and assessment of extreme events (ANA, 2026; INMET, 2026).

It should also be noted that the geographic distribution of rainfall gauge and stream gauge stations shows significant regional differences. The aggregated number of stations identified in the databases analyzed exceeds the estimated number required to meet the density standard recommended by the World Meteorological Organization for flat areas, which corresponds to a maximum spacing of about 25 km between stations, or approximately one station per 625 km² (WMO, 2019). This aggregate surplus, however, coexists with markedly uneven spatial distribution. The Northern Region accounts for 45.3% of the country's total land area, but only 8.9% of the operating stations, resulting in a density of 1,829 km² per station. The Southeast and South regions, in turn, have an average density of 110 km² per station (Figure 7.1.3). These differences are relevant for interpreting the observational data sets and help characterize the current state of observational coverage in the country.

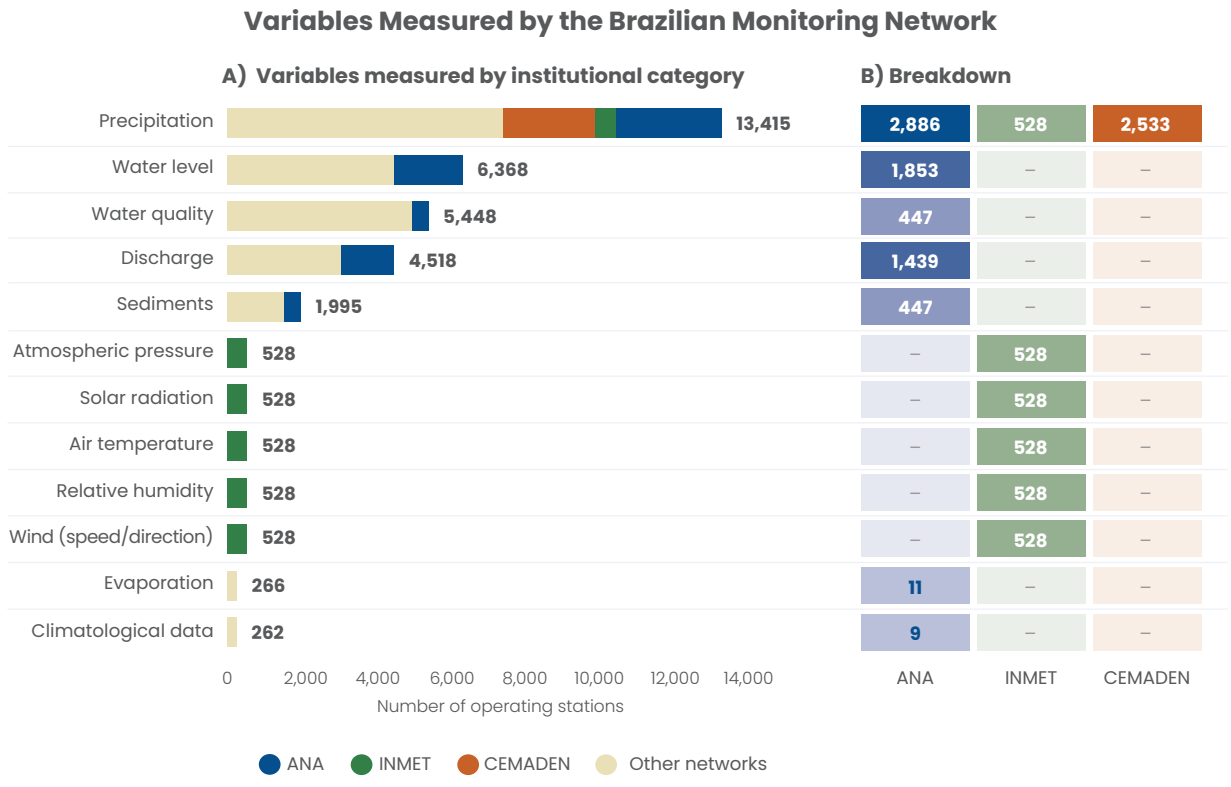
Figure 7.1.3 Density of monitoring stations by federative unit (km² per station). For the purposes of technical interpretation of the figure, the following descriptive classification of observed density is adopted: above 1,000 km²/station, lower relative density; between 625 and 1,000 km²/station, intermediate density; below 625 km²/station, a status within the reference threshold for flat areas recommended by the World Meteorological Organization (WMO, 2019).



Source: Compiled based on consolidated data from SNIRH/HidroWeb/ANA, the INMET station inventory and SIGMA/CPTEC/INPE, dated February 2026.

The Brazilian network covers a diverse set of hydrometeorological variables (Figure 7.1.4). Precipitation is the variable with the widest territorial coverage, recorded by 13,415 operational stations. Hydrological variables constitute the second thematic group, which includes the measurement of water level, discharge, water quality, and sediments. Multivariate meteorological variables, such as air temperature, relative humidity, atmospheric pressure, solar radiation, and wind speed and direction, are systematically measured by the INMET network, which serves as the national reference for long-term climate series, with historical data made available by the Meteorological Database for Education and Research (BDMEP) since 1961 (INMET, 2026). In addition to INMET, the networks operated by DECEA and DHN also measure meteorological parameters, aimed, respectively, at supporting air navigation and maritime navigation. Some of these variables, such as temperature, precipitation, wind, and greenhouse gases, are recognized as Essential Climate Variables (ECVs) by the Global Climate Observing System (GCOS, 2022)[5]. Together, this information supports applications such as climate monitoring, weather and climate forecasting, warnings, water planning, and risk management.

Figure 7.1.4 Variables measured by the Brazilian monitoring network. Panel A: Number of stations by variable and by institutional category. Panel B: Breakdown of the variables measured by the major federal networks (INMET, ANA, and CEMADEN).



Source: Compiled based on consolidated data from SNIRH/HidroWeb/ANA, the INMET station inventory and SIGMA/CPTEC/INPE, dated February 2026.

5 Essential Climate Variables (ECVs) are the set of physical, chemical, and biological variables defined by the Global Climate Observing System (GCOS) as indispensable for characterizing the climate system. The GCOS, a program established in 1992 and co-sponsored by the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO), the United Nations Environment Programme (UNEP), and the International Science Council (ISC), organizes the ECVs into three domains, namely: atmospheric, oceanic, and terrestrial, currently totaling more than fifty variables. Because they are technically feasible and highly valuable for monitoring, ECVs provide the empirical basis for understanding and monitoring climate change, informing mitigation and adaptation policies, and supporting climate services. Under the United Nations Framework Convention on Climate Change (UNFCCC), the ECVs serve as a reference for the systematic observation reporting required under Article 5, which is addressed in National Communications and Biennial Transparency Reports (GCOS, 2022).

Telemetric data transmission is essential for feeding numerical prediction models and for issuing timely warnings. As an international benchmark, the WMO's WIGOS Vision 2040 sets an indicative target of automatic data transmission for more than 80% of member countries' surface stations by 2040, a benchmark that has guided the planning of national network modernization (WMO, 2019). In the data set analyzed in February 2026, the national network telemetry rate was 44.2%, with a significant regional variation. Among the major federal networks, INMET automatically transmitted data from its 421 operational automatic stations via satellite and cellular networks. The hydrometeorological network operated by SGB under RHN/ANA operated at a telemetry rate of 42.5% across its network, and CEMADEN operated with 100% telemetry at its automatic rainfall gauge stations (ANA, 2026; INMET, 2026; CEMADEN, 2026). It should be noted that part of the satellite transmission used in this monitoring relies on infrastructure operated by foreign institutions, which is one of the current vulnerabilities of this type of network. The expansion of automation and real-time data transmission is a key factor for strengthening data integration, extreme event forecasting, and early warning systems.

Brazil also operates a network of S-band Doppler weather radars, which are integrated into the national mosaic through the Integrated Environmental Management and Monitoring System (SIGMA) of CPTEC/INPE. The network consists of 28 radars, distributed among CENSIPAM, CEMADEN, DECEA, and IPMet/UNESP - São Paulo State University (Universidade Estadual Paulista). In this context, the CPTEC/INPE serves as a national integrator, consolidating data from these networks into mosaic products and satellite precipitation estimates (INPE, 2026). The integration of radars, satellites, and surface stations enhances the capability to monitor precipitation and convective systems, supporting short-term forecasting and risk management.

Monitoring of the upper atmosphere in Brazil is carried out through Upper-Air Weather Stations (EMAs, Estações Meteorológicas de Altitude), which conduct radiosoundings by launching weather balloons equipped with sensors for pressure, temperature, relative humidity, and, via an integrated GPS module, wind direction and speed at multiple atmospheric levels. Data are collected at altitudes of up to 30 km, covering the troposphere and the lower stratosphere, and are essential for initializing numerical weather prediction models, for upper-air climate analyses, and for fulfilling Brazil's commitments under the WMO's Global Telecommunication System (GTS) (WMO, 2019).

On the other hand, the national radiosounding network is operated jointly by INMET, the Department of Airspace Control (DECEA), and the Navy's Department of Hydrography and Navigation (DHN). Under DECEA, the Upper-Air Weather Stations are operated by NAV Brasil, which in 2025 maintained EMAs[6] at four airfields, located in Alta Floresta (MT - Mato Grosso state), Londrina (PR - Paraná state), Uberlândia (MG - Minas Gerais state), and Vitória (ES - Espírito Santo state) (NAV Brasil, 2025). The international standard recommended by the WMO calls for two daily launches per station, at 00:00 and 12:00 UTC, to enable the assimilation of data into global numerical weather prediction models in near real time (WMO, 2019). Historical data from Brazilian radiosoundings are part of the Integrated Global Radiosonde Archive (IGRA), maintained by the National Centers for Environmental Information (NCEI/NOAA), promoting the interoperability of national time series with global climate analysis and reanalysis systems (Durre *et al.*, 2016; NCEI, 2023).

6 NAV Brasil, Serviços de Navegação Aérea S.A., is a public company affiliated with the Air Force Command of the Ministry of Defense, established by Law No. 14,241/2021, for the purpose of providing air navigation services in Brazilian airspace, including the operation of weather stations associated with civil and military aviation. Upper-Air Weather Stations (EMAs) are operational units that conduct radiosonde observations, that is, daily launches of weather balloons equipped with radiosondes to measure variables such as upper-air pressure, temperature, relative humidity, wind direction, and wind speed, in layers ranging from the surface to the lower stratosphere.

Greenhouse gas monitoring in the atmosphere is carried out using complementary scientific infrastructure, notably the network of flux towers of the Large-Scale Biosphere-Atmosphere Program in the Amazon (LBA) and the Amazon Tall Tower Observatory (ATTO). The LBA, managed by the MCTI and coordinated by the National Institute for Amazonian Research (INPA, Instituto Nacional de Pesquisas da Amazônia), has conducted *in situ* measurements of greenhouse gases in the Amazon since the 1990s, producing time series of CO_2, CH_4, and water vapor fluxes between the forest and the atmosphere (Brasil, 2021; INPA, 2024). ATTO, launched in 2008 as a joint Brazil-Germany project, is coordinated by INPA and the State University of Amazonas (UEA, Universidade do Estado do Amazonas) in partnership with the Max Planck Institutes for Biogeochemistry and Chemistry. Located in an area of primary forest approximately 150 km north of Manaus (AM, state of Amazonas), the observatory features a 325-meter guyed tower, the tallest in the world for atmospheric research, as well as two additional 80-meter towers and laboratories installed in climate-controlled containers. It conducts continuous monitoring of CO_2, CH_4, N_2O, aerosols, volatile organic compounds, meteorological parameters, and energy exchanges between the forest and the atmosphere (ATTO, 2026).

In addition to the Amazon, initiatives focused on other biomes also contribute to the monitoring of fluxes and greenhouse gases, such as the Fluxus Network, coordinated by Embrapa, the National Observatory of Water and Carbon Dynamics in the Caatinga Biome (INCT-ONDACBC, Observatório Nacional da Dinâmica da Água e do Carbono no Bioma Caatinga), and the Southern Brazilian Network for Surface Fluxes and Climate Change (Rede SULFLUX), in the Pampa region. Although they vary in terms of their level of consolidation and integration into the national observation systems, these networks enhance our understanding of the exchanges between the vegetation and the atmosphere in their respective biomes, supporting the calibration of climate models and the monitoring of processes that are relevant for carbon balance.

Brazil also participates in the World Meteorological Organization's Global Atmosphere Watch program (GAW), which coordinates observations of the atmosphere's chemical composition on a global scale, covering greenhouse gases, ozone, reactive gases, aerosols, ultraviolet radiation, and precipitation chemistry (WMO, 2024). The integration of national atmosphere monitoring infrastructures with global observation systems helps to expand the availability of data on atmospheric composition in regions of climatic relevance.

With regard to stratospheric ozone and ultraviolet radiation, in Brazil, this monitoring has been conducted by INPE since 1974, with measurements beginning in Cachoeira Paulista (SP) and later on in Natal (RN - State of Rio Grande do Norte). In 1985, INPE formally established a network of ozone layer and ultraviolet radiation observatories, operating with Dobson and Brewer spectrophotometers, which are WMO's reference tools for measuring total ozone column, as well as ozonesondes for measuring vertical ozone profiles (INPE, 2014). The data collected are part of the global monitoring system coordinated by the WMO under the GAW Program (INPE, 2024e). This infrastructure helps monitor atmospheric variables relevant to climate and to the protection of the ozone layer.

The country also contributes to atmospheric monitoring in the Antarctic region through the Brazilian Antarctic Program (PROANTAR, Programa Antártico Brasileiro). In Central Antarctica, the program operates the autonomous Criosfera 1 platform, installed in the 2010s and maintained in partnership by MCTI, INPE, UFRJ - Federal University of Rio de Janeiro (Universidade Federal do Rio de Janeiro), UFRGS - Federal University of Rio Grande do Sul (Universidade Federal do Rio Grande do Sul), and SECIRM – Secretariat of the Interministerial Commission for Marine Resources (Secretaria

da Comissão Interministerial para os Recursos do Mar), which continuously monitors tropospheric ozone, CO_2, aerosols, and meteorological variables (SECIRM, 2026). More recently, the program was expanded with the installation of the Criosfera 2 scientific module, which strengthens Brazil's atmospheric observation network on the Antarctic continent. These observations complement Brazil's contribution to atmospheric monitoring systems in sensitive regions of the climate system.

In recent years, air quality monitoring has also undergone regulatory and institutional advances. Law No. 14,850/2024 established the National Air Quality Policy (PNQA, Política Nacional de Qualidade do Ar), and CONAMA's (National Environment Council, Conselho Nacional do Meio Ambiente) Resolution No. 506/2024 updated the national air quality standards, including a timeline for gradual alignment with the World Health Organization's guideline values. The 2025 Annual Air Quality Monitoring Report recorded 570 monitoring stations in operation in 2024, covering pollutants such as total suspended particulates, fine and inhalable particulate matter, sulfur dioxide, carbon monoxide, tropospheric ozone, nitrogen dioxide, and lead (Brasil, 2024; 2026d; CONAMA, 2024). The public release of the data is carried out by MonitorAr, a platform managed by the MMA that consolidates information from official monitoring stations and provides the Air Quality Index (Brasil, 2025b). In addition, the CPTEC/INPE Air Quality Portal[7] provides numerical air quality forecast products, while the Integrated Environmental and Health Information System (SISAM, Sistema de Informações Ambientais Integrado à Saúde)[8], developed in partnership between the Ministry of Health and INPE under the Queimadas Program (Fire Monitoring Program), compiles historical data and air quality forecasts, meteorological information, and data on hotspots.

Brazil's atmospheric observation networks and systems provide data for monitoring climate variability, forecasting weather and climate, monitoring extreme events, assessing risks, issuing early warnings, and producing information used in national reports submitted to the UNFCCC. The continuity, integration, and modernization of these networks are key to improving the quality of observational series and expanding the national capability to generate consistent and comparable climate information over time. In this regard, the operational sustainability and long-term maintenance of the networks are essential for preserving the continuity of the time series and, consequently, the reliability of the climate analyses derived from them.

7.1.3 Oceanic and coastal observation

Oceanic and coastal observation is a key component of systematic climate observation in Brazil, given the influence of the South Atlantic on regional climate variability, precipitation patterns, temperature, extreme events, and impacts on coastal areas. With approximately 7,491 km of mainland coastline (IBGE – Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística), 2011), the country maintains systems and networks dedicated to monitoring oceanographic, marine meteorological, coastal, and ecosystem variables, including sea level, sea surface temperature, salinity, waves, currents, wind, atmospheric pressure, and coastal ecosystem coverage, which are variables that, for the most part, comprise the set of Essential Climate Variables (ECVs) recognized by GCOS (2022).

The overview presented in this section is based on primary institutional sources provided by the operating entities themselves, in particular by the Navy Hydrographic Center (CHM) and the

7 Available at: http://meioambiente.cptec.inpe.br/index.php?lang=pt. Accessed on: Aug 18, 2026.

8 Available at: https://data.inpe.br/queimadas/sisam. Accessed on: Aug 18, 2026.

Department of Hydrography and Navigation (DHN) of the Navy Command, as well as the Brazilian Institute of Geography and Statistics (IBGE), GOOS-Brazil, the Center for Weather Forecasting and Climate Studies of the National Institute for Space Research (CPTEC/INPE), the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA, Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis), and the Ministry of the Environment and Climate Change (MMA), supplemented by international programs in which Brazil actively participates, such as PIRATA and Argo[9].

Ocean and coastal monitoring in Brazil is carried out by a group of institutions with distinct and complementary mandates. The Navy Hydrographic Center (CHM)[10], under the Navy Command, plays a central role in hydrography, oceanography, and marine meteorology in Brazilian jurisdictional waters, in addition to representing the country in the International Hydrographic Organization (IHO). To fulfill its mission, the CHM maintains an observation network consisting of coastal meteorological and oceanographic stations, monitoring buoys, data collection systems on vessels, and satellite data reception, enabling the monitoring of variables such as wind, air and sea surface temperature, atmospheric pressure, waves, ocean currents, and tides (CHM, 2026). This institutional arrangement was recently strengthened by the establishment of the National Institute for Ocean Research (INPO, Instituto Nacional de Pesquisas Oceânicas)[11], an organization dedicated to generating scientific and technological knowledge aimed at the development and sustainable management of the oceans, focused on the South and Tropical Atlantic.

The data collected by the CHM are processed and integrated into numerical ocean forecasting models, such as the Hybrid Coordinate Ocean Model (HYCOM) and the WAVEWATCH III wave model, which support the issuance of meteorological and oceanographic bulletins, severe weather warnings, and tidal forecasts for ports, fisheries, navigational safety, and civil defense (CHM, 2026). This infrastructure contributes to the production of operational and meteorological information relevant to coastal risk management, navigation, and planning in marine and coastal areas.

The Department of Hydrography and Navigation (DHN) maintains the Marine Spatial Data Infrastructure (IDEM-DHN, Infraestrutura de Dados Espaciais Marinhos), an open marine geospatial data portal established to catalog, integrate, and harmonize information produced or managed by the DHN and make it available to users. IDEM-DHN also serves as the National Oceanographic Data Bank (BNDO, Banco Nacional de Dados Oceanográficos), as established by the Decree dated January 5, 1994, and fulfills international commitments regarding data exchange, including the requirements of the International Oceanographic Data and Information Exchange (IODE) of UNESCO's Intergovernmental Oceanographic Commission (IOC-UNESCO), as well as guidelines from the Marine Spatial Data Infrastructures Working Group of the International Hydrographic Organization. At the national level, the platform is integrated with the National Spatial Data Infrastructure (INDE, Infraestrutura Nacional de Dados Espaciais), established by Decree No. 6,666/2008, and with the Blue Amazon Marine Spatial Planning, coordinated by the Interministerial Commission for Marine Resources (CIRM, Comissão Interministerial para os Recursos do Mar) (DHN, 2024). The public and structured availability of these data helps expand access to oceanographic information and strengthen the integration of observation, marine management, and climate transparency.

9 Brazil's participation in international systems is described based on official publications from the PIRATA (Pilot Research Moored Array in the Tropical Atlantic), Argo, and GOOS (Global Ocean Observing System), coordinated by UNESCO's Intergovernmental Oceanographic Commission (IOC-UNESCO).

10 Available at: https://www.marinha.mil.br/chm/

11 Available at: https://inpo.org.br/. Accessed on: Aug 18, 2026.

GOOS-Brazil, the national committee of the Global Ocean Observing System (GOOS), brings together institutions that work with observational oceanography, including INPE, CHM, IBGE, federal universities, and research institutes. Its mission is to coordinate Brazil's contribution to the Global Ocean Observing System, support compliance with GOOS standards, and promote the integration of national networks into international oceanic data platforms (IOC-UNESCO, 2023). Among the initiatives included in GOOS-Brazil are the PIRATA Program and the MOVAR Project – Monitoring of Regional Variability in Heat and Volume Transport in the Surface Layer of the South Atlantic Ocean (*Monitoramento da Variabilidade Regional do Transporte de Calor e Volume na Camada Superficial do Oceano Atlântico Sul*), which contribute to the generation of observational time series on the Tropical and South Atlantic. The National Institute for Space Research (INPE), through CPTEC, contributes to the oceanic domain by producing sea surface temperature (SST) data obtained from remote sensing and integrating them into short- and medium-range weather forecast models. The IBGE, in turn, operates the Permanent Maregraphic Network for Geodesy (RMPG, Rede Maregráfica Permanente para Geodésia), a sea-level monitoring system of direct relevance for monitoring climate change (IBGE, 2024; INPE, 2024b; GOOS-Brazil, 2024).

The national ocean and coastal observation infrastructure comprises *in situ* systems, coastal networks, satellite platforms, and geospatial databases, as summarized in Dataframe 7.1.1.

Dataframe 7.1.1 Brazil's ocean and coastal observation infrastructure: systems, responsible institutions, and monitored variables.

System/Program	Responsible institution	Monitored variables
PNBOIA - National Buoy Program (Programa Nacional de Boias) (moored and drifting buoys)[12]	CHM/Brazilian Navy; INPE; GOOS-Brazil	SST, salinity, surface currents, wave height and period, wind, atmospheric pressure, air temperature
PIRATA - Pilot Research Moored Array in the Tropical Atlantic[13]	CHM/INPE (Brazil); CNRS/IRD (France); NOAA (USA)	Temperature and salinity at depths of up to 500 m, wind, pressure, solar radiation
Argo - Autonomous profiling floats[14]	INPE; federal universities (GOOS-Brazil)	Water column temperature and salinity up to 2,000 m (ECV: Ocean Temperature; Salinity)
RMPG - Permanent Maregraphic Network for Geodesy[15]	IBGE/DHN-Navy	Sea level (ECV: Sea level), long-term variation of MSL
IDEM-DHN - Marine Spatial Data Infrastructure[16]	DHN/Brazilian Navy	Open marine geospatial data: hydrography, oceanography, and marine meteorology; National Oceanographic Data Bank (BNDO)

12 Available at: https://www.marinha.mil.br/chm/dados-do-goos-brasil/pnboia. Accessed on: Aug 18, 2026.

13 Available at: https://www.pmel.noaa.gov/gtmba/pmel-theme/atlantic-ocean-pirata. Accessed on: Aug 18, 2026.

14 Available at: https://argo.ucsd.edu/. Accessed on: Aug 18, 2026.

15 Available at: https://www.ibge.gov.br/geociencias/informacoes-sobre-posicionamento-geodesico/rede-geodesica/10842-rmpg-rede-maregrafica-permanente-para-geodesia.html. Accessed on: Aug 18, 2026.

16 Available at: https://idem.marinha.mil.br/. Accessed on: Aug 18, 2026.

System/Program	Responsible institution	Monitored variables
SST via Satellite - CPTEC/INPE[17]	INPE/CPTEC	Sea surface temperature (ECV: SST); ocean altimetry (GOES-16/ABI, AVHRR, Sentinel-6, Jason)
MapBiomas[18] - Coastal Zone and Mangroves[19]	MapBiomas Collaborative Network (ITV - Vale Institute of Technology (Instituto Tecnológico Vale)/ Solved)	Mangrove and Reef Cover, 1985–2024 (Land Cover ECV)
Mapping of Brazilian Mangroves 2024[20]	IBAMA/MMA	Coverage and distribution of Brazil's mangroves (1,229,644 hectares; 11,142 fragments)
SiMCosta - Brazilian Coast Monitoring System (Sistema de Monitoramento da Costa Brasileira)[21]	Academic network coordinated by FURG – Rio Grande Federal University (Universidade Federal do Rio Grande), under INCT-Mar COI - National Institute of Marine Science and Technology – Center for Integrated Oceanography (Instituto Nacional de Ciência e Tecnologia do Mar – Centro de Oceanografia Integrada)	Water temperature and salinity, dissolved oxygen, pH, turbidity, and chlorophyll, as well as wind, atmospheric pressure, and air temperature, measured by coastal buoys.

Source: Compiled based on data from CHM (2026), IBGE (2024), IOC-UNESCO (2023), INPE (2024b), NOAA (2024), Argo (2024), PSMSL (2024), GOOS-Brazil (2024), SiMCosta (2024), IBAMA (2026) and MapBiomas (2025). SST: sea surface temperature; MSL: mean sea level; BNDO: National Oceanographic Data Bank; ECV: Essential Climate Variable (GCOS, 2022).

17 Available at: https://www.cptec.inpe.br/. Accessed on: Aug 18, 2026.

18 MapBiomas is a multi-institutional collaborative initiative comprised of universities, civil society organizations, and technology companies that uses automated methodology and satellite imagery to produce annual land-use and land-cover maps and related products for all Brazilian biomes. Although widely used and openly accessible, these data do not constitute the federal government's official database, as the government's official monitoring is conducted by agencies such as INPE through PRODES - Project for Satellite Monitoring of Deforestation in the Legal Amazon (Projeto de Monitoramento do Desmatamento na Amazônia Legal por Satélite), DETER - Real-Time Deforestation Detection System in the Legal Amazon Region (Sistema de Detecção do Desmatamento na Amazônia Legal em Tempo Real), and TerraClass.

19 Available at: https://brasil.mapbiomas.org/. Accessed on: Aug 18, 2026.

20 Available at: https://www.gov.br/ibama/pt-br. Accessed on: Aug 18, 2026.

21 Available at: https://www.simcosta.furg.br/home. Accessed on: Aug 18, 2026.

From an institutional perspective, this infrastructure links national institutions, international programs, and global observation systems, as summarized in Dataframe 7.1.2.

Dataframe 7.1.2 Institutional arrangement for ocean and coastal observation in Brazil: Institutions, links, and connections with global observation systems.

Domain	Institution/Program	Institutional link	Global connection
Marine meteorology and hydrography	CHM/IDEM-DHN/PNBOIA	Navy Command	IHO; GOOS; WIGOS/ WMO
Sea level	RMPG (IBGE/DHN)	IBGE/Navy	PSMSL; GCOS (Sea Level ECV)
Oceanography *in situ*	PNBOIA; PIRATA; Argo; MOVAR	CHM/INPE/GOOS-Brazil	GOOS; Argo GDAC; PIRATA (tripartite Brazil-France-USA)
SST and altimetry	CPTEC/INPE (via satellite)	INPE/MCTI	GCOS (SST ECV); CMIP6; ERA5
Ocean coordination	GOOS-Brazil	Multi-institutional	IOC-UNESCO; GOOS global
Coastal ecosystems	MapBiomas Coastal Zone; IBAMA/MMA	MMA/MapBiomas Network	GCOS (Land Cover ECV)

Source: Compiled based on data from CHM (2026), IBGE (2024), IOC-UNESCO (2023), INPE (2024b) and GOOS-Brazil (2024). IHO: International Hydrographic Organization; PSMSL: Permanent Service for Mean Sea Level; SST: sea surface temperature; ECV: essential climate variable.

Systematic monitoring of sea level within the country is carried out by two complementary systems: The Permanent Maregraphic Network for Geodesy (RMPG) and the National Buoy Program (PNBOIA). The RMPG is operated by the IBGE in partnership with the Navy's Department of Hydrography and Navigation (DHN). Comprising approximately 40 tide gauge stations installed along the Brazilian coast and on oceanic islands, the network provides continuous time series of sea level data based on pressure sensors and digital tide gauges (IBGE, 2024). Data from the RMPG are used for altimetric and geodetic referencing of the national territory and for long-term monitoring of sea-level changes. The RMPG stations are integrated into the global tide gauge system coordinated by the Permanent Service for Mean Sea Level (PSMSL), ensuring the international comparability of the time series (PSMSL, 2024).

PNBOIA, managed by CHM in collaboration with INPE and other partner institutions, is Brazil's leading *in situ* ocean observation program in the South and Equatorial Atlantic. The program operates moored and drifting buoys that measure variables such as water column temperature and salinity, current speed and direction, wave height and period, and surface meteorological parameters, including wind, atmospheric pressure, and air temperature (CHM, 2026). Data from

the PNBOIA buoys reach CPTEC/INPE through two complementary channels: the ARGOS system, jointly managed by the National Oceanic and Atmospheric Administration (NOAA, United States) and the *Centre National d'Études Spatiales* (CNES, France), and direct reception aboard the SCD-1, SCD-2, and CBERS data-collection satellites, managed by the Division of Meteorological Satellites and Sensors (DISSM, Divisão de Satélites e Sensores Meteorológicos) of CPTEC/INPE, which forwards the data to the CHM (GOOS-Brazil, 2024). This information supports the monitoring of ocean and marine meteorological conditions, with applications in forecasting, navigation safety, coastal management, and climate studies.

Brazil also participates in the PIRATA (Pilot Research Moored Array in the Tropical Atlantic) project, a trilateral initiative between Brazil, France, and the United States that maintains an array of moored buoys in the Tropical Atlantic, aimed at studying ocean-atmosphere interactions and their implications for regional climate variability (NOAA, 2024). The PIRATA buoys monitor temperature and salinity at depths of up to 500 meters, as well as surface atmospheric variables. These data provide input for coupled ocean-atmosphere models and for understanding the climate processes that affect the Tropical Atlantic and South America.

The geographic distribution of the RMPG stations, the PNBOIA buoys, and the PIRATA project buoys is shown in Figure 7.1.5.

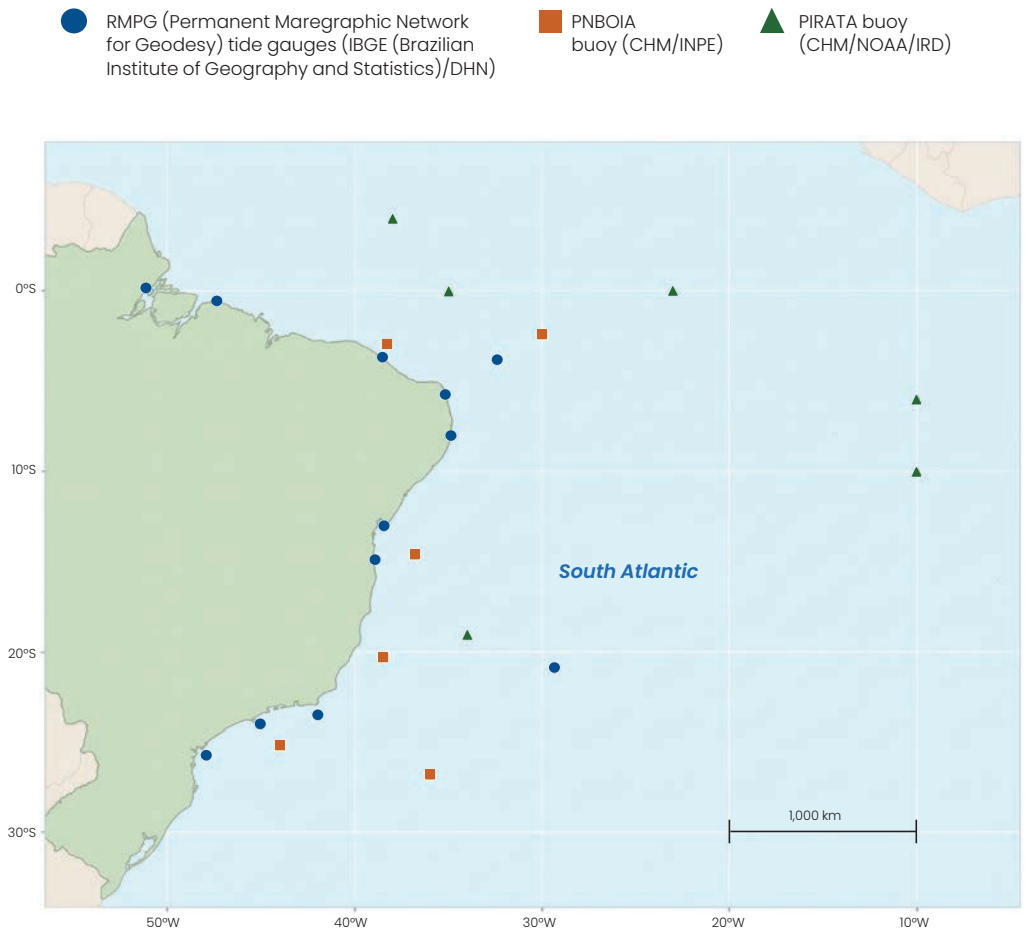
The MOVAR project - Monitoring of Regional Variability in Heat Transport in the Surface Layer of the South Atlantic Ocean[22] - has been systematically monitoring the Brazil Current between the Brazilian coast and Trindade Island since 2004. Observations are made along repeated transects, primarily using XBT (Expendable Bathythermograph) probes, allowing for monitoring of the current's thermal structure and variability. The program contributes to estimates of heat and volume transport in the Brazil Current, particularly in the region of the Vitória-Trindade Ridge, as well as to comparisons with satellite data and validation of numerical models.

As part of the Brazilian Antarctic Program (PROANTAR), the High-Latitude Oceanography Group (GOAL, Grupo de Oceanografia de Altas Latitudes)[23] conducts studies in the Southern Ocean, including the collection of physical, chemical, and biological data in the Antarctic Peninsula and the Weddell Sea, using PROANTAR vessels. These observations, combined with remote sensing and modeling, contribute to our understanding of the relationships between the ocean, the cryosphere, marine ecosystems, and climate change.

22 Available at: https://www.marinha.mil.br/chm/dados-do-goos-brasil/movar. Accessed on: Aug 20, 2026.

23 Available at: https://goal.furg.br/. Accessed on: Aug 20, 2026.

Figure 7.1.5 Geographic distribution of stations in the Permanent Maregraphic Network for Geodesy (RMPG), PNBOIA buoys, and PIRATA project buoys along the Brazilian coast and in the South and Equatorial Atlantic.



Source: IBGE/DHN (RMPG); CHM/GOOS-Brazil (PNBOIA); NOAA/PMEL (PIRATA).

Sea surface temperature (SST) is an essential climate variable that influences precipitation, ocean-atmosphere variability, and temperature anomalies on the South American continent. In Brazil, the operational monitoring of SST is conducted primarily through remote sensing, with CPTEC/INPE serving as the integrator of satellite data for climate forecasting and research purposes. CPTEC processes sea surface temperature (SST) data from multiple orbital sensors, including the GOES-16 radiometer and the AVHRR series aboard NOAA and Metop satellites. Radar altimetry data from the Sentinel-6/Michael Freilich missions and the Jason series allow the inference of sea level variations and sea surface height anomalies associated with phenomena such as El Niño and La Niña (INPE, 2024b). This integration strengthens the national capability to monitor ocean conditions associated with interannual climate variability.

The *in situ* observations are supplemented by data from the Argo program, a global network of autonomous profiling floats that measure temperature and salinity of the water column at a depth of up to 2,000 meters, with descent and ascent cycles every ten days. Brazil participates in the program through INPE and federal universities linked to GOOS-Brazil, contributing to the launching and monitoring of floats in the South Atlantic region (Argo, 2024). Argo profiles are particularly relevant for characterizing thermal and haline variability in the South Atlantic and for studying the Atlantic Meridional Overturning Circulation (AMOC), whose dynamics are now recognized as a sensitive component of the global climate system. In the context of climate observation, Argo profiles help characterize thermal and salinity variability in the South Atlantic and support studies related to ocean circulation and coastal vulnerability.

Ocean and coastal observation also includes monitoring ecosystems that are sensitive to climate change, such as mangroves and coral reefs. The 2024 Mapping of Brazilian Mangroves, released by IBAMA and the MMA, identified 1,229,644 hectares of these ecosystems distributed across 11,142 fragments along the national coastline (IBAMA, 2026). The initiative is part of ProManguezal, a program structured around six pillars, which includes among its targets for 2030 the restoration of 17,000 hectares of degraded mangroves and the creation of six new federal Conservation Units by 2028 (Brasil, 2026c).

In addition, MapBiomas provides time series of mangrove cover data dating back to 1985, derived from Landsat imagery for all Brazilian biomes, as well as beta mapping of coral reefs in shallow, clear waters along the coast (MapBiomas, 2025). The health of Brazilian coral reefs is monitored by scientific networks such as the Marine Biodiversity Network (REBIMAR, Rede de Biodiversidade Marinha), coordinated by federal universities and the Coastal Reefs Institute (Instituto Recifes Costeiros), and by ICMBio – Chico Mendes Biodiversity Conservation Institute (Instituto Chico Mendes de Conservação da Biodiversidade), which is responsible for monitoring federal marine conservation areas, including the Abrolhos National Marine Park (Parque Nacional Marinho de Abrolhos) (ICMBio, 2024). These systems and initiatives help expand the knowledge base on coastal ecosystems in relation to variations in ocean temperature, sea level, and extreme events.

7.1.4 Terrestrial observation

Terrestrial observation is a key component of systematic climate observation in Brazil, as it gathers information on land cover and land use, native vegetation, water resources, ecosystems, and carbon fluxes. In Brazil, this domain encompasses forest monitoring and land-use and land-cover monitoring, hydrological and water resources monitoring, and long-term scientific programs focused on observing carbon fluxes and interactions between the biosphere and the atmosphere, bringing together the set of national observational systems with the highest level of technical development and the greatest international prominence. Much of this information, such as land cover and land use, biomass, and carbon fluxes, is also recognized as Essential Climate Variables (ECVs) by the Global Climate Observing System (GCOS, 2022).

Forest and deforestation monitoring is conducted primarily by the National Institute for Space Research (INPE), through the Brazilian Amazon Forest Satellite Monitoring Program (PRODES), the Real-Time Deforestation Detection System (DETER), and TerraClass. PRODES, which has been in operation since 1988, is the benchmark system for estimating annual deforestation rates in the Legal Amazon. Based on an analysis of images from Landsat satellites and the Chinese-Brazilian CBERS series, the system produces annual maps of clear-cutting of native vegetation, with a

spatial resolution of 30 meters and a minimum mappable unit of 6.25 hectares, available on the TerraBrasilis platform[24] (INPE, 2024d).

PRODES methodology has been gradually expanded to other Brazilian biomes. In 2018, it was adapted for monitoring the Cerrado biome, and in 2022, it incorporated the Pantanal, the Pampa, the Atlantic Forest, and the Caatinga biomes, establishing Prodes Brasil as the official basis for monitoring the removal of native vegetation across the six biomes (INPE, 2024d). PRODES' annual estimates serve as input for calculating emissions and removals associated with deforestation, reported under the Land Use, Land-Use Change, and Forestry (LULUCF) sector of the National Inventory of Anthropogenic Greenhouse Gas Emissions and Removals (see National Inventory Report – NIR 2026).

DETER, which is also operated by INPE (INPE, 2024f), complements PRODES by issuing near-real-time warnings of deforestation and forest degradation. The system uses images from medium-resolution, high-temporal-frequency sensors, including WFI/CBERS-4A and WFI/Amazonia-1, covering the Amazon, the Cerrado, and the Pantanal biomes, with gradual expansion to other biomes (INPE, 2024g). Its warnings support environmental enforcement and monitoring activities conducted by the competent agencies, with data made available on the TerraBrasilis platform. While PRODES provides consolidated annual estimates, DETER supports the operational monitoring of changes in vegetation cover.

TerraClass, developed by INPE in partnership with Embrapa, classifies land use and land cover in areas previously identified as deforested by PRODES, distinguishing categories such as grassland, cropland, secondary vegetation, urban areas, and bare soil (INPE; EMBRAPA, 2024). This information makes it possible to characterize land-use transitions following the removal of native vegetation, contributing to analyses of land dynamics and to estimates related to the land-use, land-use change, and forestry sector, in particular the determination of emission factors associated with each post-deforestation land-use pathway used in the National GHG Inventory (Brasil, 2021). TerraClass was initially developed for the Amazon biome and was later applied to the Cerrado biome in a more recent time series.

The PRODES-DETER-TerraClass system is complemented by the National Forest Inventory (IFN, Inventário Florestal Nacional), coordinated by SFB – Brazilian Forest Service (Serviço Florestal Brasileiro). The IFN conducts field measurements on plots systematically distributed across all biomes to estimate timber volume, biomass, and carbon stocks in native vegetation and forest plantations (SFB, 2024). Data generated by the IFN contribute to the characterization of forest stocks and to the improvement of the information used in national estimates of emissions and removals associated with vegetation and land use. This information is made available through the SFB portal and integrated into the National Forest Information System (SNIF, Sistema Nacional de Informações Florestais).

Unified access to the satellite images that underpin the set of systems described is centralized on INPE's Geospatial Data Portal[25], developed as part of the Georeferenced Information Database Program (BIG, Programa Base de Informações Georreferenciadas). BIG, in turn, is an integrated infrastructure of open geospatial data, services, and applications, organized into thematic areas — land use and land cover, climate and weather, fires, and disasters — with specialized portals, interoperable geoservices based on OGC standards (Web Feature Service and Web Map Service) and cloud-based analysis tools (INPE, 2024b).

24 Available at: https://terrabrasilis.dpi.inpe.br/. Accessed on: Aug 18, 2026.

25 Available at: https://data.inpe.br/. Accessed on: Mar 23, 2026.

In the area of land use and land cover, BIG integrates BiomasBR, a program that monitors all Brazilian biomes to control deforestation and fires and support land management, with operational support from the CBERS-4A MUX cameras for biomes located outside the Amazon; PRODES TerraBrasilis, an interactive map showing polygons of native vegetation removal by biome and within the Legal Amazon; DETER TerraBrasilis, which provides near-real-time warnings of changes in forest cover; and the TerraBrasilis Situation Room (Sala de Situação TerraBrasilis), which consolidates synoptic indicators of critical areas of vegetation removal and fire hotspots by municipality (INPE, 2024g). Analytical access is provided by the BDC-Lab of the Brazil Data Cube project, a cloud-based computing environment featuring time series of Landsat and Sentinel-2 images organized as Earth observation data cubes, using modern protocols such as SpatioTemporal Asset Catalogs (STAC), which are compatible with Python and R. TerraCollect complements this suite as an open platform for collecting and validating land use and land cover samples from these time series.

Hydrological and water resources monitoring is also part of the terrestrial domain of systematic climate observation. In Brazil, this activity is organized around the National Water Resources Information System (SNIRH, Sistema Nacional de Informações sobre Recursos Hídricos), an instrument of the National Water Resources Policy managed by the National Water and Basic Sanitation Agency (ANA). In the GeoPackage version consolidated in February 2026, the SNIRH included 39,024 station records belonging to 847 different operators, including federal and state institutions, electric power concessionaires, sanitation agencies and research organizations (ANA, 2026). The system covers variables such as water level, discharge, precipitation, water quality, and suspended sediments, which are made available through the HidroWeb portal in open and interoperable formats.

In addition, the National Hydrometeorological Network (RHN, Rede Hidrometeorológica Nacional) operates under a model in which ANA, which is formally responsible for 4,780 stations, which are mostly rainfall stations (as shown in Table 7.1.1 and Figure 7.1.2), delegates the physical operation of 3,670 of them to the Geological Survey of Brazil (SGB) through a technical cooperation agreement (ANA, 2026). The SGB also maintains the Critical Event Warning System (SACE, Sistema de Alerta a Eventos Críticos), a platform for hydrological monitoring and warnings regarding floods and droughts in priority watersheds, available through the GeoSGB portal (SGB, 2026). These networks generate hydrological time series used to monitor variables related to water availability, the occurrence of floods and droughts, and water resources management.

The federal hydrological networks are supplemented by systems operated by state water resource management agencies, such as DAEE-SP, IGAM-MG, and FUNCEME-CE, among others.

Terrestrial observation also relies on scientific infrastructure that provides an interface between the biosphere and the atmosphere, as described in section 7.1.2, whose contribution to this theme lies in the generation of data on ecosystems, carbon fluxes, and energy exchanges between the earth's surface and the atmosphere. The flux towers of the Large-Scale Biosphere-Atmosphere Program in the Amazon (LBA), now in its second phase, and the Amazon Tall Tower Observatory (ATTO), for example, document, through long-term time series, the carbon and energy exchanges between the Amazon rainforest and the atmosphere, contributing to our understanding of how ecosystems work and to the calibration of climate models.

AmazonFACE[26] is a scientific research program focused on a field experiment designed to assess how rising atmospheric CO_2 concentrations affect the Amazon rainforest, its biodiversity, and ecosystem services. Located at a research station of the National Institute for Amazonian Research (INPA, Instituto Nacional de Pesquisas da Amazônia), the experiment uses Free-Air CO_2 Enrichment (FACE) technology.

In the field of the cryosphere, the Brazilian Antarctic Program (PROANTAR, Programa Antártico Brasileiro), coordinated by MCTI/CNPq – National Council for Scientific and Technological Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico) and SECIRM – Secretariat of the Interministerial Commission for Marine Resources (Secretaria da Comissão Interministerial para os Recursos do Mar)/Navy, operates the Comandante Ferraz Antarctic Station on King George Island and the autonomous Criosfera 1 platform in Central Antarctica, ensuring continuous environmental observations in a sensitive region of the climate system. In addition, Brazilian researchers participate in the international RINGS program[27], coordinated by the Scientific Committee on Antarctic Research (SCAR), which focuses on mapping the margins of the Antarctic ice sheet and studying its variations, including its relationship with sea level and associated geological and biological processes.

Rede Clima coordinates research groups at universities and science and technology institutes centered around thematic subnetworks, including land use, ecosystem environmental services, biodiversity, and coastal zones (Brasil, 2007b). Its work helps bridge the gap between data generated by observation networks and applied scientific research, in coordination with CIM's Scientific Advisory Chamber, and through the development of inputs for policy and climate reports (Brasil, 2026a). The National Institutes of Science and Technology for Climate Change (INCT-MC, Institutos Nacionais de Ciência e Tecnologia para Mudanças Climáticas), in turn, expand this capability by integrating earth system modeling, analysis of sector-specific climate impacts, and the development of applied information, including inputs for AdaptaBrasil MCTI and for studies on Impacts, Vulnerabilities, and Adaptation.

The consolidation of these data also strengthens the available technical basis regarding native vegetation, deforestation, land use and land cover, water resources, and carbon fluxes. These elements are particularly relevant for estimates in the Land Use, Land-Use Change, and Forestry sector in the National Inventory, for tracking progress regarding Brazil's Nationally Determined Contribution, for studies on impacts, vulnerabilities, and adaptation, and for monitoring public policies related to the conservation and sustainable use of natural resources.

7.1.5 Remote sensing and satellite observation

Remote sensing and satellite observation are an important aspect of systematic climate observation in Brazil, as they enable recurring and spatially detailed monitoring of environmental processes across a vast territory with a high diversity of biomes. This capability supports national systems such as PRODES, DETER, TerraClass, and BiomasBR, which are used to monitor native vegetation, land cover and land use, deforestation, and fires, in addition to contributing to the monitoring of hydrological, oceanic, and meteorological variables. In Brazil, this domain is structured primarily around the Earth observation programs operated by INPE, notably the CBERS

26 Available at: https://amazonface.unicamp.br/. Accessed on: Aug 18, 2026.

27 Available at: https://scar.org/science/cross/rings. Accessed on: Aug 20, 2026.

Program, the Amazonia-1 satellite, and the integration of data from international satellite missions.

The CBERS Program (China-Brazil Earth Resources Satellite) is the result of technical and scientific cooperation between Brazil, through INPE, and China, through the China National Space Administration (CNSA), which began in 1988 and was formalized through successive bilateral agreements. Over the course of nearly four decades, the program has launched six satellites into a sun-synchronous polar orbit: CBERS-1, launched in 1999; CBERS-2, in 2003; CBERS-2B, in 2007; CBERS-3, in 2013, which failed to reach orbit; CBERS-4, in 2014; and CBERS-4A, in 2019 (INPE, 2024c).

Images from the CBERS series are made available free of charge through the INPE website and integrated into the Georeferenced Information Database (BIG) infrastructure. The CBERS open-access data policy, adopted by INPE in 2004, is a key component of Brazil's strategy for disseminating Earth observation data, as it expands public access to satellite imagery and supports its use by government agencies, research institutions, and other users. In the context of environmental and climate monitoring applications, CBERS data serve as an important input for programs such as PRODES, DETER, TerraClass, and BiomasBR, which support the monitoring of native vegetation, land cover and land use, deforestation, and fires.

Amazonia-1 is the first Earth observation satellite to be entirely conceived, designed, integrated, and tested in Brazil by INPE. Launched on February 28, 2021, it represents a significant milestone in the development pathway of Brazil's national Earth observation capability. At the operational level, data from Amazonia-1 are integrated with CBERS-4A imagery in the PRODES and DETER algorithms. The complementarity between the time series obtained by the two satellites helps reduce gaps associated with the seasonality of cloud cover, especially during the rainy season in the Amazon, and supports deforestation warnings and annual deforestation estimates (INPE, 2024a). In addition to monitoring forest cover, data from the AWFI camera are used to monitor fires, water dynamics, and land-use changes in other biomes, including the Cerrado and the Caatinga (INPE, 2024d).

Brazil also integrates data from international satellite missions into its national climate observation systems. These data complement the information obtained by the CBERS and Amazonia-1 satellites, expanding the available spatial resolution, retrospective temporal coverage, and the diversity of observed variables. In the domain of Earth's surface, the NASA/USGS Landsat series, which has been in operation since 1972, is an important historical basis for long-term time series. The Copernicus program, coordinated by the European Space Agency (ESA) in partnership with the European Commission, complements this dataset with the Sentinel series. Sentinel-2, with a resolution of 10 meters and a five-day revisit time, is used in land cover and land use monitoring applications, while Sentinel-1, with synthetic aperture radar, enables imaging unimpeded by cloud cover, with applications in wetlands monitoring, river dynamics, and deforestation detection during the rainy season (ESA, 2024). Sentinel-3, which is also part of the Copernicus program, further contributes data on land and sea surface temperature, ocean color, and coastal altimetry, which are variables that are relevant for monitoring oceanographic and ecosystem processes of climate interest (ESA, 2024).

In the atmospheric and meteorological domain, the GOES-16 geostationary satellite, operated by the United States National Oceanic and Atmospheric Administration (NOAA), is used as a source of real-time meteorological imagery for Brazilian territory, which is received and redistributed by CPTEC/INPE. GOES-16 provides images in 16 spectral bands, which are used to monitor extreme precipitation, convective systems, fire hotspots, and incident solar radiation, and are applied in numerical weather and climate prediction models operated by INPE (NOAA, 2024). EUMETSAT's MetOp series provides vertical temperature and humidity profiles for assimilation into global

numerical weather prediction models, while the VIIRS instrument, aboard the Suomi-NPP and JPSS-1 satellites, is used operationally by INPE in the BDQueimadas system for real-time detection of hotspots (NOAA, 2024).

In the oceanographic and hydrological domains, international radar altimetry missions, such as Jason-3 and Sentinel-6 Michael Freilich, provide sea level measurements that are assimilated by the DHN and INPE as part of GOOS-Brazil. The GRACE-FO mission provides monthly estimates of changes in terrestrial water storage, which are relevant for monitoring droughts in the Amazon River Basin and the Brazilian Semi-Arid Region. Data from ESA's SMOS mission and NASA's SMAP mission complement observations of soil moisture on a continental scale (ESA, 2024; NASA/GFZ, 2024).

7.1.6 Contributions to global observation systems

Brazil's participation in global and regional climate observation systems involves reporting national data, integrating Brazilian networks with international standards, making remote sensing methodologies and products available, and providing technical cooperation at the regional level. This participation involves systems coordinated by the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO), and the Group on Earth Observations (GEO), including the Global Climate Observing System (GCOS), the Global Ocean Observing System (GOOS), the WMO Integrated Global Observing System (WIGOS), the WMO Information System 2.0 (WIS 2.0), and the Global Earth Observation System of Systems (GEOSS) (GCOS, 2022; WMO, 2019; IOC-UNESCO, 2023).

The Global Climate Observing System (GCOS) was established in 1992 as a joint program of the WMO, IOC-UNESCO, the United Nations Environment Programme (UNEP), and the International Science Council (ISC). Its mandate is to ensure the availability of the observations needed to monitor the climate system, investigate the causes of climate change, and support adaptation and mitigation efforts. The GCOS organizes its observational requirements around 54 Essential Climate Variables (ECVs), distributed across the atmospheric, oceanic, and terrestrial domains (GCOS, 2022). In Brazil, INPE and INMET perform complementary roles in their interactions with the GCOS. INPE focuses on issues related to the ECVs of the terrestrial and satellite domains, while INMET focuses on surface atmospheric ECVs. According to available GCOS/WMO records, these interactions take place through focal points linked to specific networks and components, without a single, formally designated national coordinating body for the GCOS as a whole. This structure reflects the decentralized nature of Brazil's climate observation system and helps put into context the effort to coordinate and consolidate the information presented in this chapter.

The monitoring systems described in the previous sections contribute to the monitoring of various ECVs. In the atmospheric domain, INMET's networks provide information on air temperature, precipitation, relative humidity, atmospheric pressure, and surface wind; INMET's and REDEMET's radiosounding network contributes vertical profiles of temperature, humidity, and wind; and INPE's programs, such as ATTO, LBA, the ozone network, and the Criosfera 1 and 2 stations, produce data related to atmospheric greenhouse gases, aerosols, and stratospheric ozone. In the oceanic domain, GOOS-Brazil, through RMPG, PNBOIA, the PIRATA buoys, and the Argo program, contributes to observations of sea level, surface temperature and salinity, and vertical profiles of the Atlantic. In the terrestrial domain, systems such as PRODES, DETER, TerraClass, and IFN provide information on land cover, deforestation, and forest biomass, while the National Hydrometeorological Network and the SNIRH provide data on river discharge in the country's major river basins (Brasil, 2021; GCOS, 2022). This set of systems makes it possible to link national observation networks to the essential climate variables used internationally to monitor the climate system.

Brazil also participates in the WMO Integrated Global Observing System (WIGOS), a WMO technical framework for integrating national observing networks into the global system. WIGOS sets standards for the instrumentation, calibration, transmission, archiving, and documentation of meteorological, hydrological, and climatological data, operating in conjunction with the OSCAR/Surface database, which catalogs stations and information on observed parameters, acquisition frequency, data quality, and operational status (WMO, 2019). INMET registers its stations with OSCAR/Surface and transmits data in real time to the WMO Global Telecommunication System. In 2023 and 2024, INMET completed the update of the national stations registry in OSCAR/Surface, incorporating automatic stations from the surface monitoring network and correcting metadata inconsistencies. ANA has begun the process of registering its stream and rainfall monitoring network in the WIGOS hydrological module (CMCH, 2024; WMO, 2019). These initiatives help to enhance the traceability and international interoperability of observational data produced in the country.

As part of the modernization of data exchange systems, the WMO Information System 2.0 (WIS 2.0) was adopted by the WMO to replace the legacy WIS 1.0 system and the Global Telecommunication System (GTS). WIS 2.0 introduces an architecture based on open Internet technologies, such as an MQTT broker, REST APIs, and open-format data, for the exchange of meteorological and climate data among the National Meteorological and Hydrological Centers that are members of the WMO. In Brazil, the migration to WIS 2.0 is considered an opportunity to modernize the transmission and dissemination of observational data, in coordination with INMET, CMCH, and CPTEC/INPE, particularly given CPTEC/INPE's role in satellite data processing and numerical modeling (WMO, 2019; CMCH, 2024).

Brazil's contribution is also linked to the Group on Earth Observations (GEO) and the Global Earth Observation System of Systems (GEOSS). GEO is an intergovernmental forum established in 2005 to coordinate the development of GEOSS, a framework designed to integrate the observational capabilities of its member countries for the production of environmental information of global interest. Brazil is a founding member of GEO and participates in its working groups, notably the GEO Global Forest Observations Initiative (GFOI), under which INPE coordinates the South America Node, contributing methodologies for estimating emissions from deforestation based on remote sensing. Brazil's participation in GEO is coordinated by the MCTI, with the involvement of INPE, MMA, and IBAMA, and includes contributions of data and methodologies to GEOSS environmental monitoring panels. In this context, the PRODES and DETER systems represent significant Brazilian contributions to the monitoring of tropical forests through remote sensing, using public data and methodology consolidated by INPE (INPE, 2024d; WRI, 2024).

At the regional level, the WMO Regional Association III (RA III), which brings together WMO member countries in South America, serves as a forum for technical cooperation in meteorology, climatology, and hydrology. Brazil participates in this cooperation through INMET and CPTEC/INPE, including data production and sharing, technical capacity-building, and computing infrastructure. The Regional Climate Center for Southern South America (CRC-SAS, Centro Regional do Clima para o Sul da América do Sul), co-led by INMET and Argentina's National Meteorological Service (*Servicio Meteorológico Nacional*), is designated by the WMO as a Regional Climate Center for the subregion, with responsibilities related to the production of regional reference seasonal climate forecasts and the coordination of climate monitoring activities of shared interest (WMO, 2017). This participation strengthens Brazil's integration into the WMO's regional climate observation and service systems.

In the field of climate modeling, CPTEC/INPE develops and operates the Brazilian Earth System Model (BESM), which participated in the Coupled Model Intercomparison Project Phase 6 (CMIP6),

providing long-term simulations used by the IPCC in its Sixth Assessment Report (Brasil, 2021). In the context of the CMIP6 project participation, the BESM is the only Earth system model developed by a South American country that formally participated in the round used as the basis for AR6 - a factual record that illustrates the level of maturity achieved by Brazil's modeling capability. As part of the Coordinated Regional Climate Downscaling Experiment (CORDEX), INPE participates in CORDEX-South America, providing regionalized climate projections using CPTEC/INPE's Eta regional model. These projections inform impact and vulnerability studies and can support adaptation planning processes. These initiatives link national climate modeling capability to international exercises of comparison, regionalization, and the use of climate scenarios.

Regional cooperation in meteorological observation also extends to the oceanic and hydrological domains. In the oceanic domain, Brazil participates in the PIRATA program, which focuses on monitoring ocean-atmosphere interactions in the Tropical Atlantic, as mentioned earlier. In the hydrological domain, Brazil's participation includes initiatives such as the HydroSAT program, which integrates radar altimetry data to monitor river levels in the Amazon Basin in cooperation with France and Germany, and ANA's coordination of the Multilateral Hydrometric Network of South America (Rede Hidrométrica Multilateral da América do Sul), in collaboration with hydrological agencies from the member countries of the Amazon Cooperation Treaty Organization (ACTO). These initiatives contribute to data sharing and the monitoring of transboundary water systems, especially in the Amazon Basin (Brasil, 2025a; NOAA, 2024).

In short, this section shows that Brazil's contributions to global and regional observation systems combine national networks, data platforms, remote sensing systems, climate modeling, and technical cooperation. This integration allows information generated in the country to be incorporated into international climate observation systems, and ensures that global standards for interoperability, metadata, and data dissemination support the improvement of national networks.

7.1.7 Identified needs and opportunities for continuous improvement

Identifying needs and opportunities for improvement is part of the process of continuously strengthening systematic climate observation. Under the National Communications to the UNFCCC, this reporting allows for the identification of areas where expanding coverage, technological modernization, database integration, and strengthening technical capabilities can contribute to the progressive improvement of the production, access, and use of climate information (Decision 17/CP.8, UNFCCC, 2002; Decision 18/CMA.1, UNFCCC, 2018).

In the case of Brazil, given the country's vast territory, the diversity of its biomes, the complexity of existing networks, and the multitude of institutions involved, the identified needs can be understood as inputs for an agenda to consolidate and improve the national observation system, aligned with the monitoring, assessment, and updating cycle established by the Cross-Cutting Strategy for Monitoring, Management, Evaluation, and Transparency (ET-MGAT, Estratégia Transversal de Monitoramento, Gestão, Avaliação e Transparência) of the Climate Plan 2024-2035 and the Biennial Transparency Reports (Brasil, 2026a; UNFCCC, 2018).

Among the identified opportunities for geographic improvement, there are areas where expanding or modernizing observational coverage can help improve the representation of relevant meteorological, climatic, hydrological, oceanic, and ecosystem processes. Within the Legal Amazon, the expansion and modernization of the atmospheric and hydrometeorological observation network can improve monitoring of the Amazon's water balance and the incorporation

of data into regional climate models. In the northeastern Semi-Arid region, the modernization of existing rainfall monitoring networks, including the expansion of soil moisture sensors and real-time telemetry, can support the monitoring of variables related to water availability, the occurrence of droughts, and climate risk management (GCOS, 2022).

In the oceanic and coastal domains, the gradual expansion of the monitoring of sea level and coastal ecosystems can help monitor relevant variables in areas subject to risks associated with sea-level rise, coastal erosion, extreme events, and changes in sensitive ecosystems. In this context, the northern coast can be considered an area of interest for the potential gradual expansion of the tide gauge network and the monitoring of coastal ecosystems, thereby expanding the coverage of oceanic and coastal variables associated with systematic climate observation. Another complementary opportunity is the gradual development of continuous monitoring of marine biogeochemical and ocean acidification parameters, particularly those related to oceanic ECVs recognized by GCOS, which are still poorly covered by national networks (GCOS, 2022). In addition to these efforts, there is a need to expand bathymetric data and ocean depth mapping, which are still considered significant gaps in national marine observation, and have direct implications for ocean modeling, coastal monitoring, and marine spatial planning. In the vertical domain of the atmosphere, expanding the radiosounding network in Amazonian subregions may also help improve the representation of vertical profiles of temperature, humidity, and wind in a region characterized by a vast territory and high intertropical climate variability (CMCH, 2024; WMO, 2019).

In addition to expanding observational coverage, strengthening technical and institutional capabilities emerges as a cross-cutting area for improvement. Among the relevant technical domains are quality control and the homogenization of climatological time series; the assimilation of satellite data into numerical weather and climate prediction models; the processing of radar altimetry data and ocean vertical profiles; and the estimation of Essential Climate Variables from remote sensing data. Improving these capabilities can support meteorological and hydrological networks, as well as ocean, coastal, and satellite systems, enhancing the consistency of time series, the comparability of data, and their use in models, climate analyses, and national reports (GCOS, 2022; WMO, 2019).

Therefore, the integration and interoperability among networks, systems, and databases are also key areas for improvement. Brazil already has well-established integration initiatives, such as INPE's Georeferenced Information Database (BIG), Brazil Data Cube, and the National Water Resources Information System (SNIRH), which provide data and services in open and structured formats. The gradual expansion of similar models to other surface, ocean, coastal, and air quality networks can strengthen the interoperability of the national systematic observation system, in alignment with the international standards of the WMO, GCOS, GEO, and WIGOS/WIS 2.0 (WMO, 2019; GCOS, 2022). The gradual migration to the WIS 2.0 architecture, replacing the WMO Global Telecommunication System, and the continued progress toward the indicative target set by WIGOS Vision 2040 of automatic transmission to more than 80% of surface stations represent, in this context, specific opportunities to modernize the transmission and dissemination of observational data produced in the country (WMO, 2019).

The adoption of open metadata standards, in particular the Climate and Forecast (CF) Conventions formats for gridded data and the SensorThings API standard from the Open Geospatial Consortium (OGC) for *in situ* station data, and the integration of networks from other national institutions into the WMO's OSCAR/Surface registry are examples of measures aligned with the Cross-Cutting Strategy for Monitoring, Management, Evaluation, and Transparency (ET-MGAT) of the Climate Plan

(Brasil, 2026b). The harmonization of data policies among federal observation institutions, along with the adoption of open licenses compatible with GCOS and GEO standards, can also be part of the technical dialogue on systematic observation, including within the relevant coordinating bodies, such as the CMCH (CMCH, 2024; GCOS, 2022). As a complementary measure, the adoption of regular assessment cycles for the national coverage of Essential Climate Variables, similar in format to the GCOS Status Report, can be considered a tool for the systematic monitoring of the national observation system, in coordination with the ET-MGAT cycles and Brazil's Biennial Transparency Reports (BTR), contributing to the progressive consolidation of a verifiable baseline of observational capabilities (GCOS, 2022; Brasil, 2026a).

The identified needs also highlight opportunities for international technical cooperation. Programs and mechanisms linked to the WMO, GCOS, GEO, and bilateral agreements with partner space agencies can support capacity-building efforts, technological modernization, methodological improvements, and data integration.

Progress on this agenda depends, however, on addressing the structural challenges that affect the quality and continuity of observations. Among the most significant challenges are the maintenance and modernization of networks; the phasing out of conventional weather stations, some with time series dating back a century, which could potentially impact the preservation of long and homogeneous records; the gradual replacement of conventional stations with automatic stations, a process that requires full compliance with the recommendations of the World Meteorological Organization, posing risks to the homogeneity of observational time series; and the need to strengthen national guidelines for the permanent coordination of data collection, integration, qualification, and dissemination activities. Addressing these challenges is essential for ensuring that the expansion of coverage and the technological modernization of networks effectively strengthen the generation of consistent and comparable climate data over time.

Thus, the needs and opportunities for improvement associated with systematic climate observation in Brazil can support a progressive agenda for strengthening the system, aimed at expanding observational coverage, strengthening technical capabilities, promoting interoperability, and consolidating the use of climate data in national planning processes, transparency, and international reporting. This set of needs and opportunities is aligned with the evolution of national observation systems, helping to ensure that the information produced in the country is increasingly consistent, accessible, comparable, and useful for climate action.

7.2 Education, training, and public awareness regarding climate change

7.2.1 Institutional and strategic framework

In accordance with the provisions of the UNFCCC, pursuant to Article 6, and under the Paris Agreement, pursuant to Article 12, Brazil submits key information on education, capacity-building, public awareness, social participation, access to information, and technical and scientific cooperation regarding climate change. The efforts made at the national level to generate, expand, and facilitate access to high-quality public information have guided the actions of the Brazilian government, given the importance of keeping all segments of society informed in support of climate action.

At the national level, these actions are organized primarily through the **Cross-Cutting Strategy for Education, Training, Research, Development, and Innovation** (ET-ECAPI) (Brasil, 2026f) of the Climate Plan, and are complemented by information on actions, initiatives, plans, projects, and the work of institutions that make significant contributions to the implementation of the UNFCCC, the strengthening of institutional capabilities, and the advancement of the frontiers of knowledge.

The structure of this chapter aims to highlight how these elements contribute to expanding institutional and social capabilities, strengthening climate action, and promoting a just, inclusive, and evidence-based transition.

7.2.2 Cross-Cutting Strategy for Education, Training, Research, Development, and Innovation of the Climate Plan

The Climate Plan, which outlines actions, guidelines, and targets for the adaptation and mitigation pillars through 2035, includes the Cross-Cutting Strategy for Education, Training, Research, Development, and Innovation (ET-ECAPI), approved in 2026, with the goal of expanding the training and engagement of professionals, institutions, and communities in the climate agenda, and promoting the production and dissemination of technical and scientific knowledge throughout the country. This strategy is one of the Plan's structural pillars because it plays an essential role in achieving the targets.

The working group, established in 2025 and led by the Office of the Chief of Staff of the President of the Republic and by the Ministries of the Environment and Climate Change (MMA) and Education (MEC), involving 20 ministries, was responsible for developing the cross-cutting strategy that promotes direct links with the plans and ensures that education, science, technology, and innovation are treated as foundational elements for climate action and a just transition in Brazil.

With ET-ECAPI, Brazil has a federal-level educational and training strategy that links mitigation and adaptation plans and targets to education policy, from early childhood education through post-graduate studies, across all educational levels and fields of knowledge. ET-ECAPI is a cross-cutting strategy for Brazilian climate action, as it helps build the capacity of citizens, professionals, and organizations to support a just climate transition in the country. The Strategy also identifies gaps and needs for strengthening the prioritized actions, while incorporating a gender perspective and valuing traditional knowledge.

The Strategy is organized into five pillars that reflect this integrated vision: (i) **formal education**; (ii) **non-formal education and the valuing of the knowledge of traditional and Indigenous peoples and communities**; (iii) **vocational and technical training**; (iv) **research, scientific development, and innovation**; and (v) **raising awareness and combating misinformation**.

Recognizing the central role of education and knowledge in building sustainable futures, the Strategy proposes a cross-cutting, intersectoral, and participatory approach capable of mobilizing schools, universities and institutes, research centers, traditional communities, social movements, and the business sector. It also seeks to bridge the gap between scientific knowledge, Indigenous science, and local knowledge, recognizing their contribution to climate action.

Dataframe 7.2.1 provides an overview of those pillars, their descriptions, and the educational tools considered priorities in ET-ECAPI.

Dataframe 7.2.1 Summary of the priority pillars and goals of ET-ECAPI in the Climate Plan

Pillar	Description	Goals
Formal Education	This refers to all activities carried out by formally established educational institutions, from early childhood education through post-graduate studies.	1. Strengthening governance. 2. Regulatory frameworks. 3. Infrastructure and action protocols. 4. Training of education professionals and development of teaching materials.
Non-Formal Education	It includes educational activities carried out outside formal educational institutions, promoting traditional, regional, and ancestral knowledge, as well as community-based practices in environmental education, climate justice, and active citizenship.	1. Structural policy. 2. Region-based training. 3. Promotion of different types of knowledge.
Vocational and Technical Training	It includes vocational and technical training and the training of workers and entrepreneurs in the formal and informal sectors of the economy, developing skills for a sustainable economy in sectors that are strategic for a just and ecological transition.	1. National Strategy for a Just Transition in Vocational and Technical Training. 2. Alliances for a sustainable economy and public sector capacity building. 3. Sustainable financing. 4. Quality Assessment in EPT - Vocational and Technical Training (Educação Profissional e Tecnológica) for a sustainable economy.
Research, Development, and Innovation	It coordinates and promotes science, technology, and innovation initiatives aimed at mitigation of greenhouse gas emissions and adaptation to the adverse effects of climate change.	1. Production of scientific and technological knowledge. 2. Scientific and technological infrastructure. 3. Innovation networks and ecosystems. 4. Information and evidence platforms. 5. Social impact and transformation.
Raising Awareness and Combating Misinformation	This refers to public communication and education initiatives aimed at disseminating reliable climate information and combating misinformation.	1. Climate communication. 2. Digital regulation. 3. Training and protection of communicators and the sustainability of environmental journalism.

Source: Compiled based on ET-ECAPI (Brasil, 2026f).

7.2.3 Climate education in the formal education system

Within the formal education system, incorporating climate change is a key factor in building long-term social, technical, and institutional capacities. Formal education includes all activities carried out by formally established educational institutions, from early childhood education through post-graduate studies. In this context, the ET-ECAPI's formal education pillar seeks to strengthen the integration of environmental and climate education into curricula, teacher training, and resilient schooling infrastructure.

The ET-ECAPI states that formal education in Brazil needs to be restructured to incorporate climate and socio-environmental issues as a cross-cutting pillar across all areas of knowledge, from early childhood education through post-graduate studies, with comprehensive and coordinated teacher training combined with teaching and learning resources, such as textbooks and pedagogical materials, and sustainable infrastructure.

Among the challenges mentioned regarding the integration of climate change into the curriculum is the lack of greater conceptual and methodological depth to address this issue in the school setting, which is often based on content reproduced from the media, a situation that limits the critical and proactive potential of the learning processes. In rural schools, the challenge is compounded by a shortage of context-specific teaching materials that integrate climate, agroecology, and food security (Brasil, 2026f).

Among the key instruments of the Brazilian education system are the **Law on Guidelines and Foundations of National Education** (LDB, Lei de Diretrizes e Bases da Educação Nacional) (Brasil, 1996; 2024c) and the **National Common Core Curriculum** (BNCC, Base Nacional Comum Curricular). The LDB establishes the guidelines and foundations of the national education system and organizes school education into levels, stages, and types. The BNCC, in turn, is a regulatory framework that guides school curricula by defining the set of essential learning outcomes and the progression that all students must achieve throughout the stages and types of basic education. In natural sciences, for example, in addition to a commitment to developing scientific literacy, the guidelines explicitly state that students are expected to develop a new perspective on the world around them, guided, also, by socio-environmental sustainability (Brasil, 2018).

Since 2009, the **National Education Plans** (PNE, Planos Nacionais de Educação) in Brazil have been established by law and are in force for a period of ten years. The process of developing the national education policy is characterized by the participation of state and local governments, parliamentary representatives, and civil society (Brasil, 2025j). The next ten-year plan, which runs through 2036 (Brasil, 2026a), includes, for the first time, the strengthening of the principles of the democratic rule of law as one of its general objectives, with an emphasis on promoting citizenship and sustainable socio-environmental development. This framework can support the cross-cutting integration of climate change into school subjects, educational projects, teacher training, and sustainable school management.

In addition, the country has the National Policy on Environmental Education (PNEA, Política Nacional de Educação Ambiental) (Brasil, 1999), a legal instrument established in 1999 and regulated in 2002, which aims to promote environmental education at all levels of schooling, as well as in non-formal educational activities and public awareness-raising campaigns for the preservation of the environment, the sustainable use of natural resources, and the development of a more responsible society that is committed to socio-environmental issues. With the aim of ensuring that

attention is given to climate change, the protection of biodiversity, and the risks and vulnerabilities associated with socio-environmental disasters, in 2024, the PNEA incorporated efforts to raise public awareness of the importance of prevention, mitigation, and adaptation measures across all educational levels, as well as the development of tools and methodologies to ensure the effectiveness of these measures.

In the context of higher education, the integration of climate change into academic curricula is important both for training professionals in various fields of knowledge and for preparing teachers, researchers, public administrators, and specialists who will be involved in implementing policies related to mitigation, adaptation, risk management, technological innovation, and a just transition. In 2024, Brazil had 10.2 million students enrolled in higher education (INEP, 2024), representing a 30.5% increase over the past decade. According to data from the 2022 Census (IBGE, 2025b), the proportion of the country's population aged 25 or older with a university degree increased 2.7-fold, rising from 6.8% in 2000 to 18.4% in 2022. In this same age group, women have a higher level of education than men, with 20.7% having a university degree. The Black population with a university degree, in turn, increased 5.8 times. Despite the increase and progress made, the percentage of adults with higher education is below the average for OECD countries, which stands at over 41 percent. These data indicate an expansion of the national education base, but they also highlight persistent challenges related to access and qualifications that must be taken into account when building capacity for the climate agenda.

Brazil's formal education system also includes specific programs and policies tailored to different regional and sociocultural contexts. Recognizing the specific educational needs of rural communities, Brazilian education law provides for the **National Program for Education in Agrarian Reform** (Pronera, Programa Nacional de Educação na Reforma Agrária) (Brasil, 2010c), aimed at youth and adults living in settlements established or recognized by the National Institute for Rural Settlement and Agrarian Reform (Incra, Instituto Nacional de Colonização e Reforma Agrária), the **Operational Guidelines for Basic Education in Rural Schools** (Brasil, 2008a) and the **National Policy on Education for the Population Living in Rural, Riverside and Forest Areas** (New Pronacampo - Política Nacional de Educação do Campo, das Águas e das Florestas) (Brasil, 2025e), which explicitly incorporates the topic of climate change into its goals and actions. Given the specific characteristics of Indigenous peoples, there is also the **National Policy on Indigenous School Education in Ethno-Educational Territories** (PNEEI-TEE, Política Nacional de Educação Escolar Indígena nos Territórios Etnoeducacionais) (Brasil, 2009; 2025f), which promotes the organization and provision of quality education tailored to these populations. These instruments are important for contextualizing climate education in diverse territories, ways of life, and knowledge systems, without disconnecting it from the formal education system.

The country also has the **National Pact for Learning Recovery** (Pacto Nacional pela Recomposição das Aprendizagens), established by Decree No. 12,391/2025, which consists of cooperation between the Federal Government, the States, the Federal District, and the Municipalities to ensure adequate learning and performance for all basic education students and to mitigate the impacts of climate events and/or events that give rise to a situation of emergency or public calamity. Among the practical actions taken, the Guide to Educational Actions in Response to Climate Emergencies (Guia de Ações Educacionais em Resposta a Emergências Climáticas) was developed to support education departments across the country in protecting students' school trajectories in contexts of climate crisis.

Taking into account the context, the challenges, and the legal frameworks, the ET-ECAPI's formal education pillar establishes four strategic goals aimed at integrating the climate theme across educational curricula. For each goal, actions, targets, benefits, indicators, and key actors are identified. The first goal emphasizes strengthening governance to promote regular coordination and collaboration among governmental and nongovernmental actors involved in environmental and climate education. The second goal addresses the need to revise and integrate environmental and climate education into the regulatory frameworks. The third goal explores the infrastructure and action protocols needed to prepare school systems, schools, and school communities to identify, manage, and address the risks of climate change. The fourth goal involves the training of education professionals and the development of teaching materials, with an emphasis on the qualification of these professionals and the improvement of these materials.

As an example of implementation at the federal level, the Ministry of Education (MEC) established the **Education for Citizenship and Sustainability Program** in 2025 (Brasil, 2025h), whose purpose is to consolidate pedagogical and school management practices for citizenship and sustainability at all levels of basic education. Planned actions include the provision of a Competency Framework for citizenship and sustainability education, training courses for educators, and a repository of teaching materials. The program ensures the implementation of the topics outlined in the BNCC and is linked to other federal government educational programs, such as the **Money Directly to Schools** (**PDDE, Programa Dinheiro Direto na Escola) Sustainable Schools program** - aimed at promoting adequate infrastructure to foster environmental sustainability -, and to state and local governments. One of the program's pillars emphasizes curriculum guidance and the training of education professionals, with the aim of providing schools, school districts, and education systems with technical support and training programs for teachers and administrators to help them plan educational initiatives in the areas of citizenship education and sustainability. Among the program's strategies is the development and provision of continuing education for basic education professionals.

In higher education and university extension, the contribution of the **National Policy on Agroecology and Organic Production** (PNAPO, Política Nacional de Agroecologia e Produção Orgânica) (Brasil, 2026h), through the Agroecology and Organic Production Study Centers (NEAs, Núcleos de Estudos em Agroecologia e Produção Orgânica), established at public universities, federal institutes, and other educational institutions, stands out. These centers promote educational, research, and university extension processes focused on agroecology, environmental conservation, adaptation to climate change, food security, and the valuing of the knowledge of family farmers, Indigenous Peoples, traditional communities, and other rural populations, strengthening territory-tailored education and the participatory development of sustainable solutions.

7.2.4 Non-formal climate education and educational initiatives

As a complement to the formal education system, non-formal climate education broadens the reach of the climate agenda in community, economic, regional, and sociocultural settings. The ET-ECAPI includes the pillar of **non-formal education integrated with the knowledge of Indigenous peoples and traditional communities.** Non-formal education is defined as the learning process that takes place outside of educational institutions, linked to daily life and to social, family, cultural, and work relationships, and which has an impact on individual and collective ways of life. This pillar recognizes ancestral knowledge as a strategic asset, even though there are challenges associated with the lack of structural policies and greater coordination between participatory and

intersectoral forums. According to the 2022 Census (IBGE, 2025a), Brazil is home to 391 Indigenous ethnic groups, peoples, or communities and has 295 Indigenous languages.

The diagnosis underpinning the strategy highlights the need to expand training for technical assistance and rural outreach agents, urban community leaders, and community educators, among other groups. In response, the goals for this pillar are focused on structural policies, strengthening continuing and region-specific education, and promoting local and traditional knowledge. The proposed targets are aligned with the promotion of human rights, the strengthening of regional governance, and the enhancement of local resilience, in conjunction with reliable scientific information.

Among the key instruments in this pillar are the existing policies and programs that directly engage with audiences and regions relevant to climate action. The National Policy on Technical Assistance and Rural Outreach for Family Farming and Agrarian Reform (PNATER, Política Nacional de Assistência Técnica e Extensão Rural para a Agricultura Familiar e Reforma Agrária) (Brasil, 2010a) is part of this set of instruments. Described as a continuous non-formal education service focused on rural areas, this policy can contribute to environmental and climate education by promoting the adoption of sustainable, low-carbon practices aimed at strengthening community resilience among family farmers, Quilombolas, Indigenous peoples, and women in rural areas.

The **National Policy for the Sustainable Development of Traditional Peoples and Communities (**PNPCT, Política Nacional de Desenvolvimento Sustentável dos Povos e Comunidades Tradicionais) (Brasil, 2007) and the **National Policy on Territorial and Environmental Management of Indigenous Lands** (PNGATI, Política Nacional de Gestão Territorial e Ambiental de Terras Indígenas) (Brasil, 2012), also play an important role. While the former recognizes and upholds the rights of traditional peoples and communities, the latter strengthens the autonomy of Indigenous peoples in the management of their territories and promotes the appreciation of traditional knowledge. Both contribute to the non-formal education pillar by strengthening social participation and recognizing protected areas as spaces for learning and knowledge production.

With regard to valuing traditional knowledge, the **Knowledge Cycle Program with Masters of Traditional and Popular Cultures and the Arts** (Programa Ciclo de Saberes com Mestras e Mestres das Culturas Tradicionais e Populares e das Artes) fosters interaction between higher education institutions and bearers of traditional knowledge. The initiative contributes to the recognition of the diversity of knowledge related to the sustainable management of territories, environmental conservation, the protection of socio-biodiversity, and climate adaptation, strengthening the dialogue between science, culture, and community knowledge.

The **National Policy on Environmental Education** (PNEA, Política Nacional de Educação Ambiental) also plays an important role in this context. In addition to guiding environmental education at all levels of education, the policy encompasses non-formal education initiatives and public awareness campaigns. Through the **National Environmental Education Program** (ProNEA, Programa Nacional de Educação Ambiental), the PNEA fosters collaboration between federative entities and civil society around sustainable values, knowledge, and practices. In the context of non-formal education, the program supports educational initiatives aimed at preparing communities, leaders, and young people to address the challenges of climate mitigation and adaptation. Complementing this network, the MMA's **Centers for Education and Socio-Environmental Cooperation** (CECSAs, Centros de Educação e Cooperação Socioambiental) serve as regional hubs for non-formal education, bringing schools, communities, and social movements together.

The diversity of initiatives, actors, and regions involved in the implementation of the PNEA highlights the importance of permanent mechanisms for monitoring environmental education policies. In this context, the **National Program for the Evaluation and Monitoring of Environmental Education** (ProNAMEA, Programa Nacional de Avaliação e Monitoramento da Educação Ambiental) (Brasil, 2026b) stands out, established by the Ministry of the Environment and Climate Change as an instrument designed to support the evaluation and continuous improvement of these policies on a national scale.

Brazil also has relevant experience prior to ET-ECAPI. Among these initiatives, **Cemaden Education** (Cemaden, 2019) stands out as a program of the National Center for Monitoring and Early Warnings of Natural Disasters (Cemaden) linked to the MCTI. Since 2014, the program has been promoting citizen science initiatives focused on monitoring climate risks with students and teachers, helping to foster a culture of disaster risk awareness and prevention in school communities and community centers in areas with socio-environmental vulnerability. The initiative develops educational materials, campaigns, and training activities, and has received international recognition for its good practices (UNFCCC, 2025).

Another notable initiative is the **National Electric Energy Conservation Program** (Procel, Programa Nacional de Conservação de Energia Elétrica) (ENBPar, 2026). Established in 1985, the program has established itself as one of the leading public policies focused on energy efficiency, promoting the efficient use of energy and the reduction of waste throughout the entire electricity sector. In addition to helping reduce greenhouse gas emissions and boost the country's economic competitiveness, the program carries out public awareness and training initiatives. Among its key initiatives is the Procel Seal, which applies to equipment and buildings and is widely recognized nationwide.

Non-formal climate education is also relevant in urban settings marked by sociospatial inequalities and greater exposure to climate risks. According to the 2022 Census (IBGE, 2024), Brazil has 12,348 *favelas* and urban communities, home to approximately 16.4 million people, representing 8.1% of the population. Compared to the 2010 Census, there was a 2.1% increase. This scenario underscores the need for participatory educational initiatives focused on climate adaptation in vulnerable urban areas.

In this regard, the interministerial initiative called "**Resilient Green Urban Peripheries"** (Periferias Verdes Resilientes), launched in 2026 and linked to the **Live Urban Peripheries Program** (Programa Periferia Viva), which seeks to promote climate adaptation in urban peripheries through the implementation of nature-based solutions (NBS) to address hydrological risks and high temperatures, stands out. Planned activities include planning workshops, training initiatives, the implementation of solutions, and the monitoring of results aimed at reducing the impacts of climate change in the areas covered by the program.

7.2.5 Vocational training and institutional capacity-building

7.2.5.1 Vocational and technical training

Vocational and technical training, as well as institutional capacity-building, are essential elements for the implementation of policies on mitigation, adaptation and just transition. ET-ECAPI's assessment of vocational and technical training, from the perspective of a just transition, identifies challenges related to curriculum updates, teacher training, and expanding the supply of qualified professionals in areas that are strategic for climate action. Among the challenges identified, the

need to strengthen training focused on adaptation stands out, especially in sectors related to the building and maintenance of resilient infrastructure.

According to data from the IBGE's Continuous National Household Sample Survey (IBGE, 2026), 26.1 million Brazilians are self-employed, working in the informal sectors of the economy and with little access to professional qualification training. Furthermore, there is no consolidated database that captures the full range of occupations and professional and technical skills associated with a just transition, particularly in the informal sectors of the economy. These factors highlight the importance of training strategies capable of reaching both formal vocational training systems and workers and entrepreneurs working in different economic contexts.

Brazil also has the **Federal Network for Vocational, Scientific, and Technical Education** (Rede Federal de Educação Profissional, Científica e Tecnológica) (Brasil, 2008b), comprising 686 institutions (Brasil, 2026e), located in every state of the federation and in the Federal District, which offer more than 10,100 courses free of charge. There is also the **National Program for Access to Technical Training and Employment** (Pronatec, Programa Nacional de Acesso ao Ensino Técnico e Emprego) (Brasil, 2026c), created in 2011 with the goal of expanding and democratizing the availability of technical and vocational training courses and extending their provision to inland areas, thereby increasing training opportunities and facilitating entry into the workforce for young people and adults, especially those on low incomes. The program is implemented in collaboration between the Federal Government, the States, the Federal District, and the Municipalities, with the participation of various institutions offering vocational and technical education, including institutions of the Federal Network of Vocational, Scientific, and Technical Education (Rede Federal de Educação Profissional, Científica e Tecnológica), public institutions of the state, district, and municipal education networks, higher education institutions, the National Apprenticeship Programs, and other institutions accredited under applicable legislation.

Among the key instruments for this element of the ET-ECAPI are the **National Policy on Vocational and Technical Training** (PNEPT, Política Nacional de Educação Profissional e Tecnológica) (Brasil, 2025g), the integration of secondary-level technical and vocational education with professional and technical apprenticeship programs, the National Catalog of Technical Courses[28] and programs that promote training in this area. With the recent changes to high school education, there has been an increase in demand for vocational programs at this level of education in Brazil. However, the strategy highlights the need to incorporate the climate perspective into the ecosystem.

The four strategic goals of the ET-ECAPI's vocational and technical training pillar are aimed at equipping the workforce with the skills needed for a low-carbon economy and for emerging sectors linked to a just transition. The first goal is to align vocational and technical training with the ecological transition by integrating skills for a sustainable economy and the principles of just transition into the training system. Among the initiatives are the establishment of a skills observatory for a just transition and nationwide curriculum changes to the course catalog, in addition to promoting vocational and technical training for a sustainable economy, especially for young people. The second goal emphasizes strengthening coordination among educational institutions, the productive sector, and local governments to develop skills for a sustainable economy, including training for public servants at all three levels of government. The third goal regards the incorporation of sustainability criteria into the Interest for Education program, under the State Debt Full Payment Program (PROPAG, Programa de Pleno Pagamento de Dívidas dos

28 Available at: https://cnct.mec.gov.br/. Accessed on: Mar 16, 2026.

Estados), and the use of this instrument to promote the offering of technical courses aimed at professional retraining for a just transition. The implementation of an evaluation system to recognize and reward institutional performance constitutes the fourth goal.

In the area of vocational and technical education focused on energy transition and sustainable economy, the **Program for the Development of Renewable Energy and Energy Efficiency in the Federal Network for Vocational, Scientific, and Technical Education** (EnergIFE, Programa para o Desenvolvimento em Energias Renováveis e Eficiência Energética na Rede Federal de Educação Profissional, Científica e Tecnológica), coordinated by the Ministry of Education (MEC), stands out. The Program promotes integrated actions in infrastructure, vocational and technical training, research, development, innovation and entrepreneurship, energy management, and partnership building, including professional qualification, teacher training, curriculum updating, and support for teaching and research infrastructure in renewable energy and energy efficiency. Among other initiatives aimed at strengthening vocational and technical education for a sustainable economy is the project **Professionals of the Future II: Skills for the Green Economy** (Profissionais do Futuro II: Competências para a Economia Verde), which includes curriculum development, professional capacity building, development of skills for a sustainable economy, coordination between educational institutions and the productive sector, and strengthening of employability, covering areas such as renewable energy, energy efficiency, bioeconomy, circular economy, and digital transformation. Through this project, the Training Pathway for Professionals in Strategic, Managerial, and Technical Roles in Vocational and Technical Education and Green Employment (Trilha de Capacitação para Profissionais de Atuação Estratégica, Gerencial e Técnica em EPT e Emprego Verde) is being promoted. The initiative seeks to strengthen the capacities of managers and technical teams of vocational and technical education and employment systems to guide policies, strategies, and institutional practices related to a just and ecological economic transformation. The training covers topics related to governance and financing, the development of skills for a sustainable economy and the updating of training opportunities, coordination with the productive sector and employability, equity, and digital transformation, including strategic decision-makers, tactical managers, and technical and operational teams.

7.2.5.2 Training for public administrators and institutional strengthening

In the area of institutional capacity building, strengthening public sector capacities is essential for the formulation, implementation, and evaluation of climate policies. The National School of Public Administration (ENAP, Escola Nacional de Administração Pública), established in 1986 to transform public administration, also includes the Virtual School of Government (EV.G, Escola Virtual de Governo), which focuses on distance learning. According to the indicators (Enap, 2026a), over the past five years (2021-2025), the platform has registered more than 4.8 million users and 15 million enrollments in its catalog of free courses. In total, 985 open courses are offered. In 2025, the topic of climate change took center stage in the Climate Spotlight initiative (Enap, 2025), which highlights topics relevant to public administration. In 2026, the institution launched a *lato sensu* specialization course in climate change (Enap, 2026b). The course is intended for civil servants and public employees at all levels of government who work directly in the social, environmental, and climate sectors and/or on environmental and climate policies.

In addition to the courses offered, initiatives focused on the use of evidence help improve institutional performance with regard to climate policy. The multi-institutional project called '*Good*' *evidence*: The Use of Evidence During Narrative Wars in the Brazilian Bureaucracy (D'Albuquerque et al., 2026), undertaken by ENAP, in collaboration with the Institute of Applied Economic Research (IPEA, Instituto de Pesquisa Econômica Aplicada), the Latin American Faculty of Social Sciences (Flacso Brasil, Faculdade Latino-Americana de Ciências Sociais), and the Institute of Development Studies at the University of Sussex (IDS/Sussex), assessed how evidence is understood, used, and institutionalized by different actors in Brazilian climate change policies. The total survey sample consisted of 3,777 federal civil servants from the direct and indirect federal administration. Respondents indicated that climate change has a very high (1,030 responses) or high (849 responses) impact on the field or public policy area in which they work.

On another front of this project, ENAP analyzed the use of evidence in federal climate governance decision-making processes, using the Interministerial Committee on Climate Change (CIM) and its role in developing the adaptation pillar of the 2024-2035 Climate Plan as a case study. The analysis highlighted the central role of technical and scientific sources in the decision-making process, the importance of interministerial forums as venues for the mediation between evidence and planning priorities, and the need to strengthen institutional capacities to broaden the incorporation of different types of knowledge, including regional and traditional knowledge.

The overview provided by the study reflects the reality of the development of the Climate Plan, which organized workshops and seminars and provided information, guidance, and mentoring that resulted in capacity building for the agents involved. Between 2023 and 2024, the initial phase of the development of the Climate Mitigation Plan involved widely publicizing the methodologies used for the projections carried out using the Brazilian integrated analysis model. More than 60 meetings, gatherings, workshops, and seminars were held, totaling approximately 200 hours of meetings for each participant. This amounts to more than 800 hours of work carried out by researchers dedicated exclusively to fostering dialogue among academia, civil society, and the federal government (Brasil, 2025n). A similar process took place during the development of the adaptation pillar of the Climate Plan, in which more than 300 professionals were trained to develop sector-specific plans.

7.2.5.3 Technical training and climate information for adaptation

In the urban and regional setting, capacity-building for public administrators and local actors is particularly important for incorporating adaptation, resilience, and risk management into urban planning. The **National Capacity-Building Program for Cities** (Brasil, 2023b), created in 2003 and restructured in 2023 following the reestablishment of the Ministry of Cities, aims to address cities in an integrated manner, focusing on resilience and sustainability through smart actions and interactions. Among the program's goals is the training of public and social sector officials to implement the **National Urban Development Policy**. Currently, 41 self-paced courses are available through the EV.G/ENAP platform, along with other types of training activities, such as synchronous meetings, workshops, and communities of practice, delivered through the Redus - Network for Sustainable Urban Development (Rede para Desenvolvimento Urbano Sustentável) platform[29]. The ministry is also developing the **AdaptAção** project (Brasil, 2024h), whose main objective is

29 Available at: https://capacidades.gov.br/cursos. Accessed on: Aug 18, 2026.

to integrate climate change adaptation strategies into urban policy. The municipalities receive technical assistance from the Network for the Evaluation of Urban Policy and Climate Adaptation Instruments (AIPUAC, Avaliação dos Instrumentos de Política Urbana e Adaptação Climática) of the National Institute of Science and Technology – Metropolis Observatory (Instituto Nacional de Ciência e Tecnologia - Observatório das Metrópoles).

The **Resilient Green Cities Program** (Brasil, 2024a) aims to improve the environmental quality and resilience of Brazilian cities in the face of the impacts of climate change by bringing together six thematic approaches with five lines of action, including capacity building, urban-environmental education, and information. **AdaptaCidades** (Brasil, 2024e) is an initiative of this program that supports states and municipalities in developing local or regional strategies and plans for adapting to climate change. Capacity building is a key component, with goals for technical training in climate change adaptation planning, the provision of information on municipal or regional risks, as well as methodological guidance, mentoring, and training for the development of plans, among other aspects.

Initially, 581 municipalities were selected, which together are home to a population of approximately 53 million people. The identification of priority municipalities (Brasil, 2025o) was guided by technical criteria designed to ensure greater effectiveness of public policy, notably: greater exposure to the impacts of climate change; lower technical, institutional, and governance capacity; and a larger population exposed to climate risks. The initiative's target is to reach 2,000 municipalities by 2035 (Brasil, 2025p).

The AdaptaCidades capacity-building strategy combines scale, technical depth, and institutional coordination. The training of approximately 10,000 public administrators is planned for 2026, including municipal and state-level technicians, intermunicipal consortia, and other actors involved in the climate agenda. The capacity-building approach is comprehensive and consists of multiple levels - ranging from conceptual and methodological training to practical guidance in the development of adaptation plans - structured in the form of distance learning, in-person workshops focused on the development of institutional arrangements and multilevel coordination, mentoring, and technical support in the development of the plans.

The initiative aims to raise awareness about the need to incorporate adaptation into urban planning, risk management, and fund allocation. Another key aspect is the focus on climate justice and the protection of vulnerable populations, with training content designed to prioritize the most exposed and socially vulnerable areas. AdaptaCidades, thus, aims to strengthen the link between local policies and national and international commitments, such as Brazil's Climate Plan and climate targets, contributing to more effective multilevel climate governance.

Technical capacity-building relies on public climate information platforms, which expand access to data, methodologies, and analytical tools. With regard to adaptation, the **AdaptaBrasil** platform has helped expand access to information and tools for climate risk analysis for public administrators, research institutions, the private sector, and civil society organizations. According to the platform's report (AdaptaBrasil MCTI, 2025), 1,287 professionals were trained through programs developed by the technical team in 2024 and 2025. The data show that 45% of the participants work in public agencies at the municipal, state, and federal levels; 30% in educational and research institutions; 12% in financial institutions and the private sector; and 8% in civil society organizations. The training covers the basic principles of climate change and its impacts, mitigation and adaptation, the adaptation cycle, the platform's history and methodological aspects, and the concepts of vulnerability, exposure, sensitivity, and adaptive capacity. There is

a higher concentration of participating municipalities in the Southeast, Central-West, and South regions, followed by the North and Northeast regions, which reflects the consolidation of the capacity-building network across different regional settings. This spatial distribution highlights the platform's potential to serve not only large urban centers but also small and medium-sized municipalities in the country's interior, expanding access to information and technical tools aimed at climate adaptation.

7.2.6 Research, technological development, innovation, and technical and scientific cooperation

Scientific research, technological development, innovation, and technical and scientific cooperation are essential components for informing public policy, guiding evidence-based decisions, and promoting solutions for climate change mitigation and adaptation. In this context, ET-ECAPI's research, technological development, and innovation pillar highlights Brazil's scientific potential, while also pointing to the need to expand collaboration among institutions, strengthen region-specific innovation ecosystems, and promote transdisciplinary research aimed at addressing climate challenges.

In its assessment, the strategy indicates that science and technology initiatives still face challenges related to fragmentation, limited integration among initiatives, insufficient support for social innovation and agroecologically-based production systems, as well as the discontinuation of projects and the loss of talent. It also points out that interdisciplinary and transdisciplinary research, which is essential for climate action, remains limited in undergraduate and graduate programs.

At the same time, the assessment identifies significant opportunities to strengthen the link between science, technology, innovation, and climate policy. These include the establishment and strengthening of regional centers of excellence in research, development, and innovation for climate action; the consolidation of research networks and innovation ecosystems; and the expansion of national and international scientific cooperation. One of the key points highlighted is the potential for investment in emerging sectors, such as carbon capture, utilization, and storage; bioenergy; the bioeconomy; electric mobility; and low-emission sanitation.

To address these challenges and capitalize on these opportunities, ET-ECAPI links this pillar to strategic instruments already in place in the country. Among them is the **Scientific Advisory Chamber** of the Interministerial Committee on Climate Change (CIM), established to align public policy-making with the best available evidence. In the area of energy transition, the **National Energy Transition Policy** (PNTE, Política Nacional de Transição Energética) and the **National Energy Transition Plan** (PLANTE, Plano Nacional de Transição Energética) (Brasil, 2024d) stand out and guide research, development, and innovation initiatives focused on clean energy and energy-efficient technologies and promote their integration with vocational training.

There are also other instruments that complement this effort. The **Ecological Transformation Plan** (Brasil, 2025k) promotes the development of technical skills in strategic sectors of the ecological transition and strengthens Brazil's inclusion in global low-carbon supply chains. The **National Bioeconomy Strategy** (Brasil, 2024b) supports capacity building in sustainable production chains and promotes socio-biodiversity. The **Brazilian Artificial Intelligence Plan** (PBIA, Plano Brasileiro de Inteligência Artificial, 2024–2028) (Brasil, 2024f) provides for investments aimed at climate monitoring, forecasting, and adaptation.

This ET-ECAPI pillar is organized into five strategic goals. The first aims to expand the frontiers of scientific knowledge by developing new insights and solutions to address the new climate reality, while supporting evidence-based public policies. Among the expected outcomes are the expansion of training programs for researchers and specialized professionals, the strengthening of the coordination among different areas of expertise, and the improvement of national high-resolution climate forecasting systems.

The second goal aims at strengthening, modernizing, and expanding scientific, technological, and digital infrastructure. In this context, key initiatives include those related to the modernization of research facilities, the strengthening of the national climate observation infrastructure, the integration of climate data, the consolidation of supercomputing capabilities, and the improvement of disaster monitoring and warning systems.

The third goal aims at consolidating national and international research networks and strengthening innovation ecosystems. The planned actions include promoting technological innovation in clean energy, identifying climate solutions, and expanding multilateral cooperation and integration with global scientific networks.

The fourth goal focuses on developing and consolidating platforms capable of expanding access to data, information, and evidence regarding the new climate reality. Among the planned initiatives are the consolidation of the National Climate Transparency System through the DataClima+ platform, in line with the Enhanced Transparency Framework of the Paris Agreement, the expansion of citizen science and participatory science mechanisms, and the institutionalization of permanent processes for synthesizing and disseminating scientific knowledge.

In the area of information and evidence platforms, the **MonitoraEA** System[30] also stands out. It was recognized in 2026 as the national data and information infrastructure of the **National Program for the Evaluation and Monitoring of Environmental Education** (ProNAMEA, Programa Nacional de Avaliação e Monitoramento da Educação Ambiental). The system was developed and is maintained by the National Institute for Space Research (INPE) and it supports the registration, monitoring, and evaluation of environmental education policies, programs, projects, and initiatives throughout the country, at multiple levels. The system contributes to the generation of evidence, the strengthening of transparency and governance, and the institutionalization of permanent monitoring and learning processes aimed at implementing the PNEA and monitoring actions related to adaptation, resilience, and addressing the risks and impacts of climate change.

The fifth goal aims at expanding the social impact of research and innovation through public procurement of climate innovation, technology transfer and dissemination programs, and support for initiatives focused on bioeconomy, agroecology, agroforestry systems, and other biodiverse production systems.

Brazil's scientific capacity with regard to climate change is also supported by a well-established training and research infrastructure comprising the National Graduate Studies System, research groups registered with CNPq, national and international scientific networks, and public investment in science, technology, and innovation. These elements play a key role in knowledge production, technological development, innovation, and scientific advice on climate policies.

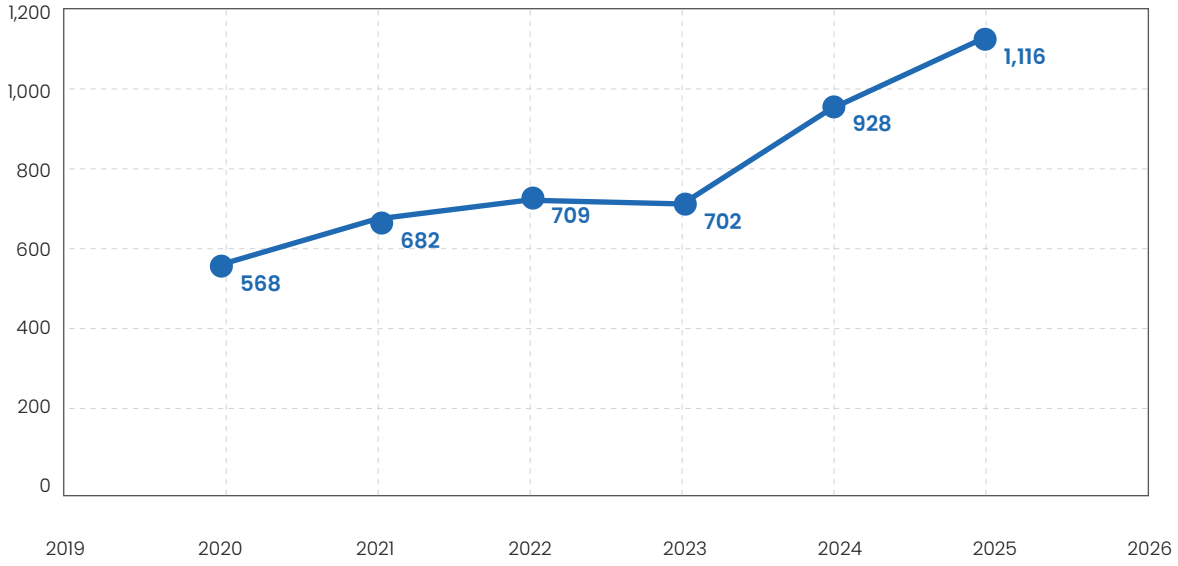
In general, Brazil has a comprehensive system for training and research. The Quadrennial Evaluation (CAPES, 2026) conducted by the Coordination for the Improvement of Higher Education Personnel

30 Available at https://www.monitoraea.org.br/. Accessed on: Aug 18, 2026.

(Capes, Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) in 2025 included 4,555 regular graduate *stricto sensu* programs. During the same period, the National Council for Scientific and Technological Development (CNPq) recorded 45,480 active research groups, distributed across 628 institutions and linked to more than 168,000 lines of research (CNPq, 2026c).

Brazilian scientific research on climate change has also seen significant growth in recent years. Data from the *Scopus* platform[31] show a 96% increase in the number of publications between 2020 and 2025, rising from 568 articles to 1,116 published works.

Figure 7.2.1 Survey of scientific publications on climate change on the Scopus platform between 2020 and 2025



Source: Compiled using data available on the Scopus platform.

The growth of national science is also reflected in **women's participation in scientific production.** Between 2002 and 2022, the proportion of women among the authors of scientific publications in the country increased from 38% to 49%. In fields related to Science, Technology, Engineering, and Mathematics (STEM), this percentage rose from 35% to 45% (Agência Bori, 2024).

Public funding remains one of the main pillars of the national research, development, and innovation system. In 2023, federal investments totaled BRL 50.9 billion, of which BRL 43.1 billion was allocated to research and development and BRL 7.8 billion to related scientific and technical activities (Brasil, 2025i). The largest investments came from the ministries of Education and Science, Technology, and Innovation.

31 The survey was conducted on the Scopus platform (https://www.scopus.com/), considered one of the most comprehensive global databases for scientific publications. The parameters used for the survey were limited to scientific articles published on the topic of climate change with Brazil as the authors' country of origin, covering all fields of knowledge, during the period from 2020 to 2025.

Scientific networks and long-term research programs play a strategic role in the integration of climate knowledge and the formulation of public policy. In this context, the **Brazilian Research Network on Global Climate Change** (Rede Clima) (Brasil, 2021) stands out. It was established in 2007 and recognized as an institutional instrument of the **National Policy on Climate Change** (PNMC). Its work contributes to the generation of knowledge and scientific and technological advancement, as well as to the production of evidence aimed at supporting public climate policies.

Linked to Rede Clima, the **Center for Synthesis on Environmental and Climate Change** (SIMAClim, Centro de Síntese em Mudanças Ambientais e Climáticas)[32] works to integrate and synthesize scientific evidence for public policymakers. Its reports support the evaluation of national and international commitments, including the SDGs and the NDC, and serve as important analyses for reducing climate and environmental impacts in various areas. In 2025, the first published reports addressed the Amazon system's tipping point[33], coral bleaching[34], the role of mangroves in climate mitigation and adaptation[35], and the concept of resilient "green-blue cities"[36].

Another public policy relevant to the creation and strengthening of networks of scientific excellence in Brazil is the National Institutes of Science, Technology and Innovation (INCTs, Institutos Nacionais de Ciência, Tecnologia e Inovação) (CNPq, 2026b; 2026c)[37]. The initiative contributes to the training of highly qualified professionals, the promotion of scientific cooperation between national and international institutions, the generation of knowledge in strategic areas - including climate action - and its dissemination to society and the productive sector. Collectively, the 242 active institutes (CNPq, 2026a) currently occupy a strategic position within the National System of Science, Technology, and Innovation by strengthening the nation's scientific capacity and expanding collaboration among research institutions in different regions of the country.

Among these, initiatives focused on topics such as climate change, the cryosphere, biodiversity, water resources, the oceans, natural disasters, socio-ecological systems, and urban development stand out, which generate relevant evidence for understanding the impacts of climate change and informing mitigation and adaptation policies.

Technical and scientific cooperation also takes the form of long-term programs focused on climate systems that are strategic for Brazil and for the global climate system. The **Brazilian Antarctic Program** (Proantar) aims to generate scientific knowledge about Antarctica and its relationship with the rest of the global climate system, including the cryosphere, the oceans, the atmosphere, and the biosphere, and has ensured the Brazilian scientific community's presence on the continent since the summer of 1982-83. Among the program's goals are to provide scientific advice for public policy and to promote advanced scientific training on polar topics. The **Ten-Year Plan for Antarctic Science** (2023–2032) (Brasil, 2023c), prepared by the National Committee for Antarctic Research (Conapa, Comitê Nacional de Pesquisas Antárticas) with broad participation from the scientific community, establishes the goals and expected outcomes of the research. The plan includes seven thematic programs: Ice and Climate, Antarctic Biodiversity, the Southern Ocean, Geology and Geophysics, the Upper Atmosphere, Humanities and Social Sciences, and Polar Health.

32 Available at: https://simaclim.com.br/. Accessed on: Aug 18, 2026.

33 Available at: https://simaclim.com.br/relatorio-amazonia/. Accessed on: Aug 18, 2026.

34 Available at: https://simaclim.com.br/relatorio-corais/. Accessed on: Aug 18, 2026.

35 Available at: https://simaclim.com.br/relatorio-manguezais/. Accessed on: Aug 18, 2026.

36 Available at: https://simaclim.com.br/relatorio-cidades/. Accessed on: Aug 18, 2026.

37 See details in Section 7.1.

The **Large-Scale Biosphere-Atmosphere Program in the Amazon**[38] (LBA) is a strategic program of the Ministry of Science, Technology and Innovation (MCTI), established in 2010 (Brasil, 2010b) based on data from the implementation committee created in 1998, and coordinated by the National Institute for Amazonian Research (INPA). The program has played an important role in training personnel, producing cutting-edge scientific research to understand how the Amazon biome works and its interactions with the climate, by analyzing the influence of changes in land use and climate on these processes and thereby strengthening international cooperation. Over the past 25 years, it has awarded master's and doctoral degrees to more than 850 Brazilians, trained more than 5,000 professionals, produced more than 150 cutting-edge research projects, and involved approximately 280 national and international institutions, and 1,400 Brazilian researchers and 900 researchers from Amazonian countries. The LBA has 20 associated projects, including the Amazon Tall Tower Observatory (ATTO) and the study on forest drought (Esecaflor, Estudo da Seca da Floresta).

The **Amazon Tall Tower Observatory** (ATTO)[39] is a scientific cooperation project between Brazil and Germany, started in 2008, aimed at understanding the interactions between the Amazon rainforest and biogeochemical cycles (such as the carbon cycle), the water cycle, and energy flows. Its goal is to determine how the forest influences the global climate and how it is affected by climate change and land use. The research infrastructure, located in an area of pristine tropical forest, consists of instrumented towers that continuously record meteorological, chemical, and biological data, such as the concentration of greenhouse gases. One of the towers is 325 m tall and can collect data within a radius of up to 100 km, even identifying dust particles from the Sahara that reach the Amazon.

AmazonFACE[40] is the scientific program established by the MCTI in 2015 (Brasil, 2025c), which is dedicated to assessing the effects of rising atmospheric carbon dioxide concentrations on the ecology and the resilience of the Amazon rainforest. Its infrastructure, which is unprecedented in a tropical forest, was completed in 2025, and the experiment began in 2026, with an expected duration of at least ten years. The program, which involves scientific cooperation between Brazil and the United Kingdom, is organized around six research areas (Lapola *et al.*, 2024): carbon, nutrients, water, biodiversity, socio-environmental aspects, and modeling.

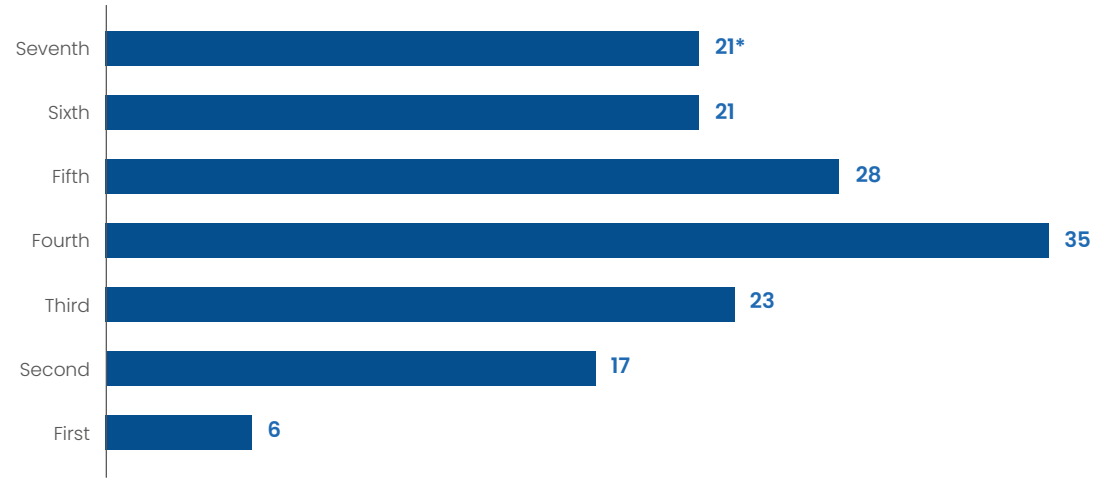
At the international level, the participation of Brazilian researchers in multilateral initiatives has been strengthening the country's scientific participation, particularly through the ongoing involvement of Brazilian scientists in the Intergovernmental Panel on Climate Change (IPCC). This ongoing participation contributes to the international circulation of knowledge and strengthens the national capacity to produce and apply scientific evidence related to climate mitigation, adaptation, impacts, and vulnerabilities (Figure 7.2.2).

38 Available at: https://programalba.cloud/. Accessed on: Aug 18, 2026.

39 Available at: https://www.attoproject.org/pt/. Accessed on: Aug 18, 2026.

40 Available at: https://amazonface.unicamp.br/. Accessed on: Aug 18, 2026.

Figure 7.2.2 Number of Brazilian scientists selected per IPCC assessment cycle



**It includes the Brazilian scientists selected for Working Groups I, II, and III and the special report on climate change and cities.*

Source: Based on 4NC and IPCC[41].

The use of scientific evidence has been progressively incorporated into public policy planning and formulation processes. The development of the Climate Plan, based on the best available science regarding the reality in Brazil, exemplifies this movement. In addition, the highest decision-making body on climate policy, the CIM, has incorporated the Scientific Advisory Chamber as a consultative body.

Likewise, the inclusion of climate change in long-term national planning (Brasil, 2024i) has been supported by studies and evidence on its economic impacts. In this context, the *Strategic Study on the Economic Impacts of Climate Change in Brazil* analyzed the varying effects of climate change on sectors, regions, and economic indicators, taking into account different time horizons and the country's socioeconomic and environmental diversity (Brasil, 2025q). These analyses provide technical input for the formulation of more effective, long-term public policies.

Economic and fiscal planning mechanisms at the federal level have also begun to take climate-related issues into account. The public expenditure classification project identified, classified, and quantified expenditure related to climate change, biodiversity, and risk and disaster management incurred by the central government between 2010 and 2023 and by state governments in 2022 (Brasil, 2025r). This information is intended to support the implementation of the Climate Plan and the Ecological Transformation Plan, as well as the drafting of the Budget Guidelines Law (LDO, Lei de Diretrizes Orçamentárias) and the Annual Budget Law (LOA, Lei Orçamentária Anual).

41 Available at https://apps.ipcc.ch/report/authors/. Accessed on: Aug 18, 2026.

7.2.7 Public awareness, communication, and combating misinformation

Public awareness of climate change depends on the dissemination of accessible, reliable, and evidence-based information, as well as on enabling society to identify incorrect or misleading information.

According to the ET-ECAPI's assessment in the Climate Plan, climate misinformation is part of a broader context of crisis and informational vulnerability. Denialist narratives and distorted perceptions of the environment that portray climate action as an obstacle to development undermine communication about the climate emergency. The assessment also highlights challenges related to sustained access to reliable information in rural areas and the limited integration of community media into government communication strategies.

Among the solutions highlighted in the strategy are the need to regulate digital platforms to curb the spread of misinformation, particularly regarding environmental and climate issues, the implementation of ongoing campaigns and the inclusion of these topics in educational and training programs, as well as the strengthening of public, community, and rural communication.

The **Brazilian Media Education Strategy** (EBEM, Estratégia Brasileira de Educação Midiática) (Brasil, 2023d) and the **National Digital Education Policy** (PNED, Política Nacional de Educação Digital) (Brasil, 2023a) are among the priority instruments that support the pillar of public awareness and the fight against misinformation. The PNED provides for the promotion of digital, media, and information skills and the development of a critical attitude toward media and digital content, which helps counter false information about climate change and strengthen public trust in science-based information. These instruments are also related to the formal education pillar. Resolution CNE – National Education Council (Conselho Nacional de Educação)/CEB – Basic Education Chamber (Câmara de Educação Básica) No. 2/2025 (Brasil, 2025a) establishes the National Operational Guidelines on the use of digital devices in school settings and the curricular integration of digital and media education. Among other points, it provides for the identification of threats to information integrity in high school and its connection with socio-environmental education.

On the international stage, Brazil has begun to play an active role in the fight against misinformation through the **Global Initiative for Information Integrity on Climate Change,** in partnership with the UN and UNESCO. To monitor and implement this agenda, the **Brazilian Steering Committee of the Global Initiative for Information Integrity on Climate Change - Brazil's Climate and Information Committee** (BRASIL, 2025b) was established, coordinated by the Office of Media Relations of the Presidency of the Republic (SECOM/PR). The committee is comprised of 12 ministries and aims to support the implementation of integrated strategies to promote the integrity of information in the public debate on climate change, based on six thematic areas: (i) Research and monitoring of the digital public debate on climate change; (ii) Strategic communication; (iii) Sustainability of environmental journalism and protection of journalists and environmentalists; (iv) Accountability and protection of rights; (v) Incentives for information integrity on climate change; and (vi) Media, environmental, and climate change education.

The committee's work is complemented by the **Network of Partners for Information Integrity on Climate Change**[42], which is part of the Brazilian Chapter of the Global Initiative for Information Integrity on Climate Change, launched by Brazil, the UN, and UNESCO at the 2024 G20 Summit.

42 Available at: https://integridadeclima.org/.

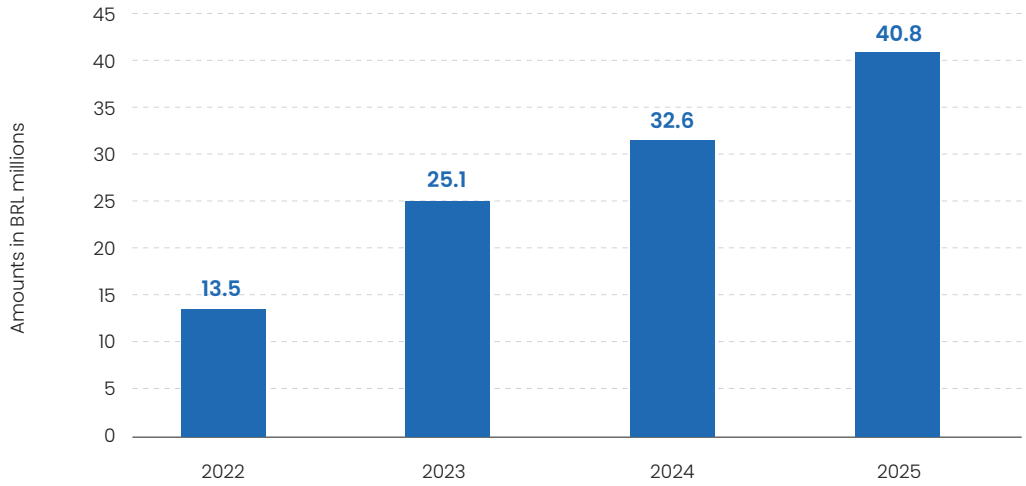
ET-ECAPI's pillar for raising awareness and combating misinformation comprises three goals: (1) to develop a national communication strategy on climate change and increase transparency regarding climate data and policies; (2) to propose regulations for online platforms and digital advertising, promoting awareness and accountability mechanisms to combat climate misinformation in order to safeguard informed public debate; and (3) to promote the ongoing training of communication professionals so that they can serve as reliable sources of information on climate change, based on scientific evidence and traditional knowledge.

The dissemination of scientific knowledge and the popularization of science are important aspects of public awareness, as they bring scientific knowledge to society and help combat misinformation. The dissemination of scientific knowledge and the popularization of science are enshrined in Brazil's legal framework for the development of science, technology, and innovation, with an emphasis on the need for public policies focused on this area, stemming from national conferences that have fostered planning initiatives (CNPq, 2021).

The 5th National Conference on Science and Technology (Brasil, 2024g), held in 2024, reinforced this guideline by identifying the popularization of science as essential for making access to knowledge more democratic, combating science denialism and misinformation, attracting talent to science, and increasing society's engagement with science and technology.

According to data from the CNPq's Science, Technology, and Innovation Fostering Panel[43], there has been an increase in the amount of funding allocated to support the dissemination of scientific knowledge and the popularization of science in Brazil. However, it is not yet possible to determine the amount of investment associated with the dissemination of scientific knowledge focused on the topic of climate change.

Figure 7.2.3 Amounts invested by CNPq in the dissemination of scientific knowledge and the popularization of science



Source: Compiled based on data from the CNPq Fostering Panel.

43 Available at: http://bi.cnpq.br/painel/fomento-cti/. Accessed on: Aug 18, 2026.

The **José Reis Award for the Dissemination of Science and Technology**[44], established by CNPq in 1978, recognizes high-level researchers and professionals, as well as institutions and media organizations that effectively contribute to the dissemination of scientific and technological knowledge, making information about science, technology, and their advancements accessible to the public. In 2025, a special edition of the awards ceremony was held to mark the 30th UN Climate Change Conference (COP30) in Belém, the capital of the state of Pará. On that occasion, the award was presented in the new "Digital Media" category, with the theme of "Scientific Pathways to Climate Change".

7.2.8 Public access to information and climate platforms

Public access to climate information complements education, capacity-building, and public awareness actions by enabling governments, the private sector, academia, civil society organizations, and citizens to use data and evidence in decision-making. Brazil has a number of institutions that monitor various climate data and publish them, in accordance with the purpose and responsibilities of each institution and/or platform. This section presents initiatives aimed at expanding access to information, promoting capacity building, and encouraging the public use of climate data.

Among the key initiatives, DataClima+ stands out, a project aimed at developing Brazil's National Climate Transparency System, in line with the Enhanced Transparency Framework of the Paris Agreement. Implemented by the MCTI, the system will consist of five modules that will provide data and information on greenhouse gas emissions, climate change adaptation, public policies, means of implementation, and tracking of the NDC. This effort contributes to strengthening the institutional arrangement for national climate transparency, as it will institutionally incorporate the data producers who provide input for the preparation of the transparency reports submitted by the country to the UNFCCC.

In addition to its technological and institutional aspects, DataClima+ provides for a capacity-building mechanism organized into three levels: (i) internal capacity-building of the MCTI, as the system operator and the entity responsible for preparing the ETF reports; (ii) intensive training for data providers and system users; and (iii) long-term capacity building over a five-year time horizon.

The long-term training strategy involves a detailed assessment and prioritization of the needs of each target group. Internal capacity building focuses on standardizing processes, as well as maintaining and updating the system. Intensive training is planned for data providers on how to make information available and how to verify it. The project is also expected to develop multimedia courses for the system's users, including decision-makers, based on the five planned modules.

In the areas of emissions transparency and climate policy monitoring, other public platforms also expand access to information. The National Emissions Registry System (SIRENE, Sistema de Registro Nacional de Emissões)[45] provides the results of the National Inventory of Greenhouse Gas Emissions and Removals, as well as data disaggregated by state and other

44 Available at: https://www.gov.br/cnpq/pt-br/acesso-a-informacao/acoes-e-programas/premios/home-pjr. Accessed on: Aug 18, 2026.

45 Available at: https://www.gov.br/mcti/sirene. Accessed on: Aug 18, 2026.

related information, such as the emission factors for the electricity sector used to prepare corporate inventories.

SIRENE Organizacionais (Organizational SIRENE), SIRENE's corporate module, is a free, public platform designed to provide visibility and transparency to corporate Monitoring, Reporting, and Verification (MRV) reports on greenhouse gas emissions. The National Simulator of Sectoral Policies and Emissions (SINAPSE, Simulador Nacional de Políticas Setoriais e Emissões - MCTI) is the Brazilian government's official tool for projecting scenarios for the implementation of sectoral public policies and calculating the potential for reducing GHG emissions, with the aim of achieving the targets set out in the Nationally Determined Contribution (NDC).

With regard to tracking the implementation of the Climate Plan, Brazil is developing the IndicaClima System, the Climate Plan Monitoring and Evaluation System, under the responsibility of the MMA. IndicaClima aims to organize, integrate, and provide transparency to information related to policies and actions under the Climate Plan, supporting monitoring and evaluation processes and expanding public access to information on national climate policy. In its initial phase, the system will include information related to the monitoring of the Climate Plan, with the prospect of expanding its functionalities as the system develops.

To support adaptation planning, Brazil also has platforms and services, such as AdaptaBrasil MCTI, which provides information on climate risk - combining hazard, exposure, and vulnerability - for Brazil's 5,570 municipalities and for strategic sectors, such as water resources, food security, energy security, port, road, and rail infrastructure, health, geo-hydrological disasters, and biodiversity. By making this information accessible to public administrators, research institutions, the private sector, and civil society, the platform contributes to technical capacity-building and to the use of evidence in adaptation planning.

Public access to climate information is also enhanced by monitoring, forecasting, and early warning systems, which support risk management and decision-making at various levels. The National Center for Monitoring and Early Warnings of Natural Disasters (CEMADEN) provides information on geo-hydrological risk scenarios and drought risks affecting family farming, and assesses and forecasts hydro-geo-climatic impacts on activities that are strategic for Brazil. The Critical Event Warning System (SACE, Sistema de Alerta de Eventos Críticos), developed by the Geological Survey of Brazil (SGB), provides information generated by the Hydrological Warning Systems, including the monitoring and forecasting of river levels for river basins.

Other national institutions also provide climate data and services relevant to different user groups. The National Institute for Amazonian Research (INPA), through the LBA, provides climate monitoring bulletins for major river basins, compiling observational data, anomalies, and information to support regional climate analysis.

The National Institute for Space Research (INPE), through the Center for Weather Forecasting and Climate Studies (CPTEC), provides subseasonal and seasonal numerical weather predictions, monthly bulletins with a quarterly outlook, monitoring of air quality and of emissions from fires, and nowcasting, among other data. The project to upgrade INPE's supercomputing infrastructure is noteworthy, and involves the development of the Model for Ocean-laNd-Atmosphere predictioN (Monan), aimed at improving the accuracy of weather and climate forecasts, covering all scales (temporal and spatial) to more accurately represent the tropical and subtropical conditions of South America.

Lastly, the National Institute of Meteorology (Inmet) provides climate information and weather warnings for the entire country in multiple formats, as well as agriculture-specific data, such as agrometeorological bulletins and the Agricultural Decision Support System (SISDAGRO, Sistema de Suporte à Decisão na Agropecuária).

Together, these platforms and public services help to increase transparency, improve access to climate information, and enhance the ability of various actors to use data and evidence in planning, capacity-building, and public policy-making processes.

7.2.9 Social participation, public engagement, and climate justice

Social participation is a complementary element of education, capacity-building, and access to information, as it enables different segments of society to contribute to the formulation, implementation, and monitoring of climate policies. Under the Climate Plan (Brasil, 2026g), **social participation** is considered a pillar for ensuring inclusive and democratic decisions that reflect the diversity of voices in society.

By engaging communities, social movements, Indigenous and traditional peoples, vulnerable populations, civil society organizations, the private sector, and scientists, the Climate Plan seeks to strengthen climate justice, climate governance, transparency, and shared responsibility in the search for sustainable, long-term solutions for climate change mitigation and adaptation. The outcome of this work is reflected in the Cross-Cutting Strategies for Just Transition and Climate Justice and for Women and Climate, in the Climate Adaptation Plan, and in its sectoral and thematic plans, particularly the thematic plans for Racial Equality and Combating Racism and for Indigenous Peoples and Traditional Communities. In addition, in 2025, a resolution of the National Environment Council (Brasil, 2025s) established principles and guidelines for incorporating climate justice and combating environmental racism into environmental policies and actions. The public consultations conducted through the *Brasil Participativo* digital platform[46] and the processes associated with the development of the Climate Plan involved: 9 regional plenary sessions; 24,088 participants; 1,292 proposals; 3,684 contributions to the National Adaptation Strategy; and 780 contributions to the National Mitigation Strategy.

In addition to the specific participatory processes related to the Climate Plan, Brazil resumed, starting in 2023, the holding of national conferences and the establishment of advisory bodies as part of its policy on participation and social mobilization in the discussion of matters pertaining to the federal government. In the Brazilian context, national conferences are processes aimed at promoting dialogue between the government and civil society, contributing to the discussion of priorities, the formulation of proposals, and the improvement of public policies. The General Secretariat of the Presidency of the Republic is responsible for coordinating social participation at the federal level.

The **5th National Conference on the Environment and Climate Change (**Brasil, 2025m), held between January 2024 and May 2025, with the topic of "Climate Emergency: The Challenge of Ecological Transformation," directly engaged 2,729 municipalities and more than 710,000 Brazilians across all biomes and regions of the country through 507 municipal conferences, 189 intermunicipal conferences, 291 open conferences, 27 state and district conferences, and one national conference. The conference gathered proposals from society on mitigation,

46 Available at: https://brasilparticipativo.presidencia.gov.br/. Accessed on: Aug 18, 2026.

adaptation, and disaster preparedness; climate justice; ecological transformation; environmental governance and education. The effort resulted in more than 10,000 proposals, which, following discussions and refinements, were consolidated into 104 responses for addressing the climate emergency.

The participation of children, adolescents, and young people has also been incorporated into public engagement and environmental education initiatives. The **National Children and Youth Conference for the Environment**[47], held in 2025, entitled "Let's Transform Brazil Through Education and Climate Justice," was the result of a joint initiative by the MEC, MMA, and MCTI, with the goal of mobilizing children, adolescents, and young people to learn about and engage in initiatives related to environmental education and climate justice. The conference is an educational and formative process that contributes to the exercise of environmental citizenship and to more in-depth learning, with the potential to bring about changes in the curriculum, school administration, and daily school life. Children and adolescents between the ages of 11 and 14, enrolled in grades 6 through 9 of elementary school, were eligible to participate as delegates.

The engagement of Indigenous peoples and Indigenous women is another initiative that is part of the recent participatory processes related to the agenda on rights, climate justice, and public policies. In August 2025, the **1st National Conference of Indigenous Women** (Brasil, 2025l) was held with the aim of fostering dialogue between the government and civil society entities regarding the agenda on the rights of Indigenous peoples, particularly Indigenous women. Organized jointly by the Ministry of Indigenous Peoples (MPI, Ministério dos Povos Indígenas) and the Ministry of Women (MM, Ministério das Mulheres), in partnership with the National Coalition of Indigenous Women Warriors of Ancestry (ANMIGA, Articulação Nacional das Mulheres Indígenas Guerreiras da Ancestralidade), the event brought together approximately 5,000 Indigenous women from 100 Indigenous Peoples, representing all regions and biomes of the country. The resolutions report[48] presented 50 priority proposals to guide and strengthen the implementation of public policies aimed at this sector.

Public engagement and social participation were significant at COP30. According to the event's executive report (COP30, 2026a), the Conference involved approximately 5,000 Indigenous people, 900 of whom were accredited for the Blue Zone, making it the largest Indigenous participation ever recorded at a COP. The Green Zone had more than 290,000 visitors, and the event extended well beyond the official Conference venues. In Belém, more than 80 venues throughout the city hosted discussions on climate change and related topics. COP30 also featured the "youth task force" (COP30, 2026b), which enabled the participation of approximately 400 young Brazilians in the event.

Finally, it is worth noting that the country has structures for social participation in the climate agenda. Since 2025, the Interministerial Committee on Climate Change (CIM) has had three Advisory Chambers: Social Participation Chamber (CPS), Scientific Advisory Chamber (CAC), and Interfederative Coordination Chamber (CAI). The aim is to broaden participatory processes and technical advice in the formulation, monitoring of implementation, and evaluation of Brazilian climate policy. The Social Participation Chamber, in particular, is responsible for mobilizing stakeholders from economic sectors and civil society to engage in plans and actions related to

47 Available at: https://www.gov.br/mec/pt-br/cnijma. Accessed on: Aug 18, 2026.

48 Available at: https://www.gov.br/mulheres/pt-br/central-de-conteudos/noticias/2025/agosto/1a-conferencia-das-mulheres-indigenas-chega-ao-fim-com-entregas-historicas-e-promessa-de-continuidade.

climate change. The **Brazilian Forum on Climate Change (FBMC**, Fórum Brasileiro de Mudança do Clima**), which coordinated the first year of the activities of the Social Participation Chamber,** is an instrument of the National Policy on Climate Change (PNMC) established in 2017 (Brasil, 2017) with the goal of mobilizing society, serving as a channel for interaction between the Federal Government and sectors of organized civil society, the business sector, and nongovernmental organizations. The FBMC is organized into thematic chambers and sectoral committees: Adaptation and Green Infrastructure; Legal and Regulatory Affairs; River Basins; Carbon Economy; Circular Economy; Environmental and Climate Education; Sustainable Finance; Green Cities; Youth; National Policy on Climate Change; Mitigation and NDC; Energy Transition.

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