FOURTH NATIONAL COMMUNICATION OF BRAZIL TO THE UNFCCC

EXECUTIVE SUMMARY

Ministry of Science, Technology and Innovations

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Brazil 2020

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FOREWORD

The Ministry of Science, Technology and Innovations (MCTI) – whose institutional view is "to play a leading role in the country's sustainable development through Science, Technology and Innovation" – coordinates the Brazilian Government's activities towards fulfilling its commitment to report updated information on various initiatives under the national climate agenda to the United Nations Framework Convention on Climate Change (UNFCCC) on a regular basis. In this regard, the MCTI implements an international technical cooperation project with international funds sourced from the Global Environment Facility (GEF) and the support of the United Nations Development Programme (UNDP) for implementation.

In fulfilling this reporting commitment under the UNFCCC, Brazil has submitted three National Communications, in 2004, 2010 and 2016. Moreover, three Biennial Updates Reports were submitted in 2014, 2017 and 2019.

In order to secure the submission of a new National Communication by December 2020, technical and scientific input have been developed from official national data, as well as through established partnerships and contracts, which represented the direct involvement of more than 400 experts from 217 renowned institutions. As part of a quality assurance procedure, the main technical documents developed were submitted to public consultation with experts not directly involved in the studies.

The five chapters of the Fourth National Communication to the Convention on Climate Change were organized towards meeting the guidelines defined by Decision 17/CP.8 for the elaboration of National Communications by developing countries. These are: Chapter 1. National Circumstances; Chapter 2. National Inventory of Anthropogenic Emissions and Removals of Greenhouse Gases; Chapter 3. Impacts, Vulnerability and Adaptation to Climate Change; Chapter 4. Climate Change Adaptation and Mitigation Measures; and Chapter 5. Other Relevant Information for Achieving the Objectives of the Convention in Brazil.

This National Communication reports the country's strides in relation to the climate agenda since its Third National Communication, submitted to the UNFCCC in 2016. Therefore, another relevant step was taken in coordinating the Brazilian engagement in processes related to transparency arrangements under the UNFCCC and the enhanced transparency framework for action and support under the Paris Agreement.

Marcos Cesar Pontes
Ministry of Science, Technology and Innovations of Brazil

EXECUTIVE SUMMARY

Brazil's Fourth National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) – hereinafter referred to as the Climate Convention, or simply the Convention – presents the results of efforts made by Brazil to improve the understanding of the global climate challenge, to advance climate change science and to implement actions to address climate change that are in line with the country's commitments, interests, and national reality.

The Fourth National Communication (4NC) has five chapters and two appendices that address the National Circumstances; the National Inventory of Anthropogenic Emissions and Removals of Greenhouse Gases; the study of Impacts, Vulnerability and Adaptation to Climate Change; Climate Change Adaptation and Mitigation Measures; and Other Relevant Information for Achieving the Objectives of the Convention in Brazil.

The development of this document involved several stakeholders – Government representatives, both at national and subnational levels, as well as representatives from scientific agencies, universities, private companies, among others –, resulting in the direct engagement of over 400 experts from 217 domestic institutions. The efforts to promote this broad coordination intended to advance knowledge and gather the best of Brazilian science available, particularly in order to provide input to the studies that were necessary to improve the National Inventory as well as impacts and vulnerabilities studies.

Chapter 1. NATIONAL CIRCUMSTANCES

The first chapter describes the diversity of Brazil's geophysical, environmental, climatic, sociocultural and economic characteristics that present opportunities, as well challenges, towards the country's sustainable development that aims at fully contributing with the Convention's commitments and objectives – based on the due capacity-building, implementation of appropriate technology, and access to climate financing.

General characterization

Brazil is a developing country, the planet's fifth largest, with 212 million inhabitants, with about 84% of its population living in urban areas and 16% in rural areas. It has a wide variety of natural features (soil, relief, vegetation and fauna), that are part of a unique natural composition. Together, the six biomes form one of the planet's richest biodiversities.

Population and urban growth brought the challenge of striking a balance among economic development, environmental conservation and social inclusion. However, the country has made progress in national development priorities. There is an incremental improvement in indicators related to access to health, basic sanitation, fighting hunger, poverty and income inequality. Brazil's HDI grew by 0,005 points in 2017 when compared to 2015, reaching 0.760, at a scale that varies from 0 to 1 – the closer to 1, the higher the human development (Figure I). However, there are still great regional inequalities among social groups, so much so that housing, health and transport deficits are seen – and these challenges need to be overcome as a priority in order to ensure the principle of human dignity.

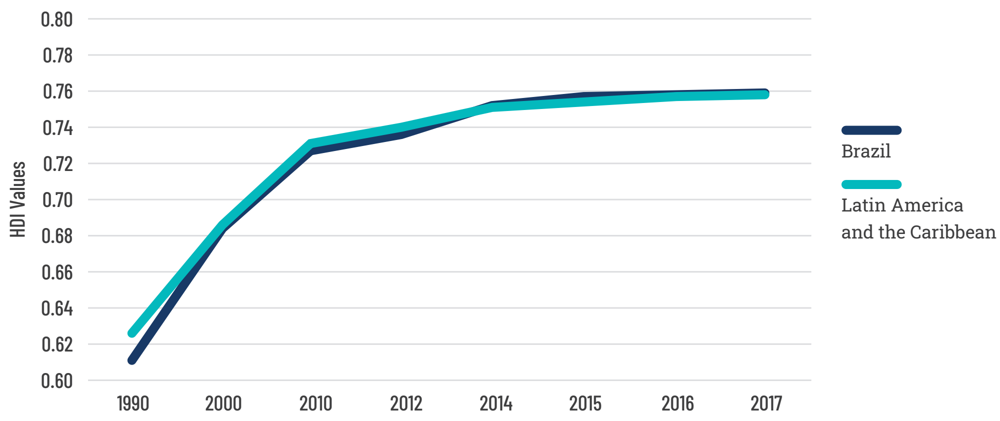


Figure I
Evolution of HDI in Brazil and Latin America and the Caribbean between 1990 and 2017.

Source: Based on UNDP (2018).

Due to its continental dimensions, the country's climatology encompasses different climate zones: subtropical, equatorial and predominantly tropical, with different temperature and precipitation patterns. For the regions with greater environmental susceptibility, i.e., areas that are more prone to experience the effects of climate change – represented by fragile ecosystems, islands, coastal zones and desertification areas – the Government has been promoting response measures and adaptation and conservation initiatives in an attempt to minimize the adverse effects.

Brazil is an urban-industrial country, with a strong agricultural sector contributing significantly for both domestic and global economies. In addition, its electricity mix is clean, and the energy mix is transitioning to be predominantly based on renewable energies. In 2018, when the country was ranked the world's ninth economy, the Brazilian GDP totaled BRL 6.83 trillion, a 13.9% increase in relation to 2015.

In 2018, the Brazilian agricultural sector contributed approximately 21% of the country's total GDP, with exports hitting a record for that year. The country's prominence, with the adoption of sustainable practices in areas with an agricultural capability and the incentive to environmental compliance for rural properties, is of note and contribute to make Brazil a world reference in sustainable agriculture. Another relevant aspect is that the sector employs 20% of Brazil's total occupied population, which is equivalent to 18.2 million people working in food, fiber and energy production.

The country's strategies by encouraging technology research and development, coupled with public policies towards a sustainable tropical agriculture have led to increased productivity per hectare, followed by economic and population growth. Adoption of conservative technologies and practices has allowed for more constant and diversified food supply. Over the past ten years, Brazil has adopted conservation agriculture practices, which are more resilient and mitigating, in over 50 million hectares.

Regarding energy circumstances, Brazil has the cleanest energy and electricity mixes among the largest global consumers. The Domestic Energy Supply (OIE, for its acronym in Portuguese) in 2019 was 294 million toe (tons of oil equivalent), slightly higher than in 2018, which was 288.4 million toe. A breakdown of the energy mix for 2018 and 2019 shows a significant increase in the share of renewable sources, from 45.5% in 2018 to 46.1% in 2019 (Table I). Brazil's share of renewables in its energy mix is currently 4.3 times larger than the average in OECD countries, and 3.3 times larger than the average for the rest of the world (MME, 2020e).

Regarding the generation of electric energy, in 2018-2019 wind energy supply increased by 15.5% and hydro generation rose by 2.3%. Photovoltaic solar generation deserves special notice, since it reported a significant 92% increase in this period (Table I). This means the country's electricity mix remains primarily based on renewable sources, with the prospect of increasing its share over the next few years given the growing competitiveness of wind and solar sources. Brazil has a share of 83% of renewable sources in its electricity mix, i.e., 2.9 times larger the average in OECD countries and almost 3.1 times larger than the average for the rest of the world (MME, 2020e).

Table I
Share of renewable and non-renewable sources in Brazil's energy and electricity mixes.

	SOURCES IN DOMESTIC SUPPLY	SHARE (%) 2018	2019
ENERGY MIX	**NON-RENEWABLE**	**54.5**	**53.9**
	OIL AND OIL BY-PRODUCTS	34.4	34.4
	NATURAL GAS	12.4	12.2
	MINERAL COAL AND COKE	5.7	5.3
	URANIUM (U_3O_8)	1.4	1.4
	OTHER NON-RENEWABLE (a)	0.6	0.6
	RENEWABLE	**45.5**	**46.1**
	WATER	12.6	12.4
	WOOD AND CHARCOAL	8.8	8.7
	SUGARCANE BY-PRODUCTS	17.3	18
	OTHER RENEWABLE SOURCES (b)	6.8	7
ELECTRICITY MIX	NON-RENEWABLE	17	17
	WATER	61.1	61.1
	SUGARCANE BAGASS	5.6	5.7
	WIND POWER	7.6	8.6
	SOLAR	0.5	1.02
	OTHER RENEWABLE	3	2.8
	OIL	1.5	1.1
	NATURAL GAS	8.6	9.3
	COAL	2.2	2.4
	NUCLEAR	2.5	2.5
	OTHER NON-RENEWABLE	1.9	1.9
	IMPORTATION	5.5	3.8

Institutional arrangements for the implementation of the Convention

Regarding the efforts to implement the Convention in the country, the Government put together a cross-cutting institutional arrangement through coordinated activities at different levels (national and subnational). The Interministerial Committee on Climate Change (CIM, for its acronym in Portuguese), of a permanent nature, was established for this purpose, aiming at establishing guidelines, arranging and coordinating the implementation of the country's climate-related public actions and policies. In addition, the country instituted, via Decrees, the National Committee for Reducing Emissions from Deforestation and Forest Degradation, Conservation of Forest Carbon Stocks, Sustainable Forest Management and Enhancement of Forest Carbon Stocks (CONAREDD+), and the Executive Committee for the Control of Illegal Deforestation and Recovery of Native Vegetation, coordinated by the Ministry of the Environment (MMA).

As part of the Ministry of Science, Technology and Innovations' organizational framework, the General Coordination of Climate Science and Sustainability (CGCL, for its acronym in Portuguese) is responsible for the elaboration of National Communications and Biennial Update Reports, and for the National Emissions Registry System (SIRENE, for its acronym in Portuguese), the government's official instrument for Measurement, Reporting and Verification (MRV) of anthropogenic greenhouse gas (GHG) emissions. Additionally, it coordinates the implementation of several climate projects and is the country's National Designated Entity (NDE) for the Convention's Technology Mechanism and the Clean Development Mechanism (CDM). It is worth mentioning that the Brazilian Research Network on Global Climate Change (Rede CLIMA) was created in 2007 in order to support the MCTI at the national scope, contemplating the contribution of dozens of research groups in universities and science and technology institutes.

The Ministry of Agriculture, Livestock and Supply (MAPA, for its acronym in Portuguese), in turn, created the General Coordination of Climate Change, Planted Forests and Conservation Agriculture (CGMC, for its acronym in Portuguese), responsible for promoting the sustainability of agricultural production systems through the promotion of technology innovation, the adoption of conservative production systems and low carbon emissions, which are more resilient to climate change.

Among the regulatory frameworks and management tools aimed at implementing the UNFCCC in the country, the National Policy on Climate Change (PNMC, for its acronym in Portuguese) stands out, as it established the legal framework to tackle climate change in Brazil by 2020 by conducting Nationally Appropriate Mitigation Actions (NAMAs), aimed at a reduction of greenhouse gas emissions between 36.1% and 38.9% according to 2020 projected levels. Brazil deposited the Instrument of Ratification of the Paris Agreement in September 2016, in which the country pledged to adopt measures to reduce GHG emissions through its Nationally Determined Contribution (NDC) (MRE, 2016). Moreover, the country ratified the Doha Amendment to the Kyoto Protocol in December 2017.

In order to comply with the Convention's Transparency Agenda, CGCL/MCTI is the agency responsible for implementing the enabling activity project that assists the Brazilian Government in the preparation of its National Communications and Biennial Update Reports (BURs), in agreements with the Brazilian Cooperation Agency (ABC, for its acronym in Portuguese). This project, under a modality of National Implementation, is funded through international resources from the Global Environment Facility (GEF), and is supported by the United Nations Development Programme (UNDP) as an implementing agency. The development of the 4NC counted on the relevant engagement of over 400 experts under a number of public and private institutions, such as universities, research institutes and bodies, businesses and associations that have a direct contribution by providing data and developing analyses. In addition to these, other institutions were indirectly involved in this work by providing official national data available on public platforms.

Chapter 2. NATIONAL INVENTORY OF ANTHROPOGENIC EMISSIONS AND REMOVALS OF GHG

The second chapter presents the results of anthropogenic emissions by sources and removals of GHG not controlled by the Montreal Protocol for the historical series that covers the period from 1990 to 2016, according to the IPCC 2016 methodology.

The National Inventory of Anthropogenic Emissions by Sources and Removals of Greenhouse Gases (GHG), from 1990 to 2016, was updated based on the methodologies described in the "2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories" (hereinafter referred to as IPCC 2006). Using the IPCC 2006 guidelines to conclude this Inventory shows the country's effort to ensure improvement of its emissions estimates. Additionally, data from the national technical and scientific advances were incorporated with the purpose of improving the accuracy of this quantification, especially for the country's most significant emission sources. Also, the use of this methodology is in line with the commitment stipulated in the Paris Agreement, according to which all countries must use IPCC 2006 when preparing their emissions inventories.

Emissions sources considered in the Inventory are organized according to the activities under the following sectors: (1) Energy; (2) Industrial Processes and Product Use (IPPU); (3) Agriculture; (4) Land Use, Land-Use Change and Forestry (LULUCF); and (5) Waste. Greenhouse gas removals are accounted for only in the LULUCF sector, as a result of an increase in carbon stock due to, for example, vegetation growth. It is noteworthy that removals from some agriculture activities are also accounted for by the LULUCF sector. However, due to the scope of the methodology used for national inventories, some of the efforts made by the country, for example, recovery of degraded pastures, are not incorporated as removals.

The GHGs estimated in this Inventory include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). Indirect GHG such as carbon monoxide (CO), nitrogen oxides (NOx) and other non-methane volatile organic compounds (NMVOCs) are also presented and their emissions have been included whenever possible.

Development of this Inventory was a collective and multidisciplinary effort, which involved about 185 institutions and over 300 experts from all regions of the country. This complex institutional arrangement involved an important part of the Brazilian scientific and business community, in addition to several government institutions, trade associations, third sector organizations, universities and research centers, which were largely represented by Rede CLIMA.

The methodological details are documented in the Sectoral Reference Reports, which are available, together with the emissions time series, on the website of the National Emissions Registry System (SIRENE), in compliance with the principle of transparency.

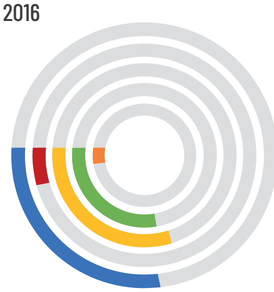
See the infographic on the extensible page for more information.

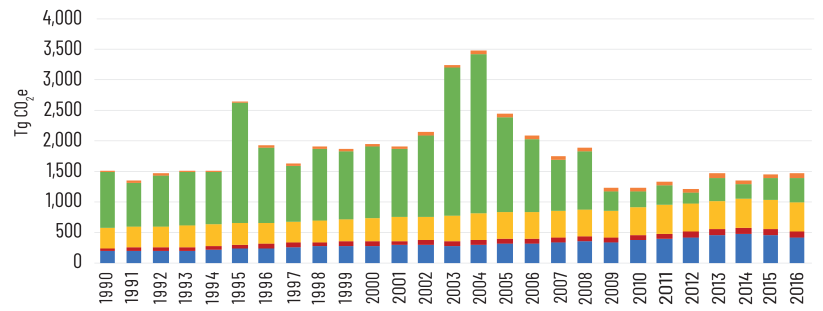
GHG emissions from Brazil totaled 1,467 Tg CO_2e[1] in 2016, and the times series reflects the country's over a decade-long effort to align emissions reductions with increased productivity and national development (Figure II). Results of these estimates are presented in Table II and the complete time series is in the 4NC Appendix.

It should be pointed out that the methodology used for inventories does not consider the balance of flows and stocks in agricultural production systems so as to explicitly report the efforts undertaken by the sector to contribute to GHG emissions reductions by adopting Plan ABC's technologies.

1 According to UNFCCC Decision 17/CP.8, the results of the inventory must be expressed in absolute gas units. If the country chooses to report its emissions in CO_2 equivalents (CO_2e) in its National Communications, it could use the Global Warming Potential (GWP) values for a 100-year horizon, published in the Second IPCC Assessment Report (SAR) (IPCC, 1995). All analyses and results expressed as CO_2e in this chapter used the GWP metric of the SAR (100 years). However, for fact checking purposes, the 4NC also presents data aggregated using GWP-100 and GTP-100, both in the IPCC Fifth Assessment Report (AR5).

2016





28.9% – Energy
6.4% – IPPU
33.2% – Agriculture
27.1% – LULUCF
4.5% – Waste

2016

59.5% – CO_2
27.7% – CH_4
12.4% – N_2O
0.4% – HFCs

SECTOR	1990	1995	2000	2005	2010	2016	VARIATION 2010-2016
	Tg CO_2e						%
1. Energy	192.8	231.0	288.2	313.4	374.7	423.6	13.1
2. IPPU	53.6	64.0	73.8	78.9	87.1	93.4	7.2
3. Agriculture	329.5	359.2	370.1	438.0	458.1	487.0	6.3
4. LULUCF	907.5	1,966.8	1,175.0	1,564.1	252.5	397.4	57.4
5. Waste	26.2	34.3	42.6	51.6	56.7	66.0	16.4
TOTAL	**1,509.6**	**2,655.2**	**1,949.6**	**2,445.9**	**1,229.0**	**1,467.3**	**19.4**

Figure II
Total GHG emissions from 1990 to 2016 in Tg de CO_2e.

- The Energy sector (1) totaled 423,580 Gg CO_2e in 2016, a 13% increase in relation to the sector's emissions in 2010. In 2016, 96% of the sector's CO_2 emissions derived from Fuel Combustion Activities (1.A). The Transport category (1.A.3) was the most prevalent due to the wide coverage of this activity in the country, contributing 50% of CO_2 emissions. Regarding CH_4 and N_2O, emissions from the 1.A. subsector corresponded to 67% and 99%, respectively. According to the IPCC 2006 methodology, CO_2 emissions from the consumption of biomass fuels are reported but are not accounted for the sector's total emissions.
- The IPPU sector (2) totaled 93,359 Gg CO_2e in 2016, which represented a 7% increase in relation to 2010. The Metal Industry subsector (2.C) contributed most of the emissions, representing 52% of the sector's CO_2e emissions in 2016. The Mineral Industry subsector (2.A) was the second most prevalent, with 31%. Regarding CO_2 emissions, whose gas corresponds to nearly all the sector's total (92% of the sector's total in CO_2e), the Metal Industry (2.C) and Mineral Industry (2.A) subsectors contributed approximately 56% and 34%, respectively. HFC gases corresponded to 6% of the sector's emissions, with emphasis on the Product Uses as Substitutes for Ozone Depleting Substances subsector (2.F), which represented almost 100%. In 2016, CH_4 had a 0.8% share of the sector's GHG emissions in 2016, and N_2O accounted for 0.4% of emissions.
- The Agriculture sector (3) contributed 487,005 Gg CO_2e in 2016, a 6.3% emissions increase in relation to 2010 – but this is a small increment if compared to the sector's growth in the same period, whose advance in production efficiency and emissions reduction are presented in the Box ahead. The Enteric Fermentation subsector (3.A) reported emissions of 282,713 Gg CO_2e in 2016, while emissions from Managed Soils (3.D) were 153,065 Gg CO_2e. CH_4 emissions are the most prevalent for the sector and derive mainly from the Enteric Fermentation subsector (3.A). Then there are N_2O emissions, whose main emission source was the Managed Soils subsector (3.D). CO_2 represented a new quantification of emissions for the Agriculture sector, which accounted for 4% of the sector's total emissions, mainly related to the application of lime in the soil (Liming - 3.G).
- LULUCF (4) net emissions totaled 397,357 Gg CO_2e in 2016. It should be emphasized that the Action Plans for Prevention and Control of Deforestation have been contributing to the reduction of emissions in this sector since 2005. Moreover, in 2010 the Sectoral Plan for Mitigation and Adaptation to Climate Change for the Cosolidation of a Low-Carbon Economy in Agriculture (ABC Plan) started to be implemented, which between 2008 and 2010 recovered 26.8 million hectares of degraded pasture, whose removals are not fully accounted for in this National Inventory due to methodological limitations. In terms of the share by gas, in 2016 CO_2 contributed 92% of total net emissions, while CH_4 and N_2O emissions represented 5% and 3%, respectively. In 2016, the sector's most significant emissions came from the Grassland subsector (4.C) (640,377 Gg CO_2e), while the largest removals were from the Forest Land subsector (4.A), which contributed -347,821 Gg CO_2e. In addition, in 2016, 9.8 million hectares of pasture were substituted by annual, perennial, and semi-perennial crops, and

another 4 million were regenerated (3.1 million hectares) or reforested (1.8 million hectares), resulting in a removal of -192,852.1 Gg CO_2 since 2010, which is significant for the balance of emissions and removals flow. CH_4 and N_2O emissions, which resulted from the burning of biomass associated with land use and cover processes, came mainly from the Grassland subsector (4.C), which contributed 18,104 Gg CO_2e (or 83%) and 8,273 Gg CO_2e (or 81%) of emissions for these gases in the sector, respectively, in 2016.

- The Waste sector's (5) emissions totaled 65,954 Gg CO_2e in 2016, a 16.4% increase compared to 2010. The Disposal of Solid Waste subsector (5.A) was the second most prevalent in 2016, with 59.1% of the total emissions. The Wastewater Treatment and Disposal (3.D) contributed 25,794 Gg CO2e in 2016, 39.1% of the sector's total. The main gas emitted by the sector was CH_4 (95.1%), with Solid Waste Disposal (5.A) as the most significant emission source, followed by Wastewater Treatment and Discharge (5.D), corresponding to 62.1% and 37.0% of the sector's total CH_4 emissions, respectively. N_2O and CO_2 had a smaller share of emissions in terms of CO_2e (4.1% and 0.8%, respectively).

Greenhouse gas emissions and removals from Brazil

5. WASTE

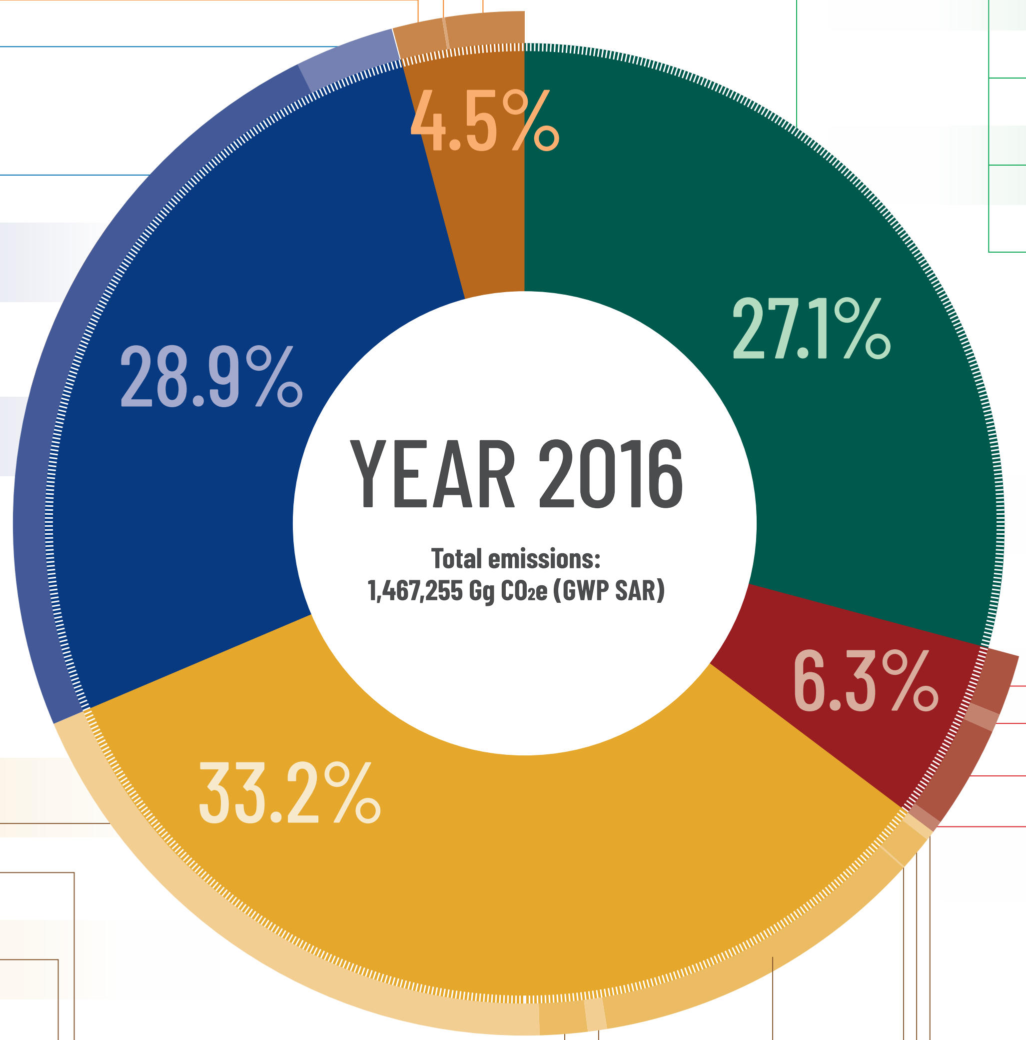
- 2.7% 5.A SOLID WASTE DISPOSAL
- 0.1% 5.C INCINERATION AND OPEN BURNING OF WASTE
- 1.7% 5.D WASTEWATER TREATMENT AND DISCHARGE

1. ENERGY

- 27.6% 1.A FUEL COMBUSTION ACTIVITIES
  - 5.4% 1.A.1 Energy Industries
  - 5.1% 1.A.2 Manufacturing Industries And Construction
  - 14.1% 1.A.3 Transport
- 1.3% 1.B FUGITIVE EMISSIONS

3. AGRICULTURE

- 19.3% 3.A ENTERIC FERMENTATION
  - 18.7% 3.A.1 Cattle
- 1.5% 3.B MANURE MANAGEMENT
- 0.6% 3.C RICE CULTIVATION
- 10.4% 3.D MANAGED SOILS
- 0.03% 3.F FIELD BURNING OF AGRICULTURAL RESIDUES
- 1.1% 3.G LIMING
- 0.3% 3.H UREA APPLICATION



4. LAND USE, LAND-USE CHANGE, AND FORESTRY SECTOR (LULUCF)

- 4.A FOREST LAND -23.7%
- 4.B CROPLAND 9.1%
- 4.C GRASSLAND 43.6%
- 4.D WETLANDS 0.6%
- 4.E SETTLEMENTS 0.4%
- 4.F OTHER LAND 0.6%
- 4.G HARVESTED WOOD PRODUCTS -3.5%

2. INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)

- 2.A MINERAL INDUSTRY 2.0%
  - 2.A.1 Cement Production 1.4%
- 2.B CHEMICAL INDUSTRY 0.6%
- 2.C METAL INDUSTRY 3.3%
  - 2.C.1 Iron and Steel Production 3.0%
- 2.F PRODUCT USES AS SUBSTITUTES FOR OZONE DEPLETING SUBSTANCES 0.4%

	CO_2	CH_4	N_2O	PFCs	HFCs	SF_6
Energy	46%	2.9%	5.6%	0%	0%	0%
IPPU	9.8%	0.2%	0.2%	100%	100%	100%
Agriculture	2.3%	76.1%	87.1%	0%	0%	0%
LULUCF	41.8%	5.4%	5.6%	0%	0%	0%
Waste	0.1%	15.5%	1.5%	0%	0%	0%

- CO_2 Carbon Dioxide
- N_2O Nitrous Oxide
- SF_6 Sulfur Hexafluoride
- CH_4 Methane
- PFCs Perfluorocarbons
- HFCs Hydrofluorocarbons

Notes: **(1)** Numbers before the sectors, subsectors and categories refer to the codes presented in the Common Reporting Framework Tables (CRF Tables), required by the UNFCCC for the submission of member countries' National Inventory results. **(2)** The percentages presented in this infographic's graphic reflect the relative sectors' shares of total CO_2e emissions. Since 2010, due to deforestation control, the national emissions profile presents shares of the Energy, Agriculture and LULUCF sectors more proportionally.

Table II
Greenhouse gas emissions in Brazil,1990, 1995, 2000, 2005, 2010 and 2016, by sector.

Gg = 1 thousand tonnes

SECTOR	YEAR	UNIT	CO_2	CH_4	N_2O	HFC-23	HFC-32	HFC-125	HFC-134A	HFC-143A	HFC-152A	HFC-227EA	HFC-365MFC	CF_4	C_2F_6	SF_6	NO_x	CO	NMVOC
ENERGY	1990	Gg	177,046	543.3	14.04												1,444.7	9,001.3	1,696.0
	1995		216,613	463.9	14.93												1,720.7	8,692.3	1,595.7
	2000		272,173	496.7	17.94												1,959.3	7,051.8	1,222.1
	2005		292,351	660.4	23.15												2,037.5	7,057.5	1,164.3
	2010		352,903	609.6	28.92												2,265.1	7,028.2	1,008.4
	2016		401,690	557.1	32.88												2,191.3	6,398.9	799.2
	Var. 90 / 05	%	65	22	65												41	-22	-31
	Var. 05 / 10		21	-8	25												11	0	-13
	Var. 10 / 16		14	-9	14												-3	-9	-21
INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)	1990	Gg	45,192	42.9	11.55	0.1202	-	-	-	-	-	-	-	0.3022	0.0263	0.0112	26.5	1,096.4	1,782.9
	1995		53,139	37.7	18.20	0.1530	-	-	-	-	-	-	-	0.3060	0.0264	0.0154	26.6	1,106.4	2,039.8
	2000		64,506	41.0	20.73	-	-	0.0014	0.3805	0.0016	0.0001	-	-	0.1465	0.0117	0.0168	29.3	1,154.9	2,507.8
	2005		67,660	51.1	23.79	-	-	0.0022	0.9156	0.0026	0.1748	-	-	0.1239	0.0104	0.0270	38.9	1,430.3	2,597.0
	2010		82,049	41.9	1.51	0.0000	-	0.0044	2.1809	0.0052	-	0.0014	0.0003	0.0822	0.0064	0.0101	38.5	1,200.2	3,014.5
	2016		85,943	34.5	1.27	0.0000	0.0730	0.0848	4.1289	0.0140	-	0.0054	0.0061	0.0381	0.0028	0.0123	39.5	800.5	2,441.8
	Var. 90 / 05	%	50	19	106	-100	NA	NA	NA	NA	NA	NA	NA	-59	-61	142	47	30	46
	Var. 05 / 10		21	-18	-94	NA	NA	98	138	98	-100	NA	NA	-34	-39	-63	-1	-16	16
	Var. 10 / 16		5	-18	-15	356	NA	1,832	89	170	NA	280	1,665	-54	-56	22	2	-33	-19
AGRICULTURE	1990	Gg	9,771	11,102.7	279.30												61.1	1,681.7	
	1995		6,765	12,179.7	311.96												67.0	1,805.6	
	2000		10,645	12,208.4	332.56												59.2	1,596.2	
	2005		9,975	14,352.9	408.30												77.1	2,078.4	
	2010		13,698	14,406.5	457.60												68.0	1,832.1	
	2016		19,732	14,715.7	510.46												18.5	498.3	
	Var. 90 / 05	%	2	29	46												26	24	
	Var. 05 / 10		37	0	12												-12	-12	
	Var. 10 / 16		44	2	12												-73	-73	
LAND USE, LAND-USE CHANGE AND FORESTRY (LULUCF)	1990	Gg	860,893	1,520.1	47.43												421.9	23,819.4	
	1995		1,875,495	2,996.2	91.47												783.9	46,525.2	
	2000		1,110,480	2,111.6	65.12												568.0	32,927.7	
	2005		1,479,731	2,760.2	85.03												740.2	43,020.2	
	2010		220,461	1,036.8	33.14												306.4	16,411.3	
	2016		365,404	1,037.2	32.81												298.5	16,346.5	
	Var. 90 / 05	%	72	82	79												75	81	
	Var. 05 / 10		-85	-62	-61												-59	-62	
	Var. 10 / 16		66	0	-1												-3	0	

SECTOR	YEAR	UNIT	CO_2	CH_4	N_2O	HFC-23	HFC-32	HFC-125	HFC-134A	HFC-143A	HFC-152A	HFC-227EA	HFC-365MFC	CF_4	C_2F_6	SF_6	NO_x	CO	NMVOC
WASTE	1990	Gg	533	1,145.2	5.20														
	1995		585	1,510.7	6.28														
	2000		926	1,878.9	7.08														
	2005		1,108	2,287.2	7.99														
	2010		1,154	2,523.1	8.17														
	2016		504	2,988.7	8.67														
	Var. 90 / 05	%	108	100	54														
	Var. 05 / 10		4	10	2														
	Var. 10 / 16		-56	18	6														
TOTAL	1990	Gg	1,093,435	14,354.3	357.52	0.1202	-	-	-	-	-	-	-	0.3022	0.0263	0.0112	1,954.2	35,598.9	3,478.8
	1995		2,152,596	17,188.2	442.84	0.1530	-	-	-	-	-	-	-	0.3060	0.0264	0.0154	2,598.1	58,129.4	3,635.5
	2000		1,458,729	16,736.8	443.43	-	-	0.0014	0.3805	0.0016	0.0001	-	-	0.1465	0.0117	0.0168	2,615.8	42,730.6	3,729.8
	2005		1,850,825	20,111.8	548.25	-	-	0.0022	0.9156	0.0026	0.1748	-	-	0.1239	0.0104	0.0270	2,893.7	53,586.4	3,761.3
	2010		670,265	18,617.9	529.34	0.0000	-	0.0044	2.1809	0.0052	-	0.0014	0.0003	0.0822	0.0064	0.0101	2,678.1	26,471.8	4,022.9
	2016		873,272	19,333.2	586.09	0.0000	0.0730	0.0848	4.1289	0.0140	-	0.0054	0.0061	0.0381	0.0028	0.0123	2,547.7	24,044.1	3,241.0
	Var. 90 / 05	%	69	40	53	-100	NA	NA	NA	NA	NA	NA	NA	-59	-61	142	48	51	8
	Var. 05 / 10		-64	-7	-3	NA	NA	98	138	98	-100	NA	NA	-34	-39	-63	-7	-51	7
	Var. 10 / 16		30	4	11	356	NA	1,832	89	170	NA	280	1,665	-54	-56	22	-5	-9	-19
GREENHOUSE GAS EMISSIONS FOR INFORMATION PURPOSES, NOT INCLUDED IN THE INVENTORY:																			
BUNKER FUELS	1990	Gg	3,228	1.8	1.79												2.2	2.0	1.8
	1995		6,217	4.1	4.20												4.7	4.5	4.2
	2000		11,313	9.3	9.31												9.8	9.6	9.3
	2005		15,255	10.9	11.05												12.1	11.7	11.1
	2010		18,350	12.8	12.92												14.4	13.6	12.9
	2016		17,666	10.9	11.13												12.9	12.1	11.1
	Var. 90 / 05	%	373	524	516												461	480	515
	Var. 05 / 10		20	17	17												19	17	17
	Var. 10 / 16		-4	-14	-14												-10	-12	-14
BIOMASS FUELS	1990	Gg	165,951																
	1995		168,703																
	2000		166,349																
	2005		228,317																
	2010		302,004																
	2016		320,192																
	Var. 90 / 05	%	38																
	Var. 05 / 10		32																
	Var. 10 / 16		6																

The country has made progress in the improvement and transparency of emission estimates in every issue of the National Inventory, seeking new scientific research, and the use of emission and removal parameters and factors that reflect national conditions. This effort results in greater accuracy of national emission estimates and encourages continued scientific advances, thus contributing to the development of national and world science.

Box. The production efficiency of beef and dairy cattle in Brazil

Brazil has been committed and made progress in increasing animal productivity and efficiency by implementing public policies that promote the improvement of herd and forage plant genetics, digestibility, animal comfort, early slaughter, efficient breeding strategies, more efficient pastures, use of technologies for the treatment of animal waste, among other actions. These initiatives have helped promote sustainable and low-carbon livestock farming in the country, showing a promising trend for the coming years.

Outstanding actions include, but are not limited to, strides in the adoption of technologies and production systems such as integrated systems like crop-livestock-forest and their combinations, no-tillage system, biological nitrogen fixation, treatment of animal manure, and recovery of degraded pastures. These contribute to the improvement of tropical agriculture production processes.

These are some of the sector's most relevant results:

- Research conducted in Brazil shows that the improved digestibility of ruminants in recent years directly favored the production efficiency of the herd by improving food intake and weight gain, and as a co-benefit diluted GHG emission per product. The analysis of CH_4 emissions from enteric fermentation per head of beef cattle shows a reduction of 8.2% between 1990 and 2016.
- Dairy cattle also shows improved productivity. From 1990 to 2016, the number of dairy cows increased by 2.6% while milk production increased by 133%, i.e., milk productivity (liters per cow per year) increased by 127% (IBGE, 2018). CH_4 emissions from dairy cattle decreased by 2% from 1990 to 2016. When CH_4 emissions per liter of milk produced are considered, there was a 58% decrease during the same period.

According to Herrero et al. (2013), the intensity of GHG emissions differs across geographic regions and production systems and is mainly influenced by the efficiency of feed conversion (quantity of food consumed per unit of product), which improves with the quality of animal diet, in terms of digestibility and protein content. Therefore, improving the quantity and quality of food will result in improved production and animal feed efficiency, thus reducing GHG emissions (particularly CH_4) per unit of animal product, whether beef or dairy cattle (HRISTOV et al., 2013). Even with technological advances, the total gross emissions of a region or country are expected to increase if the number of head increases more than the avoided emissions of a stabilized herd (LATAWIEC et al. 2014).

Chapter 3. IMPACTS, VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

Chapter 3 presents the main observed and projected climate trends using global and downscaled models. In addition, it presents integrated analyses of Water, Energy, Food and Socioenvironmental Securities in order to assess impacts and vulnerabilities from an approach based on warming levels, with an indication of adaptation options in this context.

The studies on Impacts, Vulnerabilities and Adaptation (IVA) presented herein were guided based on methodological strategies towards integrating approaches and the identification of interdependencies and synergies, in order to allow national policies to consider the complex and multidimensional interactions among the several sectors and levels of governance, from local to global, when it comes to adaptation and climate change (Adelle and Russel, 2013; Mickwitz et al, 2009; Weitz et al., 2017).

These studies were structured from Water, Energy, Food, and Socioenvironmental Securities. Securities are not only related to the availability of resources, but also to sustainability-based elements – possibility of fair access and distribution of these resources to the population, environmental protection and economic development – and involve political, conjunctural and institutional issues. This is an evolution over sectoral approaches (IISD, 2013; Ringler, Bhaduri and Lawford, 2013, p.617; Simpson and Jewitt, 2019).

In order to promote a detailed and well-founded survey of the necessary data to develop such unprecedented studies in the country, a relevant part of the national scientific community was involved, represented largely by Rede CLIMA. Over 100 experts engaged in conducting analyses aiming at contributing to this Brazilian endeavor to cope with climate change effects and, during this process, adapt the several production and consumption models towards protecting society, development and the environment.

Climate Change in Brazil

The analysis of current climate trends in Brazil considered the changes that have occurred over the past four decades (1980-2018) as well as future projections, based on global warming levels of 1.5 ºC, 2 ºC and 4 ºC (SWL1.5, SWL2 and SWL4), and it was found that change signs generally intensify with more pessimistic SWL and emissions scenarios (RCP8.5), and are more prominent at SWL4 (Box I).

The CPC/NOAA (temperature) and CHIRPS (precipitation) data sets were adopted as observation databases. Future projections considered simulations from the Eta regional model (which based the IVA studies herein) and the HadGEM3-A model (Project Helix).

Panel 1
Climate macrotrends in Brazil.

*According to estimates, over the last three decades there has been a global rise in the average sea level of +3.37 mm/year, with the increasing rate getting higher with time, and with a broad range of future scenarios according to GHG concentrations.

OBSERVED	TEMPERATURE	A temperature increase has been observed in all regions of Brazil over the past decades. In general, a 0.5 °C increase per decade was found in average minimum and maximum temperatures, reaching 1 °C in certain regions in winter and spring. This trend is followed by an increase in the number of days with extreme maximum temperature, with an over-30% increase nearly throughout the country.
OBSERVED	PRECIPITATION	Significant regional changes were observed both in reducing and increasing annual rainfall. Reductions (up to 20 mm) in the annual accumulated average were observed in the southwestern part of the Northern region, in the eastern part of the Central-western region, and in the Northeastern and Southeastern regions. Increases have been noted in the far north of the Northern region (up to 40 mm), in the Southern region (up to 20 mm), and in areas in the Northeastern and Central-western regions. The observations also point to increases in the frequency and intensity of extreme precipitation events, such as increased droughts in the country's central part.
PROJECTIONS	TEMPERATURE	Projections indicate that the temperature rise trends observed in the country should continue throughout the 21st century at a rate above the global average. It is projected that most Brazilian regions will experience at least a 4 °C increase in average temperatures with a high GHG emissions pathway.
PROJECTIONS	PRECIPITATION	Changes are projected in average precipitation values, rainy season characteristics, and the frequency and intensity of extreme events throughout the 21st century. Decreased average precipitation is projected in the Northeastern, Northern and central regions of the country, whereas an increase is projected in the Southern region. Increased extreme droughts are expected mostly in the Northeastern and Northern regions, and depending on the scenario, in the Central-western and Southeastern regions as well, mostly during summer (season of higher precipitation accumulation). Projections also point to a significant increase of precipitation extremes in most of the territory, with greater consistency of the models in the Southern and Southeastern regions, and in other regions depending on the scenario, such as the northwestern part of the Amazon.

Impacts and Vulnerabilities

Possible implications resulting from future climate scenarios in which the average global warming is 1.5 ºC, 2 ºC and 4 ºC (or simply SWL1,5, SWL2 and SWL4, respectively)[2] have been analyzed. The fact that greater changes may be expected as SWLs intensify, which will probably produce stronger impacts, was taken into account.

A summary of the main impacts and vulnerabilities analyzed in Water, Energy, Food and Socioenvironmental Securities is shown hereafter:

- In relation to WATER SECURITY, future scenarios point to an amplification of the current impacts and vulnerabilities related to climate in Brazil. The reduction in water availability in the Caatinga, Cerrado and Atlantic Forest biomes, whose territories are marked by high population concentration and multiple uses of water, shows the fragility in the correlation between water supply and demand in different warming scenarios. The vulnerabilities that exist in all biomes, especially in the Amazon, Atlantic Forest and Caatinga in relation to the occurrence of floods and the low quality of water in metropolitan regions are also worth mentioning. Likewise, there are vulnerabilities associated with environmental sanitation, such as access to drinking water and sewage. Regarding governance, although the Brazilian legislation is advanced and emphasizes the decentralization of water management, Brazil has a huge variation in terms of institutional capacity across the various states and municipalities.
- As to ENERGY SECURITY, climate change will have an impact on all energy chains in Brazil. The most vulnerable energy sources are water for hydroelectricity generation (mainly in the Amazon and Caatinga biomes), and bioenergetic crops (soy and sugarcane) for the production of biofuels (in the Atlantic Forest and the Cerrado biomes) or for bioelectricity generation from sugarcane bagasse. On the other hand, energy generation from wind and solar energy sources (for centralized and decentralized generation) could be maintained and/or increased (although, in the case of wind energy, the scenarios indicate a reduction in the potential in areas of the Northeast, where much of the installed capacity is currently found). The reduction in hydroelectric generation, which represents 66.6% of the country's installed capacity, will require its replacement by other generation technologies, which imply an increase in the marginal energy cost of the electric system and the final price of electricity. However, the Brazilian electric system has a high adaptive potential by allowing the partial offset of hydroelectric generation by other renewable sources, in addition to fossil sources, if necessary.
- Regarding FOOD SECURITY, the demand for food in the country has been increasing in recent decades, mainly due to population growth and per capita consumption. In parallel, the migration of family farmers to cities leads to greater pressure on production, as the number of producers decreases and the number of consumers in the market increases. In addition, the high volume of food losses and waste in the country leads to an increase in costs and prices, which affects food availability and access, especially for low per-capita income households or those in extreme poverty. Climate change has direct effects on agricultural production capacity, influencing,

See the infographic on the extensible page for more information.

2 SWL – *Specific Warming Level* represents the global average anomaly variation of the air temperature in the surface regarding the pre-industrial period (approximately 1870-1899).

among others, crops suitability to new local climate conditions. Greater losses and costs in the production chain due to more intense and frequent extreme events may require a greater allocation of financial resources for agricultural insurance, causing an increase in prices and a reduction in producer profits. There are also projections of greater need for irrigation, especially in the Cerrado and Caatinga biomes, with potential conflicts over water use. In fishery, changes in ocean temperature and water pH may lead to the migration of schools or even their mortality, and production reduction (capture) in the entire coastal range, rivers and lakes, strengthening the role of aquaculture to ensure fish production.

- In SOCIOENVIRONMENTAL SECURITY, aspects of vulnerability and exposure are related to sensitivity to increased temperatures, intensification of extreme events and changes in precipitation patterns, which overlap with the structural dimensions of poverty, socioeconomic inequalities, socio-spatial segregation in cities, level of access to basic services (such as health and education), marginalization by gender and ethnicity (indigenous peoples, traditional communities, black people) and institutional capacity from government agents to deal with climate change and its consequences. Future scenarios indicate losses in climate suitability associated with climate change in all biomes, with loss of biodiversity and ecosystem services. Projections indicate a significant increase in temperature and an increase in the incidence of extremes of drought and floods, fires and hot spots, as well as vector and water borne and heat-related diseases and disasters, affecting all biomes, even if unevenly. This context is verified not only in poorer and farthest regions, away from services and information to allow a timely response, and in what affects traditional peoples and communities, but also in large urban areas, where there are marginalized and poor populations.

Adaptation

The adaptation options presented herein consider impacts and vulnerabilities described in the context of Securities, and indicate not only a way to deal with and minimize the adverse effects of climate change, but also foster sustainable development and the improvement of the population's well-being.

Water resources management has a cross-cutting role in the adaptation to climate change, given that water is a vital resource for food production, biofuels, energy generation, and others. The strengthening and political-institutional coordination to manage multiple uses and efficient water use are essential to minimize water crises and measures such as the establishment of reservoirs and related infrastructures.

In addition, the diversification of generation sources (including solar photovoltaic and wind power) is an important adaptation option, given the predominance of water sources in the electricity mix (vulnerable to variations in flows and water balance). Likewise, considering climate scenarios in energy planning can strengthen the energy system's resilience and adaptability, knowing that its assets have high cost and useful life. Complementarities among different sources, such as hydro-wind and hydro-solar sources, provide additional opportunities in the Brazilian context, notwithstanding the importance of promoting the user sectors' energy efficiency.

Adaptation strategies in the agricultural sector are necessary to guarantee food supply, reduce losses, and yield drop in production, maintain the producer's income and landscape. The adoption of sustainable farming practices involving the appropriate use of resources, in particular soil and water, ecosystems maintenance, and the development of varieties that are more resistant to water and thermal stresses are measures that can benefit Food and Energy Securities, in addition to contributing to aspects of water quality and quantity, health and others.

Additionally, changes in agro-climate risk and productivity conditions have generated a strictly technical assessment, proposals for the migration of crops to more favorable areas, and a potential response from the productive sector. In this regard, it will be necessary to consider the strengthening of territorial planning policies in order to reconcile production activities with the conservation of natural environments and ecosystem services.

Ecosystem services are fundamental to society, as they include food provision, disease control, soil conservation, climate regulation, and the hydrological cycle, among others. Thus, adaptation solutions based on the integrated management of natural resources contribute significantly to the strengthening of cross-cutting and effective resilience through the maintenance and recovery of natural environments and the integration between green (natural) and gray (built) infrastructures. Such adaptation measures could, for example, act as natural barriers during extreme precipitation events, thus minimizing the occurrence of disasters (flash floods, river floods, and landslides), and improving the quality of urban environments.

In this regard, integrated urban planning represents an instrument capable of enhancing the use of green infrastructures, promoting solutions that make cities more efficient in the use of resources such as water and energy; as well as more equitable, with better access to infrastructure, urban services and quality of life, with special attention to precarious settlements. The control of urban expansion over areas of risk or environmental sensitivity is also urgent, in the sense of not generating new social vulnerabilities and pressures on ecosystems.

Finally, it must be emphasized that adaptation can potentially minimize impacts and risks, but it cannot eliminate them altogether. Thus, systems for monitoring and communicating risks to the population and public managers are becoming increasingly essential.

Main impacts and vulnerabilities by security

Water security

WATER AVAILABILITY

Increase of critical water exploitation areas (flow reduction and high water extraction for the supply of metropolitan areas, irrigation poles and mining) and extreme droughts .

ACCESSIBILITY**

Poor access to basic sanitation services: sewage network covers 65% of the country , and poor drainage system and waste management.

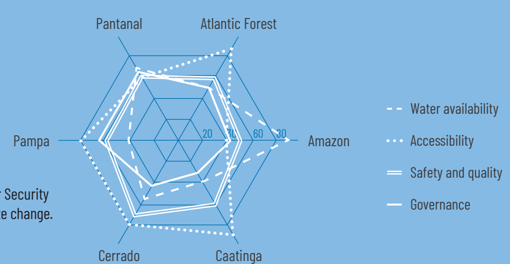
SAFETY AND QUALITY**

Vulnerabilities related to the occurrence of floods , low quality of water in metropolitan areas and weirs .

GOVERNANCE**

Poor water management to cope with extreme events and conflicts over the use of water, particularly the Water Resources Plans and Basin Committees .

Current water security level by ISHmc* dimensions



*ISHmc (for its acronym in Portuguese) stands for Water Security Index in the context of climate change.
**Dimension only represents the current context.

GROUNDWATER

Lack of control of difuse pollution may cause groundwater contamination.

Energy security

HYDROPOWER SUPPLY (AND ELECTRICITY MIX)

Changes in flow and affluent natural energy (ANE) point to a decrease by 6% to 41% in hydroelectric generation capacity, particularly in the Northern and Central Western systems, which alter the electricity mix and impact on the marginal cost of energy.

WIND AND SOLAR ENERGIES AVAILABILITY

Maintenance or increase in solar availability for photovoltaic generation . Increase in countrywide wind availability, except for areas in the states of Rio Grande do Norte and Paraíba , which have over 50% of the country's installed capacity and may present a minor decrease.

Complementarities among renewable sources

The degree of complementarity among sources might be altered in different periods and regions/subsystems. Complementarities among hydro-wind and hydro-hydro sources among the SIN subsystems are of note.

DEMAND FOR THERMAL COMFORT

Upward trend for countrywide cooling energy demand, particularly in the Atlantic Forest biome due to its population density.

TRANSMISSION AND DISTRIBUTION INFRASTRUCTURE

Transmission and distribution infrastructures, which connect the different regions and provide the Brazilian Interconnected System with adaptive capacity, are vulnerable to climate extremes across the country.

BIOFUELS

A decrease in areas with low agroclimate risk for soybeans (around 80%) and sugarcane (over 30%) affect biodiesel and ethanol production, respectively, thus leading to a greater need for irrigation, among other impacts.

Food security

PRODUCTIVITY AND SUITABLE AREAS FOR PRODUCTION

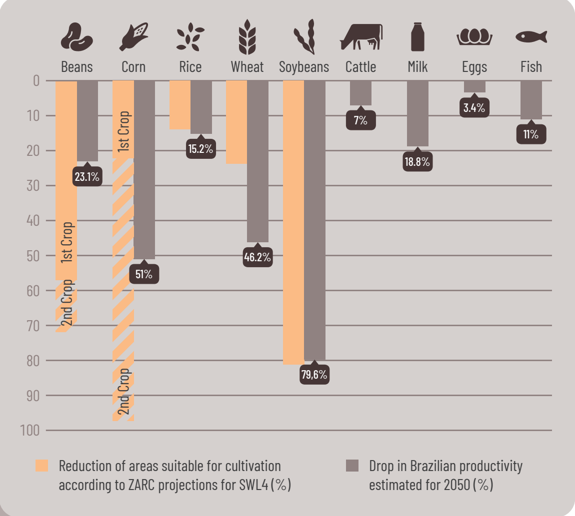
Reduction of productivity and suitable areas for cultivation with temperature increase and rain variability. As a result, a 45% increase in the demand for irrigation is expected by 2030, requiring a compatibilization with other uses of water.

AGRICULTURAL LOSSES AND COSTS

Increased losses in agriculture and other parts of the productive food chain, with impacts on costs, prices and expenses with agricultural insurances, mostly during extreme climate periods. Production and supply losses across the country are estimated between 10% and 40%.

GROWING DEMAND

Population and per capita consumption growth, in addition to the rural exodus of smallholders, generate pressures on the productive food chain.



FOOD WASTE

Food waste (retail and consumption) is estimated in over 40kg per person every year, particularly rice, meat, beans and chicken, which pressures the productive food chain.

Socioenvironmental security

DISASTERS

Urban vulnerability and exposure index (IVUExp, for its acronym in Portuguese)

Disaster records correspond to areas of major demographic density, as well as precarious urban infrastructure and social conditions.

Floods

Floods are focused in the Southeastern, Northeastern (mainly the states of Rio Grande do Norte and Paraíba) and Southern (mainly the states of Santa Catarina and Rio Grande do Sul) regions.

Landslides

Hotspots located in the Southern, Northeastern (border of the states of Pernambuco and Alagoas, in the region of Serra da Roncadeira), and Southeastern (Serra da Mantiqueira) regions.

BIOME RESILIENCE

All biomes lose stable states due to climate change (worsened by non-climate pressure), with loss of biodiversity and ecosystem services. In the case of the Amazon biome, a 40% loss of original forest distribution may represent a tipping point, with risks for continental climate.

Migration

Water scarcity may lead to migration processes and precarious urbanization.

DISEASES

Exposure Risk by Heat Stress (WBGT)

An increase in warm days and heat stress is observed (WBGT>28 °C) across Brazil. Capital cities in the Northen and Northeastern regions and in the states of Mato Grosso, Rio de Janeiro and Espírito Santo will have over 90% of warm days in that condition.

Respiratory (elderly) and cardiovascular (ages 45 and over) diseases

The percentage of heat-related deaths and hospital admissions caused by respiratory diseases may get to 40% in the Northern region, 30% in the Southeast region, and 23% in the Southern region, while admissions caused by cardiovascular diseases may get to 12% in the Northeastern and Southeastern regions or 10% of deaths and in the Southern region. Today, these figures are relatively low in most capitals.

Water-borne deseases

Increased incidence of child diarrhea in the Northern region and in the Northeastern semi-arid region (associated to climate change and social and environmental vulnerabilities).

Vector-borne diseases

Change in the incidence distribution of vector-borne diseases, particularly dengue fever, yellow fever, viral leishmaniosis and malaria, pressuring the national health systems, generating a need to adapt it.

Chapter 4. CLIMATE CHANGE MITIGATION AND ADAPTATION MEASURES

Chapter 4 presents the main public policies, programs, projects and other initiatives towards mitigation and adaptation to climate change. It also presents information on initiatives and investments for mitigation actions.

Brazil has established projects, activities, programs and political actions in order to monitor and mitigate emissions, monitor impacts and adapt to climate change. A set of regulatory frameworks and management tools has since been improved in the country. As a result, government programs and initiatives for the follow-up of the implementation of actions and emission reductions have either been enforced, or are under development.

The National Policy on Climate Change (PNMC, for its acronym in Portuguese) established the principles, objectives, guidelines, and instruments that inform the development and implementation of public policies and government programs, as reflected by Decree No. 9,578/2018, which is primarily aimed at fulfilling their voluntary national commitment pertaining to Nationally Appropriate Mitigation Actions (NAMAs). These actions were supported by the implementation of sectoral mitigation and adaptation plans under the PNMC, such as the Action Plan for the Prevention and Control of Deforestation and Forest Fires in the Cerrado (PPCerrado, for its acronym in Portuguese), the Action Plan for the Prevention and Control of Deforestation in the Legal Amazon (PPCDAm, for its acronym in Portuguese), the Sectoral Plan for Mitigation and Adaptation to Climate Change for the Consolidation of a Low-Carbon Economy in Agriculture (ABC Plan), and the Sectoral Plan to Reduce Emissions in the Steel Industry.

It is of note that over the past ten years other relevant actions have also been developed at the national and subnational levels with a view to mitigating national emissions and adapting the country to climate change. Some of these actions culminated in the development of other related initiatives and projects, such as Brazil's strategy for the Green Climate Fund (GCF), the National Adaptation Plan (NAP), the Climate Change Policy Programme (PoMuC, for its acronym in Portuguese), the Technology Needs Assessment project (TNA_Brazil), CITInova, the National Strategy for Integrated Natural Disaster Risk Management (GIDES, for its acronym in Portuguese) and the Brazil Partnership for Market Readiness (PMR) Project, which are discussed in the Fourth National Communication as an illustration of this array of supporting measures that have been adopted. It is also worth mentioning the existence of cross-cutting national policies, which focus on a different issue to climate change, but which strongly contribute to the achievement of the results of the PNMC, such as the Forest Code, the National Biofuels Policy (RenovaBio, for its acronym in Portuguese) and the National Policy for the Recovery of Native Vegetation (Proveg, for its acronym in Portuguese).

In addition to the national efforts discussed in this chapter, countless public policy instruments and initiatives that contribute to adaptation under the jurisdiction of subnational entities are recognized, as well as initiatives by the business sector and the civil society. It should be pointed out that 16 of the 27 Brazilian states have an approved state climate change policy in place, 17 states have set up climate change forums, and 10 states have adaptation plans in place. In addition, several municipalities have climate policies and/or strategies in place.

Similarly, there is great potential for private sector actions in the country, which often has the support of the academic community and civil society organizations in implementing adaptation, including the following: Thematic Chamber on Energy and Climate Change (CEBDS, for its acronym in Portuguese); Adapta Sertão (Coalition of family farming cooperatives and Redeh); Xingu Program (ISA, for its acronym in Portuguese); Agroclimatic Intelligence Project (IAC, for its acronym in Portuguese) (businesses, farmers, Embrapa and others); Observation and Monitoring System for the Indigenous Amazon (SOMAI Platform in Portuguese), (the Institute of Environmental Research of the Amazon, National Indian Foundation, the Coordination of Indigenous Organizations in the Brazilian Amazon and Brazil's Indigenous People Articulation); the Corporate Platform for the Climate (EPC, for its acronym in Portuguese) (the Center for Sustainability Studies – FGVces, for its acronym in Portuguese); Adaptation Project based on Ecosystems in Marine, Terrestrial and Coastal Regions (CI for its acronym in Portuguese; Municipality of Porto Seguro; SOS Mata Atlântica; Porto Seguro Advocacy Movement; the Federal University of Santa Catarina and the University of São Paulo); Brazil Network in the Global Compact - Energy & Climate WG (Ethos Institute, the Brazilian Global Pact Committee and associated businesses).

With these measures, Brazil is confident that the promotion of the National Policy on Climate Change, instituted by law, is positively compatible with economy growth and with the task of reducing greenhouse gas emissions and poverty and social inequality simultaneously.

By making these efforts, the country cooperatively joins the global climate movement and reaffirms its tradition to strengthen multilateralism as the most adequate regime to look for solutions to the challenges faced by the international community. In this regard, climate financing is of utmost relevance so that the country can successfully implement actions to tackle climate change – a broad topic as it involves a large number of institutions. These institutions include funding sources, banks, programs either with or without a limited duration, initiatives by donor or recipient governments, non-governmental organizations, and other actors. As such, the National Fund on Climate Change (FNMC, for its acronym in Portuguese, or simply Climate Fund) and the Amazon Fund deserve special notice at the national level. The Climate Fund has the purpose of ensuring resources to support projects or studies and for the financing of projects that have as their objective the mitigation of climate change. The Amazon Fund aims at raising donations for nonrecoverable investments in actions of prevention, monitoring and combating deforestation and at promoting the conservation and sustainable use of forests, especially in the Amazon biome.

Chapter 5. OTHER RELEVANT INFORMATION FOR ACHIEVING THE OBJECTIVES OF THE CONVENTION IN BRAZIL

The final chapter provides information on awareness-raising initiatives on issues regarding climate change, efforts to promote capacity building, and the indication of technological, financial and capacity-building needs in order to achieve the objectives of the Climate Convention.

Although the climate change issues are complex, difficult to understand by lay people, and reading material avaiable in Portuguese is limited, there has been an attempt to expand education, public awareness and training on these issues. Public awareness plays an extremely important role for society and the government to join efforts to mitigate greenhouse gas effects and to adapt to climate change.

At the national level, the National Emissions Registry System (SIRENE, for its acronym in Portuguese), the AdaptaBrasil MCTI program, the Integrated Information System of the Sectoral Plan for the Consolidation of a Low Carbon Economy in Agriculture (SIN-ABC, for its acronym in Portuguese), and the Climate Vulnerability System (SisVuClima, for its acronym in Portuguese) are of note, as they consolidate and systematize results of national GHG emissions, the analysis of integrated information on climate and risk impacts in Brazil, relevant information on the implementation of the mitigation action plan in the national agricultural sector, and indicators at the municipal level to assess the population's vulnerability to climate change in six states of Brazil: Amazonas, Espírito Santo, Mato Grosso do Sul, Maranhão, Paraná, and Pernambuco, respectively. Other programs are the Modular System for Monitoring Actions of Greenhouse Gas Emissions Reductions (SMMARE, for its acronym in Portuguese), whose development is being revised in light of the Paris Agreement and national commitments thereto, in order to monitor the implementation of actions described in the country's sectoral mitigation plans.

In the core issue of domestic capacity-building, the Brazilian academic-scientific sector has played a major role in the development of knowledge to bridge the information gaps and expand understanding of the implications of climate change for the various national contexts. At least 15 actions focused on building climate change capacity in Brazil are presented herein. A common characteristic of these initiatives is the coordination with the Government, aiming at contributing to the effectiveness of Brazil's climate change policy; the work with networks – incluing some international ones – and the multisectoral and interdisciplinary perspective required by the scientific knowledge on climate change.

In order to respond to the vast and diversified scope of Brazilian mitigation and adaptation initiatives, the Government developed a governance structure that adopts a cross-cutting approach to climate change by aggregating the collective and coordinated production of various ministries and government agencies, including the actions that have been undertaken by the subnational governance levels in the states. In this regard, Brazil set its national priorities and presented its strategy for engagement to the GCF to obtain funds to finance projects and programs. The Country Program document was prepared under the coordination of the Ministry of Economy (ME), which is Brazil's Designated National Authority (DNA) under the GCF. The document discusses opportunities for the preparation of funding proposals under the GCF, which not only meet the Fund's criteria, but are also consistent with national priorities, are economically viable and result in transformational impact.

Public funds committed to Brazilian entities are obtained through multilateral institutions and bilateral channels (Parties included in Annex II of the Convention), with concessional loans and grants as the main funding instruments. From 1996 to 2006, the main source of funds for climate issues at the Federal Government level was the GEF.

As of 2008, the number of actors responsible for the funding support provided to Brazil to tackle Climate Change was expanded. These included the Inter-American Development Bank (IDB); GEF; the World Bank (IBRD) and its arm for the private sector, the International Finance Corporation (IFC); the New Development Bank (NDB); the bilateral cooperation with Norway and Germany; the Development Bank of Latin America (CAF); the European Investment Bank (EIB); the French Development Agency (AFD); the German Development Bank (KfW); the Japanese Bank for International Cooperation (JBIC); and the Plata Basin Financial Development Fund (FONPLATA).

The allocation of funds to Brazil in 1996-2017 was over USD 6 billion, 53% of which came from multilateral channels and 47% came from bilateral channels. Compared to 2008-2013, in 2014-2015 there was a significant increase in the funding received, in excess of USD 3 billion. However, in 2016-2017, there was a 12% reduction in relation to the support received in the previous biennium, with a noticeable reduction in the amounts contributed by the cooperating countries and entities also in the 2018-2019 period.

The allocation of funds to Brazil in 2018-2019 totaled approximately USD 1.874 billion, with less than 6% allocated through bilateral channels. There was a decrease in relation to the bilateral support received in previous biennia, from more than USD 437 million in 2016-2017 to about USD 100 million in 2018-2019. It should also be noted that the multilateral contributions for 2018 and 2019 did not reach 50% of contributions in 2017.

In view of the importance of international financing in catalyzing climate change action, Brazil has stressed the need for the financial contribution to be adequate, predictable, sustainable, new, and additional. In recalling the commitment of developed countries to commit USD 100 billion per year by 2020, Brazil stresses that the curent status of implementation of this commitment is not clear. International funding and cooperation from both bilateral and multilateral sources are fundamental elements for Brazil to continue to make progress regarding actions to tackle climate change.

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