National Adaptation Plan to Climate Change

General Strategy

VOLUME I

Ministry of Enviroment

National Adaptation Plan to Climate Change

Volume I: General Strategy

MMA Order 150 of 10th May 2016

Federative Republic of Brazil
Dilma Vana Rousseff
President

Michel Temer
Vice President

Ministry of Environment
Izabella Mônica Vieira Teixeira
Minister

Executive Secretariat
Carlos Augusto Klink
Secretary

Secretariat for Climate Change and Environmental Quality
José Domingos Gonzalez Miguez
Secretary

General Coordination of the Working Group on Adaptation to Climate Change

Director for Licensing and Environmental Assessment (MMA)
Karen de Oliveira Silverwood-Cope

General Coordinator for Global Climate Change (MCTI)
Márcio Rojas da Cruz

MMA Technical Team
Adriana Brito da Silva, Jaqueline Leal Madruga, Juliana Faria Nunes, Luiz Gonçalves da Motta, Mariana Egler, Nelcilândia Pereira de Oliveira Kamber, Pedro Christ

MCTI Technical Team
Andrea Araújo, Lidiane Melo, Ricardo Pavan, Sonia Bittencourt

Federal Government Institutions participants of the National Adaptation Plan to Climate Change

ANA	National Water Agency
CAISAN	Inter-ministerial Chamber for Food and Nutritional Security
Casa Civil/PR	Staff of the Presidency of the Republic
Cemaden	National Centre for Monitoring of Natural Disasters
EMBRAPA	Brazilian Agricultural Research Corporation
FBMC	Brazilian Forum on Climate Change
FUNAI	National Indian Foundation
FioCruz	Oswaldo Cruz Foundation
IBAMA	Brazilian Institute for Environment and Natural Renewable Resources
ICMBio	Chico Mendes Institute for Biodiversity Conservation
INPE	National Institute for Space Research
MAPA	Ministry of Agriculture, Livestock and Food Supply
MCTI	Ministry of Science, Technology and Innovation
MI	Ministry of National Integration
MCid	Ministry of Cities
MRE	Ministry of External Relations
MME	Ministry of Mines and Energy
MDA	Ministry of Agrarian Development
MDS	Ministry of Social Development and Combating Hunger
MDIC	Ministry of Development, Industry and Foreign Trade
MMA	Ministry of Environment
MPOG	Ministry of Planning, Budget and Management
MS	Ministry of Health
MT	Ministry of Transport
SFB	Brazilian Forestry Service
CPRM	Geological Survey of Brazil

State, civil-society and private-sector representatives also contributed to the drafting of this plan. See the complete list on the Ministry of Environment website.

Credits of Images: ASCOM/MMA, Paulo Hilst

International Publication Catalogue Data - CIP

B823p Brazil. Ministry of Enviroment.

National Adaptation Plan: Volume I: general strategy : MMA Order 150 of 10th May 2016 / Ministry of Environment – Brasilia : MMA, 2016 . 2. v

44 p., il. (some colour.)

ISBN: 978-85-7738-271-2

1. National Adaptation Plan. 2. Climate risk. 3. Climate change. 4 Sectoral plans. 5. Mitigation and adaptation. I. Secretariat for Climate Change and Environmental Quality. II. Title.

CDU: 551.583(083.9)

Ministry of Enviroment

Library

Table of Contents

List of Tables and Figures

List of Figures

List of Tables

Introduction

The purpose of the Brazilian Federal Government's National Adaptation Plan, hereinafter referred to as the National Adaptation Plan (NAP) is to guide initiatives for management and reduction of long-term climate risks, as established in Ministry of Enviroment (MMA) Order 150 of 10th of May 2016, published in the Official Gazette (DOU) of 11th May 2016. The Plan was drawn up by the Executive Group of the Inter-ministerial Committee on Climate Change (GEx-CIM) between 2013 and 2016, as provided for in the National Policy for Climate Change (PNMC- Law 12.187/09) and its enabling decree (Decree 7.390/10). The NAP was drawn up in consonance with the National Plan for Climate Change, with sectoral mitigation and adaptation plans, and with decisions on adaptation undertaken by Brazil within the framework of the Conference of the Parties (COP) on Climate Change.

The drafting of this plan received contributions from thematic networks comprised of experts from various sectors and included extensive public participation by means of a public call for inputs and a public consultation process.

Also considered were reference documents representing the current status of knowledge, such as: the First National Assessment Report of the Brazilian Panel on Climate Change; recommendations of the Third National Environment Conference, attended by over 115,000 people, the theme of which was "Climate Change"; and a report entitled "Inputs for drafting of the National Adaptation Plan to Human Impacts of Climate Change", prepared by the Brazilian Forum on Climate Change (FBMC).

Impacts of climate change can already be observed. The Brazilian Panel on Climate Change (PBMC) has systematized data and information indicating that the characteristic climates of the various regions of Brazil are already experiencing change. It forecasts that these changes will affect Brazil's natural, human, infrastructure and productive systems, in non-uniform ways. Rises in temperature may lead to an increase in the frequency of extreme events in various regions of Brazil, as well as changes in rainfall patterns, with greater frequency of occurrence of droughts, heavy rainfall, flooding, landslides, and consequent population displacement in the affected regions. Such changes will have serious consequences for society, ecosystems and various sectors of the economy.

Risk management associated with climate change will require coordination and cooperation among the three levels of government, sectors of the economy, and civil society, since the impacts of climate change will occur on a local level, but measures for facing up to them will depend upon actions coordinated and deployed through a variety of sectoral or thematic strategies.

This Plan proposes actions, strategies and guidelines for management and reduction of climate risk in Brazil, with a view to facing up to the adverse effects of the social, economic and environmental dimensions of climate change. It also proposes institutional mechanisms for concerted deployment among states and municipalities, economic sectors and the general public, and for scheduled implementation of structural measures to overcome gaps observed in the national context.

The NAP is presented in two volumes. Volume I – General Strategy – features and details structural components of the plan: its legal framework, objectives, goals and governance. Volume II – Sectoral and Thematic Strategies – discusses Brazil's main vulnerabilities in face of climate change, and proposes guidelines to include risk management associated with climate change, with a view to increasing the climatic resilience of 11 thematic sectors, namely: Agriculture, Biodiversity and Ecosystems, Cities, Disasters, Industry and Mining, Infrastructure (Electric Power, Transport and Urban Mobility), Vulnerable Populations, Water Resources, Health, Food and Nutritional Security, and Coastal Zones.

1 Context

The National Policy for Climate Change (PNMC - Law 12.187, of 29th December 2009) provides the legal framework for preparation of the National Adaptation Plan (NAP). Article 4, inset V of the PNMC establishes the need to implement measures to promote adaptation to climate change by the three levels of government.

Equally important, the Sectoral Plans for Mitigation and Adaptation to Climate Change, formalized by Decree 7390 of 2010, seek to guide actions that promote resilience of sectors in facing up to the adverse impacts of climate change, taking into account the specificities inherent to each plan. In various cases, in addition to risks arising from an increase in the frequency of extreme events, changes in climate patterns can negatively affect the routine activities of specific sectors. Thus, in consonance with guidelines laid down in this NAP, sectoral plans need to strengthen the strategic agenda for adaptation, in convergence with planned mitigation actions, when appropriate, without prejudice to other sectoral policy instruments for adaptation to climate change.

A relevant example of existing synergies between initiatives for adaptation to climate change provided for in this Plan and the national risk-management framework for natural disaster warnings is the National Civil Defence and Protection Policy, instituted by Law 12.608, of 10 of April 2012. The relevance of this relationship becomes even more evident in scenarios of increasing occurrence of extreme events, foreseen in climate-model projections. It is therefore incumbent upon the Federal Government, the states, the Federal District and municipalities to adopt all measures necessary to reduce disaster risks, including empowerment of municipalities and collaboration among public and private entities and society in general.

Furthermore, the National Civil Defence and Protection Policy also provides for implementation of risk reduction and risk prevention measures. It is thus in alignment with strategies for adaptation to climate change, with a focus on expansion of adaptive capacity and reduction of vulnerability, for purposes of climate risk management.

On an international level, the United Nations Framework Convention on Climate Change (UNFCCC), to which the Brazil is a Party, is the main global response to the challenge presented by climate change. The Convention places a number of commitments upon the Parties, among them, the drafting of plans for adaptation to climate change.

The Conference of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC) recognized that national planning for adaptation can assist developing and less developed countries in preparing their assessments of vulnerabilities, to incorporate climate-change risks into their national policies, and promote adaptation. The COP also acknowledged that climate-change risks intensify development challenges, and that there is the need to address planning for adaptation, within a broader context of sustainable development.

Brazil´s commitment to promoting adaptation was reaffirmed at the Conference of the Parties (COP 21) in Paris, by means of submission of its proposed

2 Observed and projected climate change

The need for adaptation becomes more pressing as evidence mounts of impacts associated with the climate change. Such impacts may have positive or negative repercussions on natural, human, productive and infrastructure systems, affecting biodiversity, coastal zones, water resources, power generation, industry, transport, cities, urban mobility, agriculture, food and nutritional security, vulnerable populations and disaster risk management.

When promoting adaptation to climate change, it is important not only to observe current exposure to climatic events, but also to assess future exposure. This can be achieved through the use of various techniques and tools, such as building of scenarios and application of climate models.

Scientific observations have revealed increases in average global air and ocean temperature levels, widespread melting of snow and icecaps and overall rises in sea levels. Such phenomena are unequivocal evidence of global warming. Moreover, average global temperatures are forecast to rise by almost 2° C by the end of this century. Such an increase is unprecedented, and higher than any recorded since pre-industrial times, according to the Intergovernmental Panel for Climate Change (IPCC, 2014).

Possible impacts of climate change in Brazil and South America include: extinction of habitats and species, mostly in tropical regions; replacement of tropical forests by savannahs, and of semi-arid vegetation by dessert; an increase in water stress in various regions, i.e., lack of sufficient water to fulfil demands of the population; increases in agricultural pests, and of diseases such as dengue fever and malaria (PBMC, 2013); and displacement and migration of populations.

Reports of the PBMC and IPCC in the context of Working Group II (WGII) have been unanimous in revealing that South America and Brazil are already facing changes foreseen in climate models:

Rises in temperature of up to 2.5°C in coastal regions of Brazil between 1901 and 2012;
Increase in the number of days with rainfall above 30 mm in Brazil’s Southeast region;
Rises in sea temperatures and changes in salinity in the South Atlantic;
Increased frequency, intensity and influence of El Niño Sothern Oscillation (ENSO) events in the continental climate (Equatorial eastern-Pacific El Niño, La Niña and Central-Pacific El Niño).

Climate change associated with global warming may change the frequency, intensity, spatial distribution, duration and periodicity of extreme events, resulting in unprecedented extreme conditions (IPCC, 2012). Changes in average, variance and/or distribution of the probability of such events, and changes in the behaviour of seasonal series, may also lead to changes in the frequency of occurrence of extreme events.

In recent years, an intensification of extreme events has been observed in Brazil, alongside a shorter recurrence interval of such extreme events. Such changes are consistent with the forecasts of global climatic models and attributable to increased concentrations of greenhouse gas emissions. However, a lack of reliable and consistent historical data series covering the entire Brazilian landmass is indicative of the need to expand and systematize the availability of knowledge and of information sources for monitoring climate change throughout Brazil.

Climate models that represent the climate system and its interactions with external forces (such as the Sun, aerosols, gases, etc.) seek to provide answers as to how the climate will behave in various emissions scenarios. The Fifth IPCC Assessment Report (2014) proposed four new emissions-level scenarios, known as Representative Concentration Pathways (RCP 2.6, 4.5, 6.0 and 8.5). For these projections, each scenario considers various factors, including greenhouse-gas emissions, different energy-generation technologies, and information on land-use patterns.

The RCP 2.6 scenario assumes that the Earth system will store an additional 2.6 watts per square metre (W/m^2) of energy, and represents a gradual reduction of greenhouse-gas emissions, reaching zero emissions around 2070. At some point, gas absorption processes may outweigh emissions and, when that happens, expected average temperature rises will amount to between 0.3°C and 1.7°C from 2010 to 2100, with sea levels rising between 26 and 55 cm. This scenario is considered "very optimistic" and is rejected by most climate-projection analysts.

The second scenario, RCP 4.5, assumes storage of 4.5 W/m^2 and represents a stabilization of greenhouse-gas emissions soon after 2100. It foresees rises in terrestrial temperatures of between 1.1°C and 2.6°C, and a rise in sea levels of between 32 and 63 cm. This is one of the most commonly accepted scenarios.

The RCP 6.0 scenario assumes storage of 6.0 W/m^2 and stabilization of greenhouse-gas emissions soon after 2100. It foresees a rise in terrestrial temperatures of between 1.4°C and 3.1°C, and a rise in sea levels of between 33 and 63 cm.

The RCP 8.5 scenario, considered the most "pessimistic", features an unmitigated rise in emissions without stabilization, i.e., emissions continue to rise over time as do greenhouse-gas concentrations. This scenario foresees storage of 8.5 W/m^2 and, according to the IPCC, warming of the Earth´s surface could range between 2.6°C and 4.8°C during this century, causing sea levels to rise by between 45 and 82 cm.

Brazil has played a prominent role in development of regional and global climate models. To develop a model capable of generating climate-change scenarios of relevance for the entire country, researchers of various institutions, members of the Research Program on Global Climate Change of the Sao Paulo Research Foundation (FAPESP), the Research Program on Global Climate Change (*Rede Clima*), and the National Science and Technology Institute on Climate Change (INCT-MC), have prepared the Brazilian Earth System Model (BESM) under coordination of INPE (NOBRE et al., 2013). It is the first Brazilian global model to be incorporated into the IPCC models, and enables Brazilian climatologists to perform climate-change studies specifically for Brazil.

INPE developed a regional version of the ETA model (PESQUERO et al., 2009; CHOU et al., 2012) used to generate climate simulations for studies of impacts and vulnerabilities, adapted for use in Brazil and South America. The ETA model was used during preparation of the Research Program on Global Climate Change (MCTI, 2016) to detail simulations of two global climate models, namely: the English HadGEM2-ES; and the Japanese MIROC5 models; under two emission scenarios (RCPs 4.5 and 8.5) with a horizontal resolution of 20 km and a coverage area encompassing

South America, Central America and the Caribbean. These regionalised downscaling simulations encompass four periods from the present to the end of the 21st century: 1961-2005; 2006-2040; 2041-2070; and 2071-2100. The 1961-2005 period adopts current CO_2 equivalent concentrations, while periods from 2006 onwards adopt CO_2 equivalent concentrations corresponding to the RCP 4.5 and 8.5. scenarios.

No numeric model can accurately simulate a future climatic event, in view of uncertainties as to emissions levels; natural climate variability and modelling uncertainties (of global, regional and impact models). These factors, termed "uncertainties" by the scientific community, are common to all climate-change projections. That is why it is important to consider the effects of the above-listed uncertainties with respect to the magnitude and/or patterns of climate change. One way to account for these is to prepare or use sets of simulation models in different emissions scenarios, preferably those that point to different projected average global temperature rises, by means of which the effects of different sources of uncertainty can be analysed.

Figures 1 and 2 show changes in temperature and rainfall levels for two seasons of the year, southern-hemisphere summer and winter, over 30-year periods: from 2011 to 2040; from 2041 to 2070; and from 2071 to 2100, as simulated by the ETA model (CHOU et al., 2014a; CHOU et al., 2014b). The lower and upper change thresholds stemming from these simulations indicate possible intervals of change derived from these regionalised simulations.

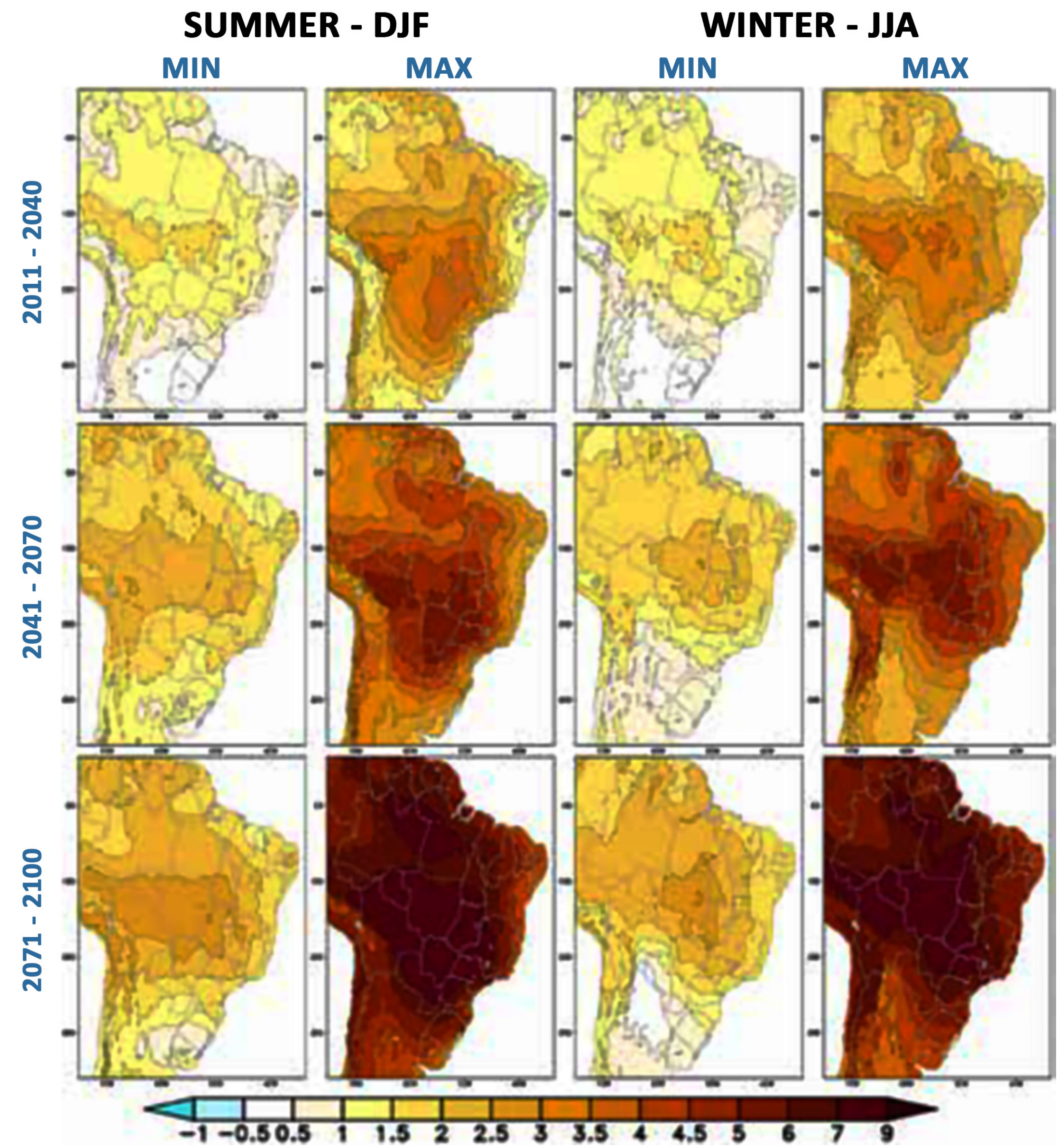


Figure 1. Regionalised temperature-change projections (°C) between the present and different future periods. The lower (MIN) and upper (MAX) change thresholds are taken from the four ETA model simulations, nested in HadGEM2-ES and MIROC5 models, for two Representative Concentration Pathway scenarios (RCP 4.5 and 8.5), for December-January-February (DJF) and June-July-August (JJA).

Warming is foreseen for the whole continent in all emission scenarios. The highest warming levels are foreseen for the Central-West region, in all seasons of the year. Such maximum warming will extend to the North, Northeast and Southeast regions of Brazil by the end of the 21st century, by which time, maximum average warming levels may range between 2°C and 8°C in some areas

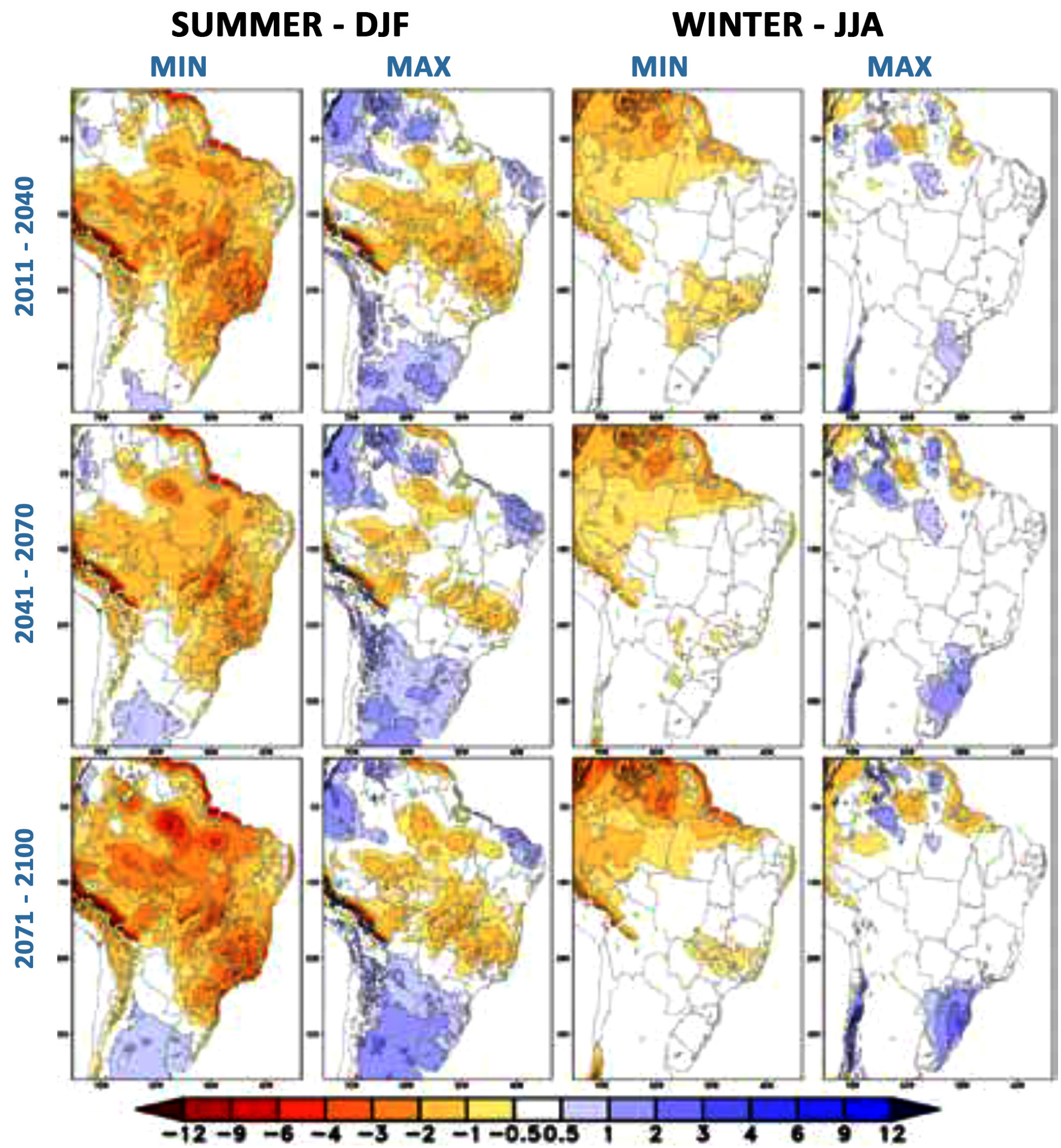


Figure 2. Regionalised rainfall change projections (mm/day) between the present and different future periods. The lower (MIN) and upper (MAX) change thresholds, taken from four simulations of the ETA model nested in the HadGEM2-ES and MIROC5 models, for two Representative Concentration Pathway scenarios (RCP 4.5 and 8.5), for December-January-February (DJF) and June-July-August (JJA)

It can be observed that, during the summer, the centres of maximum rainfall reduction are positioned over Brazil's Central-West and Southeast regions, in areas under the influence of the South Atlantic Convergence Zone (SACZ) phenomenon, which causes accumulation of rainfall. The centres of maximum rainfall reduction extend into parts of the Amazon region. In the north-eastern most part of Brazil's Northeast region, projections suggest a possible reduction or increase in rainfall during the summer. These simulations also foresee increased rainfall in the South region under the various scenarios. Such increases in rainfall over the South region, extending into the southern part of the Southeast region occur more prominently in summer (DJF) and in spring (SON). Increases in rainfall are foreseen for 2011-2040, becoming more intense toward the end of the century.

It should be noted that Brazil's Southeast region is an area of transition, the rainfall regime of which, during the summer, depends strongly upon the SACZ precipitation bands. Moreover, rises or falls in average rainfall levels may represent variations in the frequency of occurrence of extreme events, i.e., there may be a reduction in accumulated rainfall over the year in a certain area, with a concurrent increase and/or intensification of strong or very strong rainfall in another. Positioning of the band further to the north or to the south may result in positive or negative rainfall anomalies, causing further difficulties for conduct of simulations for the region. There is great uncertainty in climatic projections for Brazil's Southeast region, the climatic predictability of which is acknowledged to be low.

Temperature time series show that warming trends are greater in simulations nested in HadGEM2-ES than in those nested in MIROC5 but that, in all simulations, the increase in the inter-annual variability extends up until the end of the century, i.e., the difference between extreme highs and extreme lows increases. More intense rainfall levels are projected for the centre-south of Brazil up until the end of the century. Within the four simulations, mixed signals of changes in rainfall are to be found in an area between the South and Southeast regions. Moreover, increases in the number of consecutive dry days in Brazil's Northeast region and fewer consecutive wet days in the Amazon region are commonly found characteristics of these simulations.

Annual temperature and rainfall cycles do not suggest changes in the regime of rainy and dry periods. There is some indication in the projections of extended periods of drought in the North and Northeast regions. However, these simulations should be considered as inputs for studies of the impacts of climate change on different sectors, and it should be remembered that they stem from scenario projections containing uncertainties.

Though the results presented above do not exhaust all possibilities of analysis, they illustrate future exposure for Brazil's national territory. It is important that information stemming from climate projections be used for management of risks arising from climate change. In part, this process is linked to identification of current vulnerabilities of systems and of the population to the impacts of climatic events and changes already observed in the behaviour of extreme events.

3 Objective

The **general objective** of this Plan is to promote reduction and management of climate-risk considering the effects of climate change, by taking full advantage of emerging opportunities, avoiding losses and damages, and building instruments to prepare natural, human, productive and infrastructure systems to adapt to climate change.

Effective adaptation implies that the strategy to be deployed must integrate appropriate climate-change risk management into current public-sector and thematic planning, policy making, and national development strategies. The aim is to influence public-policy instruments and/or governmental programmes, by providing cross-cutting guidelines and instruments foreseen in the National Policy on Climate Change and in this Plan, with a view to broadening the coherence of adaptation strategies among public policies.

The bodies responsible, at the three levels of government must have access to appropriate methodologies and the basic information necessary to perform vulnerability analysis and risk management and to develop adaptation measures.

The Ministry of Environment website (www.mma.gov.br/clima/adaptacao) displays methodological guidelines and provides tools and information to facilitate adaptation planning.

The **vision** underlying this Plan, for the next four-year horizon, is that all government-policy sectors considered vulnerable to impacts of climate change must have climate-risk management strategies in place.

The Plan aims to ensure satisfactory and coordinated deployment of sectoral and thematic risk-management strategies, especially in the fields of food and nutritional security and of water and electric power, taking into account synergies and the cross-cutting nature of these themes throughout different sectors of the economy. Adaptation measures must likewise be aligned to stimulus for the productive sector, while ensuring fairness of the transition for society, in line with national goals for socioeconomic development and reduction of regional inequalities, through the coordination of public policies at the federal, state and municipal levels.

From a long-term perspective, by 2040 (the scientific timeframe for impact modelling) the NAP will have contributed to augmenting Brazil's capacity to adapt, and to a systematic reduction of climate risks.

The NAP, the integration of climate-change risk-management into current public policies and thematic and sectoral plans, and the national development strategies targeted at reducing vulnerability to climate change, shall observe the following **principles**, taking into account the characteristics and peculiarities of each sector or theme:

Establish vertical governance guidelines and adaptation measures at the three levels of government, taking into account specificities of the territorial impacts of climate change, setting complementary, coordinated, synergistic and coherent strategies;
Establish horizontal governance for formulation of adaptation responses, ensuring an integrated understanding of vulnerabilities among sectors and promoting interactions and synergies, respecting their particularities and institutional and social dimensions;
Approach adaptation from a sectoral and thematic standpoint and, when applicable, from a territorial standpoint, respecting the needs and peculiarities of each sector or theme;
Encompass social, cultural and economic dimensions for promoting adaptation, with particular attention to more vulnerable groups and populations, such as indigenous, ***quilombola*** and riparian populations, that require multi-sectoral, regionalised and priority approaches, including application of gender-sensitive and racial/ethnic criteria;
Implement adaptation and mitigation measures from the standpoint of co-benefits;
Promote integration and strategic alignment of adaptation with development-planning, consolidating adaptation through a strategy for promoting the productive sector while ensuring a fair transition for workers and economic growth aligned with strategies for reducing poverty, regional and socioeconomic disparities, and including observance of prevention and precaution principles;
Base adaptation initiatives on scientific, technical and traditional knowledge, with the aim of drafting and implementing appropriate adaptation measures, while respecting territorial, institutional, legal and technical particularities;
Promote and integrate a crosscutting Ecosystems-based Adaptation (EbA) methodology for all sectors, for use of ecosystem services as an alternative and/or complementary adaptation strategy;
Promote South-American regional cooperation among Adaptation Plans and Strategies, with a view to promoting exchanges of best practices, expansion of regional knowledge, and identification and treatment of the direct and indirect impacts of trans-boundary climate change.

4 Goals

This chapter presents the specific objectives of the NAP, a priority agenda for its implementation over the next four years, and guidelines and recommendations for public bodies and society in general.

4.1 Specific objectives

Activities of the Federal Government to promote adaptation to climate change need to provide structure for a sustainable development process that provides resilience from various sectoral and thematic perspectives. Based upon observation of current domestic and international best practices and through dialogue with society, governmental bodies and the private sector, the following specific goals of the NAP were assigned as responsibilities of the Federal Government:

1. Guide the expansion and dissemination of scientific, technical and traditional knowledge in support of the production, management and dissemination of information on climate risks, and develop capacity-building measures for governmental bodies and society in general;
2. Promote coordination and cooperation among public bodies for climate-risk management, by means of public-participation processes, with a view to fostering continuous improvement of climate risk-management actions;
3. Identify and propose measures to promote adaptation to and reduction of climate risk.

4.2. Sectoral and thematic strategies

Eleven sectors and themes are encompassed by the NAP, namely: Agriculture* , Biodiversity and Ecosystems, Cities, Disaster Risk Management, Industry* and Mining*, Infrastructure (Electric Power, Transport and Urban Mobility*), Vulnerable Populations, Water Resources, Health*, Food and Nutritional Security, and Coastal Zones. These were defined based on a comprehensive discussion process within the scope of the GEx-CIM. Alongside legal aspects relating to sectoral themes, criteria for sharing of responsibilities at the federal level and priorities and urgency in relation to vulnerabilities were considered.

Volume II presents guidelines for the development of adaptation measures and inclusion of a climate-change adaptation component into the planning instruments

* Sectoral Plans for Mitigation of and Adaptation to Climate Change are contemplated by Law 12187, of 2009 and Decree 7390, of 2010.

of each sectoral and thematic strategy.

Emphasis should be placed upon the systemic nature of adaptation approaches for attaining objectives foreseen in the NAP, both from the standpoint of vulnerabilities and impacts, and that of the need for responses and adaptation measures.

4.3 Goals and guidelines of the NAP

With a view to deploying specific objectives 1 and 2 of this Plan, structural goals for their implementation are presented. These goals, shown in Table 1, are to be attained within a four-year timeframe, as of publication of this Plan. Achievement of these goals will result in fostering of the essential requisites for effective adaptation, thereby facilitating attainment of the specific objectives and promotion of synergies between sectoral and thematic strategies. These same goals also feature in the 2016-2019 Multi-Year Plan.

With the aim of attaining specific objective 3, the goals of those sectors that possess an accumulation of historical knowledge or actions relating to climate change, and that have attained a degree of institutional maturity enabling them to participate in discussions for setting of their own specific goals, are presented.

4.4 Details of the NAP goals

Table 1 presents goals of the NAP, broken down by specific objective, listing the main initiatives, agency responsible, impacts, and monitoring indicators. Further details of these goals will be presented in their implementation plans, which are to be displayed on the MMA website within the first year of the NAP's coming into effect.

Table 1 . Description of the goals of the National Adaptation Plan, broken down by specific objectives

Objective 1. Expansion and dissemination of scientific, technical and traditional knowledge: production, management and dissemination of climate-risk information

Goal 1.1	Initiatives	Responsible
Draw up and implement a strategy to enhance the quality of climatic projections, as inputs for public policies for adaptation.	Drafting of climatic projections for the present and future based on integration of Global Climatic Models (GCMs), with regionalised views on a scale of 20Km X 20Km or of 5Km X 5km, using regional models;	MMA/ MCTI
	Development of the ETA model to incorporate the INLAND and NOAH-MP dynamic vegetation models, with regionalised views on a scale of 5Km X 5Km;	
	Climatic projections to be drafted from integration of the 27 Global Climatic Models, with regionalised views on a scale of 20Km X 20Km, using statistical methods.	
Indicator/Monitoring:	Progress of the development of enhanced climatic projections.	
Impact:	The goal expands scientific knowledge on climatic projections on a regional scale based on use of dynamic and statistical models using different Global Climatic Models (GCMs);	
	Enables definition of the best regionalisation method to be adopted for different sectoral challenges. Improves the quality of climatic projections relating to impact on vegetation cover for each of the Brazilian biomes;	
	Expands scientific knowledge on climatic projections on a regional scale based on a large number of GCMs in view of their computational efficiency, providing a range of products with greater spatial resolution and at low cost for sectoral users.	

Objective 1. Expansion and dissemination of scientific, technical and traditional knowledge: production, management and dissemination of climate-risk information

Goal 1.2	Initiatives	Responsible
Draft a Plan of Action on Technology Needs for Adaptation (TNA)[2].	Conduct mapping and evaluation of Technology Needs for Adaptation (TNA) through partnerships with national key players;	MCTI
	Identify priority sectors and technologies for adaptation;	
	Draw up a roadmap for identified priority technologies. Prepare the Technology Plan of Action on demand for technology transfers with the United Nations.	
Indicator/Monitoring:	Progress in drafting of the TNA plan of action.	
Impact:	Information qualified (climate technologies panorama) made available as inputs for decision making and the efficient application of investments.	

Goal 1.3	Initiatives	Responsible
Development and delivery to society of an online platform for management of knowledge on adaptation.	Develop a platform to share knowledge on adaptation to climate change, with a focus on its impact on Brazilian society and on adaptation measures and initiatives;	MMA
	Delivery of the platform online.	
Indicator/Monitoring:	Progress in development of the platform (%).	
Impact:	Availability of information on an official platform, transparency of actions, exchange of information and experiences among governmental bodies and sectors.	

2 Technology Needs Assessment (TNA) – a set of actions in which countries identify and determine their technology needs (new equipment, techniques, services, skills and competencies) for implementation of mitigation strategies for reducing greenhouse gas emissions, reducing the vulnerability of sectors and livelihoods to climate change. (http://unfccc.int/ttclear/ templates/render_cms_page?TNA_home).

Objective 1. Expansion and dissemination of scientific, technical and traditional knowledge: production, management and dissemination of climate-risk information

Goal 1.4	Initiatives	Responsible
Establish and deploy a strategy to expand and strengthen the Brazilian Research Network on Global Climate Change (*Rede Clima*).	Mapping of new players in the Network;	MCTI
	Induce and support the development of research on the following climate-change related themes: impacts, vulnerability, adaptation and development of technologies for adaptation.	
Indicator/Monitoring:	Progress reports on deployment of the strategy;	
	Publications;	
	Reports on Activities of ***Rede Clima***.	
Impact:	Support for development of tools and generation of knowledge as inputs for climate-change mitigation and adaptation strategies;	
	Expand understanding of interactions among ecological and social systems and of the functioning of the Terrestrial System;	
	Foster generation of inputs for formulation of public policies targeted at mitigation, adaptation and reduction of vulnerability to climate change.	

Goal 1.5	Initiatives	Responsible
Prepare and deploy a data-integration project for monitoring and observation of the impacts of climate change- SISMOI.	Develop an online platform for sharing data on the impact of climate change, with a decentralised and integrated approach, with the aim of identifying, monitoring and understanding the effects of climate change for the priority module.	MCTI
Indicator/Monitoring:	Progress reports on development and implementation of SISMOI.	
Impact:	Foster availability of high-quality data on the effects of climate change, in response to increasing demand from academia and the public and private sectors;	
	Facilitate access to public data;	
	Foster dissemination of information and knowledge relating to impacts of climate change on the various sectors;	
	Foster integration among institutions, public players, productive sectors and society in general;	
	Stimulate national production of knowledge;	
	Expand the capacity to respond to impacts of climate change.	

Objective 2. Coordination and cooperation among public agencies and society

Goal 2.1	Initiatives	Responsible
Draw up and deploy a capacity-building strategy for adaptation for various target publics.	Conduct awareness-building and public mobilization activities;	MMA
	Conduct a capacity-building programme for professionals and active leaders in strategic areas and among more vulnerable groups;	
	Promote the production and dissemination of knowledge on adaptation by strengthening institutions and research groups that work in this field and encourage creation of new research groups;	
	Technical support for states, municipalities and the Federal District;	
	Foster integrated actions among institutions and/or federal bodies.	
	Target public: Public-sector professionals operating at the federal, state and municipal levels, vulnerable communities, education and research professionals and students, communications/media professionals, social-sector leaders and professionals, private-sector entrepreneurs and professionals, the general public.	
Indicator/Monitoring:	Number of training courses provided, number of people trained.	
Impact:	Development of capacities for adaptation, increased mobilization and awareness on the theme;	
	Greater support to effective implementation of public policies for adaptation.	

Goal 2.2	Initiatives	Responsible
Development and deployment of the NAP monitoring and evaluation (M&E) system.	M&E system for adaptation integrated into the monitoring system of the national policy for climate change;	MMA
	Includes goals, activities and indicators foreseen in the NAP and in sectoral strategies;	
	May include the actions for adaptation of federal, state and municipal bodies and of civil society.	
Indicator/Monitoring:	Progress in development and implementation of the system (%).	
Impact:	Updated information on progress and performance of the NAP and its sectoral strategies;	
	Provide transparency for deployment of adaptation policies and enable sharing of information among government bodies and society in general;	
	Inputs for drafting of international reports to be submitted by Brazil to the UNFCCC.	

Objective 2. Coordination and cooperation among public agencies and society

Goal 2.3	Initiatives	Responsible
Publish a study with systematized information on funding and economic incentives for adaptation.	Develop and deliver information on funds and economic incentives for adaptation;	MMA
	Promote debate on climate risk among agencies responsible for regulation of the financial system.	
Indicator/Monitoring:	Progress in development of the study.	
Impact:	Distribution of funding available for adaptation and on-going projects;	
	Systematise resources/incentives available for adaptation and provide functional knowledge and information on access to target publics;	
	Disseminate current knowledge and information on funding for adaptation to climate change in Brazil;	
	Foster demand related to adaptation;	
	Increase Brazil´s capacity to tap funding and improve allocation of resources targeted at adaptation.	

Goal 2.4	Initiatives	Responsible
Drafting of a strategy to promote formulation by federal bodies of public policies for adaptation.	Form an inter-federative working group;	MMA
	Support formulation of an adaptation strategy, with inputs of knowledge, methodologies and training;	
	Prepare the strategy.	
Indicator/Monitoring:	Document prepared;	
	Number of federal bodies engaged;	
Impact:	Increased mobilization and awareness of the theme among federal bodies;	
	Increased capacity of municipalities and states to face up to negative aspects of climate change;	
	Incorporation of climate risk assessment into federal, state and municipal policies.	

Objective 3. Identify and propose measures to promote adaptation to and reduction of climate risk

Sectoral and Thematic Strategy: Agriculture*		
Goal 3.1	**Initiatives**	**Responsible**
Develop and deploy an Agricultural Risk and Vulnerability Monitoring and Simulation System.	Organize information collected from climate and agricultural observation systems;	EMBRAPA
	Enhance methods for modelling and estimation of climate risk;	
	Enhance the monitoring of impact on major production systems;	
	Develop the Agricultural Risk and Vulnerability Monitoring and Simulation System, utilizing and optimizing legacy systems;	
	Regional Vulnerability Analysis (development of indices, medium and long-term vulnerability indicators), climate-risk maps (local, regional and national), classification of the regions of Brazil in terms of climate risk for the main agricultural activities; propose a vulnerability scale; identify priority areas;	
	Identification of adaptation measures for efficient water use, phytosanitary management, integrated with development of methods and crops, with a view to increasing agricultural resilience in priority areas.	
Indicator/ Monitoring:	Number and frequency of analyses undertaken;	
	Number of parameters evaluated;	
	Agricultural Risk and Vulnerability Monitoring and Simulation System deployed;	
	Number of systems and models made available;	
	Percentage of the territory classified by a vulnerability and climate-risk scale.	
Impact:	Ensure appropriate and effective investment of resources for adaptation of agriculture to climate change;	
	Collaborate with national food and nutritional security authorities in facing up to increased frequency of extreme events, improving readiness, adaptive capacity and resilience of farm sector;	
	Assist with the planning of exports.	

* The Centre for Climate Intelligence for Agriculture comprises two components: the Agricultural Risk and Vulnerability Monitoring and Simulation System, and its integration with the Monitoring and Early Warning Networks of the National Plan for Reduction of Risks and Disasters (CEMADEN/MCTI; CENAD/MI).

Objective 3. Identify and propose measures to promote adaptation to and reduction of climate risk

Sectoral and Thematic Strategy: Agriculture

Goal 3.2	Initiatives	Responsible
Establish a Centre for Climatic Intelligence for Agriculture, for application of climate risk analysis in Brazilian Agricultural Policy.	Establish an inter-institutional working group involving the key players (INMET, EMBRAPA, MAPA, MCTI, MDA, MI, MMA, IPEA, IBGE, INPE, and ANA);	MAPA
	Integration of the Agricultural Risk and Vulnerability Monitoring and Simulation System with national monitoring and early-warning networks (CEMADEN and CENAD);	
	Draft a work plan: analyse current and potential scope for generation of information by existing monitoring networks; define technical requirements for the development of platforms and systems to guarantee compatibility with existing platforms; assess current demand for information; define methodologies, design flows and processes, etc;	
	Develop support systems for the inputting of secondary data;	
	Set up a system for spatial and integrated analysis of social, economic, environmental and institutional vulnerabilities;	
	Set up a system for prioritizing vulnerable regions and land-use planning;	
	Create the Climate Intelligence Centre for Agriculture – Communications and Early-Warning Network;	
	Develop Contingency Plans and provide support for Brazilian Agricultural Policy.	
Indicator/ Monitoring:	Versions of the Agricultural Risk and Vulnerability Monitoring and Simulation System harmonised with other early-warning and monitoring networks;	
	Climate Intelligence Centre for Agriculture - Communication and Early-Warning Network consolidated;	
	Number of systems and models made available;	
	Percentage of the territory classified by the vulnerability and climate-risk scale.	
Impact:	Application of climate-risk assessment in planning of actions of Brazilian Agricultural Policy;	
	Establishment of a secure business environment for decision-making of farmers, government and investors;	
	Improve predictability of agricultural insurance planning;	
	Ensure appropriate and effective investment of resources for adaptation of agriculture to climate change;	
	Collaborate with national food and nutritional security authorities to face up to increased frequency of extreme events, and improve readiness, adaptation capacity and resilience of the farm sector;	
	Assist in the planning of exports and agricultural commodity negotiations with futures markets;	
	Support for agricultural zoning policies.	

Objective 3. Identify and propose measures to promote adaptation to and reduction of climate risk

Sectoral and Thematic Strategy: Biodiversity and Ecosystems

Goal 3.3	Initiatives	Responsible
Preparation of Ecosystem-based Adaptation strategy measures in areas at risk of extreme events and other climate change impacts.	Establish a working group;	MMA
	Identify potential areas for implementation of Ecosystem- based Adaptation (EbA) measures;	
	Prepare a strategy in conjunction with governmental bodies, private sector and civil society.	
Indicator/Monitoring:	Percentage of the strategy drawn up;	
	Criteria for implementation of EbA measures in high-risk areas defined.	
Impact:	Strengthen current government policies for recovery and conservation of ecosystems and native vegetation;	
	Support for reduction of disaster risk;	
	Support for reduction of vulnerability to climate change of the general population;	
	Foster identification, promotion and conservation of ecosystem services;	
	Foster increased resilience to climate change of cities and metropolitan regions, especially to impacts of flooding and landslides.	
Goal 3.4	**Initiatives**	**Responsible**
Modelling of the impact of climate change on biodiversity for use in public policies for conservation, recovery and sustainable use of biodiversity.	Identify the impact of climate change on biodiversity;	MMA
	Promote incorporation of climate risk into current policies for conservation, restoration and sustainable use of biodiversity.	
Indicator/Monitoring:	Number of scenarios and maps available in an appropriate format as inputs for public policies on biodiversity;	
	Number of public policies for biodiversity management that incorporate climate modelling;	
	Number of staff of governmental and non-governmental agencies trained.	
Impact:	Foster incorporation of information on climate change into the policies of sectors involved;	
	Integrate information on climate change into the process of drafting actions for biodiversity management, thereby enhancing the effectiveness of such instruments;	
	Increase Brazil´s capacity to face up to the negative aspects of climate change, and particularly impacts that affect biodiversity and provision of ecosystem services, while fostering a climatic standpoint for such policies.	

Objective 3. Identify and propose measures to promote adaptation to and reduction of climate risk

Sectoral and Thematic Strategy: Biodiversity and Ecosystems		
Goal 3.5	**Initiatives**	**Responsible**
Deployment of monitoring in 50 federal Conservation Units, for *in situ* evaluation and monitoring of the impacts of climate change on current and future biodiversity.	Develop and implement an in situ programme for monitoring biodiversity in terrestrial ecosystems in 40 Conservation Units (CUs), covering different biomes, and in 10 CUs located in coastal marine ecosystems, with emphasis on critical ecosystems such as coral reefs and mangroves.	ICMBIO
Indicator/Monitoring:	Number of Conservation Units with monitoring implemented and maintained per year.	
	Number of biodiversity diagnoses in monitored CUs;	
	Number of reports and trend analyses on relationships between biodiversity and climate, including reports on specific formations/ taxons;	
	Early-warning system deployed and number of warning reports issued since its deployment;	
Impact:	Systematic gathering of information on monitoring of endangered species and biodiversity in CUs, as inputs for analysis of the relationship between climate and biodiversity;	
	Enable evaluation of the contribution of CUs to reduction of the effects of climate change;	
	Increased capacity for local response - since monitoring is carried out in a participatory manner, at a local level, involving numerous institutions, thereby enabling adoption of adaptation measures at a local level, with rapid responses;	
	Increased capacity for response on a regional and national scale – since the initiative works in articulation with several others, such as the Brazilian Forestry Service (inventory grid); the Rapeld system; RedeLep, and entails a dataflow, storage and distribution system.	

Objective 3. Identify and propose measures to promote adaptation to and reduction of climate risk

Sectoral and Thematic Strategy: Vulnerable Populations

Goal 3.6	Initiatives	Responsible
Diagnosis of Vulnerability to Climate Change of target populations of the National Territorial and Environmental Management Policy for Indigenous Lands- (PNGATI)	Spatial analysis of climate risk of target populations of the National Territorial and Environmental Management Policy for Indigenous Lands (PNGATI);	FUNAI
	Analysis of the degree of vulnerability of each group using pre-set and agreed-upon indicators;	
	Establish a vulnerability scale for identification of priority groups.	
Indicator/Monitoring:	Progress of on-going activities.	
Impact:	Identification of priority groups for support under governmental programmes.	

Goal 3.7	Initiatives	Responsible
Diagnosis of Vulnerability to Climate Change of target populations of the National Food and Nutritional Security Plan (PLANSAN).	Spatial analysis of climate risk of target populations in Federal Government's Unified Register of Social Programmes (CadUnico), especially Traditional and Specific Population Groups (TSPGs) identified in the register;	MDS/ SESAN/ CAISAN
	Analysis of the degree of vulnerability of each group using pre-set and agreed-upon indicators;	
	Create a vulnerability scale for identification of priority groups.	
Indicator/Monitoring:	Percentage of *CadUnico* population groups classified by vulnerability indicators and the climate-risk scale.	
Impact:	Identification of priority groups for support under governmental programmes.	

Objective 3. Identify and propose measures to promote adaptation to and reduction of climate risk

Sectoral and Thematic Strategy: Vulnerable Populations		
Goal 3.8	**Initiatives**	**Responsible**
Diagnosis prepared and vulnerability to climate change reduced for vulnerable populations and beneficiaries of public policies for agro-extractivism.	Analysis of the degree of vulnerability of peoples and traditional communities residing in the 10 priority territories;	MMA
	Analysis of the degree of vulnerability, by means of establishment of a vulnerability scale for identification of priority groups;	
	Foster application of measures to foster resilience in populations classed as vulnerable.	
Indicator/Monitoring:	Progress of on-going activities;	
	Progress of actions for reducing vulnerability applied to vulnerable populations in the territories listed.	
Impact:	Identification of vulnerable populations for support under public policies for agro-extractivism.	

Sectoral and Thematic Strategy: Water Resources		
Goal 3.9	**Initiatives**	**Responsible**
Incorporate measures for adaptation to climate change into actions carried out by the National Water Agency.	Identify/propose "no regrets" adaptation measures, targeted at enhancing capacity to respond of the National Water Resources Management System and at reducing vulnerabilities of the main water-user sectors, populations and ecosystems to foreseen adverse effects.	ANA
Indicator/Monitoring:	Progress in deployment of water resources management projects and instruments.	
Impact:	Enhanced the capacity of ANA and of other component bodies of the National Water Resources Management System (SINGREH) to respond to challenges posed by climate change	

Objective 3. Identify and propose measures to promote adaptation to and reduction of climate risk

Sectoral and Thematic Strategy: Water Resources

Goal 3.10	Initiatives	Responsible
Develop integrated climatic and hydrological models and assess their impact on water resources management	Use of new modelling techniques with dynamic and statistical methods borrowed from other Global Climatic Model (GCM) families, thereby increasing the number of projections available for analysis of the impact of climate change on water resources;	ANA
	Develop studies using Economics of Climate Adaptation (ECA) methodology, based on the Piracicaba-Capivari-Jundiai River Basin project;	
	Enlist scientific and technological inputs, by means of a specific call for proposals to be drafted jointly with CNPq, targeted at the climate-change/ water-resources interface.	
Indicator/Monitoring:	Progress in the development of projects.	
Impact:	Enhanced capacity of component bodies of SINGREH to respond to challenges posed by climate change.	

Sectoral and Thematic Strategy: Health

Goal 3.11	Initiatives	Responsible
Expand the scope of the National Drinking Water Quality Surveillance Program (VIGIAGUA) to reach 85% of Brazilian municipalities, by 2019.	Enhance the National Drinking Water Quality Surveillance Information System (SISAGUA) incorporating new features and health-risk management reports;	MS (SVS)
	Expand and establish the network of laboratories for monitoring, follow-up and dissemination of information on the quality of drinking water;	
	Record on SISAGUA information on registration, control and surveillance of drinking-water quality;	
	Draw up risk maps on the supply of drinking water, based on the information generated by SISAGUA.	
Indicator/Monitoring:	Percentage of municipalities with information on registration, control and surveillance of drinking-water quality recorded on SISAGUA.	
Impact:	Strengthened surveillance of drinking-water quality;	
	Enhanced information on water supply for human consumption;	
	Reduction of risks to human health related to drink-water supply;	
	Support for attainment of sustainable-development goals relating to access to water of quality compatible with current standards.	

Objective 3. Identify and propose measures to promote adaptation to and reduction of climate risk

Sectoral and Thematic Strategy: Health

Goal 3.12	Initiatives	Responsible
Establish a study, research, monitoring and communication network on climate and health, with a view to expanding technical-scientific knowledge and inputs for health-status analysis and for consolidated decision-making of the Unified Health System (SUS)	Integrate climatic, environmental and socioeconomic risk analysis into SUS procedures for monitoring of public-health emergencies;	MS (SVS/ FIOCRUZ)
	Establish centres for studies and research on climate and health within the SUS;	
	Establish a panel for strategic information on climate and health to support the strategic management in the SUS;	
	Establish a Centre for Integration of Health, Environment and Sustainability Technologies (CITSAS) within the National Climate and Health Observatory and the Knowledge Centre on Public Health and Disasters (CEPEDES).	
Indicator/ Monitoring:	Network established and consolidated;	
	Cooperation agreement drafted and implemented;	
	Network project drafted;	
	CITISAS project drafted;	
	Protocol for monitoring public-health emergencies integrated with analysis of climatic, environmental and socioeconomic risk drafted;	
	Panel for strategic information on climate and health established;	
	Integration Centre for Health, Environment and Sustainability Technologies established.	
Impact:	Enhanced quality of information, management capacity, and disclosure of information on climate risk to human health;	
	Stimulus for production of scientific and technical knowledge on the relationship between climate and health and climate-sensitive diseases, in support of decision-making and definition of adaptive measures, within the SUS.	

Objective 3. Identify and propose measures to promote adaptation to and reduction of climate risk

Sectoral and Thematic Strategy: Coastal Zone		
Goal 3.13	**Initiatives**	**Responsible**
Establish Reference Centres for Coastal Management and build and organise information and tools for climate-risk modelling and generation of qualified responses within the Coastal Zone	Establishment of 4 Reference Centres for Coastal Management;	MMA
	Qualification and provision of instruments and tools for modelling and a knowledge-management platform for adaptation in the Coastal Zone;	
	Capacity-building for government and non-government players on deployment of adaptation activities.	
Indicator/Monitoring:	Number of Centres installed;	
	Number of managers trained;	
	Percentage of the knowledge-management system made available to the public.	
Impact:	Reference Centres established and working on models for analysis of the impacts of climate risks, for generation of qualified responses for public-policy management, and for government, civil-society and private-sector decision-making;	
	Foster coordination and cooperation among public bodies for management of climate risk;	
	Implement monitoring and evaluation of adaptation measures, with a view to continuous improvement of climate-risk management actions;	
	Promote and disseminate knowledge and include a climatic viewpoint into the methodology of the Waterfront Project (Projeto Orla) through enhancement of Ecosystems-based Adaptation actions.	

Objective 3. Identify and propose measures to promote adaptation to and reduction of climate risk

Sectoral and Thematic Strategy: Coastal Zone

Goal 3.14	Initiatives	Responsible
Draft, deploy and earmark funding for a strategy to harmonise continental altimetry with marine bathymetry (AltBat).	Establish a work plan, with methodology, cost-assessment and pilot studies, to harmonize altimetry and bathymetry with measures and guidelines for prevention of the effects of erosion and flooding;	IBGE (CONCAR) e MMA
	Draw up a strategy, with short and medium-term actions, for deployment of a methodology and systems for harmonization of altimetry and bathymetry;	
	Preparation of standards for strategy implementation (structure for governance and budget);	
	Implementation of pilot projects in priority areas.	
Indicator/Monitoring:	Percentage of the work plan completed;	
	Percentage of the strategy presented;	
	Pilot project signed (but not executed);	
	Draft of standards presented.	
Impact:	Qualification of information for studies and projects in port, coastal, oil-producing, navigation and coastal-settlement areas;	
	Enable appraisal of insurance for works and projects in the Coastal Zone, where potential risk is assessed at R$136 billion.	
Goal 3.15	**Initiatives**	**Responsible**
Macro-diagnosis of the Coastal Zone (Macro-ZC) reviewed, considering climate-change related vulnerabilities.	Database for review of the Macro-diagnosis of the Coastal Zone organized from the standpoint of environmental, economic, social and cultural integration;	MMA
	Term of Reference for the review of the Macro-diagnosis of the Coastal Zone drafted and validated by a group of experts (researchers and coastal managers);	
	Macro-ZC review published and distributed; and managers, researchers and civil-society trained.	
Indicator/Monitoring:	Percentage of the work plan completed;	
	Publication drafted and distributed;	
	Number of managers, researchers and civil-society staff trained.	
Impact:	Provision of inputs for Coastal Zone managers at different levels, and guidance for public and sectoral policies and for intervention actions in support of adaptation to climate change.	

4.5 General recommendations for sectoral agencies, federal bodies and society in general

The promotion of adaptation policies throughout Brazil is a complex process, entailing coordinated efforts on the part of stakeholders in various sectors, governmental bodies at the three levels, and a variety of civil-society players. The following table presents general recommendations for sectoral agencies, federal, state and municipal bodies, and society in general.

Table 2. Recommendations for sectoral agencies, federal, state and municipal bodies, and society in general

General Recommendations
Incorporate the principles and guidelines of this Plan into planning and management instruments, so as to engender greater synergies and effectiveness of adaptation initiatives, while taking into account the relevance and characteristics of each segment; Analyse the characteristics, demands and vulnerabilities of different sectors and, when appropriate, draw up management strategies targeted at reducing climate risk;
Integrate climate-risk management into planning and management instruments for drafting and review of public policies, based on technical, scientific and/or traditional knowledge that validates its relevance;
Promote systematic collection and analysis of evidence of vulnerability and of climate risk, while respecting the various institutional competencies, in a manner compatible with current monitoring and evaluation systems and with those proposed in this Plan, to ensure dissemination of information and knowledge through an online platform;
Raise awareness of all players of the importance of the theme “Adaptation to climate change”, by means of information, training, mobilization, engagement, and expansion of participatory processes within society;
Enhance interaction among public authorities, sectoral bodies of the Brazilian economy, academics, civil society and other stakeholders, as a means of fostering continuous development of national adaptation strategies for facing up to the impacts of climate change.

5 Management of the Plan

This chapter presents the proposed management structure of the NAP. It describes the institutional framework of the Plan, involving participation of civil society and of federal, state and municipal bodies; makes considerations regarding funding for its implementation; and provides guidelines for monitoring and management of knowledge on adaptation to climate change.

5.1 Institutional Framework

Drafting of the NAP is foreseen in the PNMC guidelines and therefore in consonance and in synergy with other institutional instruments established by Law 12187/09.

Coordination of the NAP is entrusted to the Technical Group for Adaptation to Climate Change. This group was established for the purpose of providing technical and policy guidance for actions within the scope of the Plan. It is also responsible for monitoring, evaluation and review functions, for detailing routines, and for setting up operational management mechanisms.

In parallel to actions of the coordination group, networking mechanisms are to be established in the states and among civil-society organisations, as described in the following sections.

5.1.1 Federative governance

For purposes of networking among the three levels of government, a standing forum is to be established for consultation with state governments and municipal administrations. The role of this forum is to draft and propose guidelines and technical recommendations. The federative coordination unit is also responsible for harmonization of methodologies for identification of impacts, climate-risk management, vulnerability assessment, adaptation options, and provision of inputs for preparation, implementation, monitoring and review of the NAP.

5.1.2 Governance of civil-society participation

Public participation in the NAP is to be achieved by means of the Brazilian Forum on Climate Change (FBMC), through other more direct means and instruments, and as yet undefined arrangements for civil society representation.

The FBMC was instituted by Decree 3515, of 20th of June 2000, and brought into effect by Decree 6263/07, for the purpose of permanently enabling participation of civil society in government forums on themes relating to climate change.

Enhanced participation of civil society is also provided for by means of regular dialogue among Plan coordination unit and sectoral and thematic councils and forums. The purpose of dialogue with these councils and forums is to broaden public engagement on the theme and promote integration of the adaptation agenda into other sectoral agendas. Themes that may be presented at these councils and forums include: (1) development of the Plan and of its strategies; (2) goals and results achieved; (3) dissemination of reports and studies; and (4) consultations for technical guidance. Other forms of social participation or discussion with civil-society players, including calls for proposals and technical inputs on themes relating to the Plan issued through the Ministry of Environment website, may be deliberated by the Plan coordination unit.

5.2 Funding sources and economic instruments

Actions foreseen in the Plan shall be funded by the various agencies that have thematic or sectoral responsibilities for its execution. Such funding originates from the public budget and from especially constituted funds, in line with government planning under the Multi-year Plan (PPA).

In addition to the Multi-year Plan, the National Adaptation Plan is to provide strategic guidance for application of other fiscal, budgetary and funding instruments, with a view to ensuring implementation and monitoring of initiatives that promote resilience. Foremost among these are funds relating to the National Policy for Climate Change, namely: the Amazon Fund, the Low-Carbon Agriculture Programme (Plano ABC), and the National Climate Change Fund.

Other international funding sources, such as the Green Climate Fund, the Adaptation Fund of the United Nations Framework Convention on Climate Change (UNFCCC), and other multilateral and bilateral funding sources may also be tapped for attainment of goals and guidelines of this Plan.

Funding from other Brazilian financial and fiscal incentives and, when applicable, international sources, may also be made available. Further information on such funding mechanisms can be found on the Ministry of Environment website.

5.3 Monitoring and evaluation of the Plan

The NAP is to have four-year execution cycles, each with its respective review, in accordance with legal guidelines prescribed in the National Plan on Climate Change (Decree 6263/2010). It will also have its own monitoring and evaluation system.

The review process for the following NAP cycle is to be carried out during the final year of the current cycle, in the light of its monitoring and evaluation results, with a possible extraordinary review prior to this deadline.

The objectives of the monitoring and evaluation system of this Plan are: 1) to monitor the scope of proposed goals, 2) to monitor thematic and sectoral adaptation guidelines, and any local actions that may contribute toward climate-risk management in Brazil, as is presented in Volume II; 3) to promote feedback on analyses carried out for fostering continuous improvement of the policy and of its management; and 4) to ensure ample information on adaptation actions.

The monitoring proposal will be presented during the course of the first year of implementation, detailing its content, format and frequency. It will cover monitoring of the NAP, of its activities and processes. This system will be integrated with other information systems, as appropriate, including that of the National Policy for Climate Change.

Monitoring will also be carried out and reports prepared on progress achieved and challenges identified during assimilation of climate-risk management into the policies of state and municipal bodies and of civil society initiatives, by means of strategies as yet to be defined jointly, as appropriate, with these players.

New goals and initiatives may be proposed by the Plan coordination unit. Updated information on monitoring and management of the Plan can be viewed on the Ministry of Environment website.

Plans for attainment of the goals agreed upon, shown in Table 1, shall be drawn up by the agencies responsible during the course of the first year of the NAP and shall contain, in compliance with a proposition of the Plan coordination unit, mechanisms for monitoring and evaluation of such initiatives. It is worth noting that drafting and implementation of plans and deployment of guidelines is optional, and that the decision to prepare them is up to the agencies responsible for sectoral strategies.

5.4 Management of knowledge and information on impacts, vulnerabilities and climate risk

The technical-scientific information necessary for performance of assessments of national vulnerabilities and of climate risk is to be found within the scope of agencies, institutions and research networks pertaining to different Ministries. The following sectoral institutions were identified as official information sources: the National Institute for Space Research (INPE), the National Centre for Monitoring and Early-Warning of Natural Disasters (CEMADEN), the National Centre for Disaster and Risk Management (CENAD), the Geological Survey of Brazil (CPRM), the Ministry of Science, Technology and Innovation (MCTI), the Brazilian Research Network on Global Climate Change (Rede Clima), the Brazilian Panel on Climate Change (PBMC), the National Meteorology Institute (INMET), the National Water Agency (ANA), Brazilian Agricultural Research Corporation (EMBRAPA), the Institute for Applied Economic Research (IPEA), the Brazilian Institute of Geography and Statistics (IBGE), the Ministry of Environment (MMA), among others. The Ministry of Environment website (www.mma.gov.br) provides updated methodological guidelines, tools and information to facilitate adaptation planning.

ANA and INMET, that manage databases on water resources and weather respectively, are responsible for providing ample access to such information, through technical and monitoring reports for the government and the general public.

The Brazilian Geological Survey (CPRM), a public company linked to the Ministry of Mines and Energy, is responsible for generating and disseminating the basic geological and hydrological knowledge necessary for promoting sustainable development in Brazil.

EMBRAPA plays a vital role in the farm sector, actively contributing to the development of essential knowledge and technologies for sustainable production of food, fibres and energy. Not only does it evaluate vulnerability and specific sectoral risks, but also contributes essential knowledge on changes in land use and management of natural resources such as soil, water and biodiversity. This encompasses knowledge, conservation and use of genetic resources, an essential element for analysis and for addressing regional and local vulnerabilities. It has proven effective in promoting adaptive responses to the challenges imposed by climate change on the farm sector, and has contributed toward adaptation initiatives in other sectors. Moreover, EMBRAPA performs an important role in fostering understanding of climate change and of its impacts on local, regional and national scales, as in the case of the project for Simulation of Future Agricultural Scenarios (SCAF) based on regionalised climate-change projections, for example. EMBRAPA also coordinates the Multi-Institutional Platform for Monitoring Reduction of Greenhouse Gas Emissions in Agriculture (ABC Platform) founded through a partnership with members of Rede Clima, which involves public research and teaching institutions in measuring, reporting and verification (MRV) activities. All of this work is being carried out in view of a growing awareness of climatic uncertainties, with the aim of producing information to provide greater certainty for decision making of farmers and public-policy managers.

INPE is responsible for generating updated climatic projections, in accordance with the IPCC's revised greenhouse-gas emission scenarios. It also develops mathematical models for production of other technical-scientific information needed for identification of impacts, vulnerabilities and potential long and short-term adaptation measures, encompassing not only the physical and biological aspects, but also human dimensions. Moreover, through its Earth System Science Centre (CCST) INPE will also contribute toward the drafting and deployment of short and long-term adaptation policies, based on national sustainable-development scenarios, and derived from monitoring of remote-sensing networks, environmental and socio-economic data, and Earth-system modelling.

The MCTI, through its *Rede Clima* is responsible for generating information needed for the conduct of future vulnerability and adaptation analyses relating to strategic sectors susceptible to impacts associated with climate change. The MCTI and INPE are jointly responsible for management and dissemination of such information to sectoral agencies and to the general public. An important source of information on Brazil's vulnerabilities is the National Communication to the UNFCCC, containing a compilation of information on emissions inventories and a climate-change vulnerability assessment.

The role of CENAD is to consolidate information on risks in Brazil, including maps of areas susceptible to landslides and flooding, and data relating to the occurrence of natural and technological disasters and associated damage. Management of this information enables the Centre to provide assistance to states and municipalities in preparing for disasters, with a special focus on more vulnerable communities.

The Brazilian Panel on Climate Change (PBMC) is responsible for drafting of a National Evaluation Report, which provides significant systematized scientific findings for governments and the public. The first report, published in 2013, presented an analysis of national vulnerability, and subsequent reports are due at four-year intervals.

IBGE and IPEA are important national statistical and research agencies and play a significant role in the preparation of social, economic and environmental indicators and in providing information required for integrated diagnosis and analysis of Brazil's vulnerability to climate change.

To facilitate disclosure of and free access to this data, the government is developing a System for Monitoring and Observation of the Climate Change Impacts (SISMOI), under coordination of the MCTI. This purpose of this system is to provide governmental and other stakeholders and parties affected by climate changes with essential information on the vulnerabilities of physical, biological and socioeconomic systems to climate change.

The National Natural-Disaster Monitoring and Early-Warning System, was established by MCTI/CEMADEN to respond to the increase in occurrences of such phenomena in Brazil in recent years. Its purpose is to enhance capacity to reduce the effects of natural disasters and the number of victims and of damage, by means of providing information on imminent risk of natural disasters.

The dynamics of the System are as follows. Data relating to occurrence of natural and man-made disasters and consequent damage, provided by a variety of government agencies, is received by the system. After having been processed and assessed by specialists, this information on the risk of occurrence of disasters is referred to state and municipal-level bodies responsible for Protection and Civil Defence, so that warnings can be issued, depending upon the intensity of the event. This enables better planning of actions for recovery from disaster scenarios while, at the same time, assisting with disaster prevention activities, in the light of better knowledge of areas affected and their vulnerabilities. CENAD and CEMADEN are the bodies most engaged in this process.

There are also a number of international initiatives that contribute toward management of the climatic knowledge in Brazil. Recently Brazil, represented by INPE, joined the Earth System Grid Federation (ESGF) a worldwide data-storage and distribution network whose mission is to provide global access to climate data and information. This initiative will enable access to information on scenario simulations using the latest climatic models, satellite observations, and reanalysis of data to complement other currently available and future information distribution strategies.

Ministério do
Meio Ambiente

GOVERNO FEDERAL
BRASIL
PÁTRIA EDUCADORA

National Adaptation Plan to Climate Change

Sectoral and Thematic Strategies

VOLUME II

Ministry of Enviroment

National Adaptation Plan to Climate Change

Volume II: Sectoral and Thematic Strategies

MMA Order 150 of 10th May 2016

Federative Republic of Brazil
Michel Temer
President

Ministry of Environment
José Sarney Filho
Minister

Executive Secretariat
Marcelo Cruz
Secretary

Secretariat for Climate Change and Environmental Quality
Everton Frask Lucero
Secretary

General Coordination of the Working Group on Adaptation to Climate Change

Director for Licensing and Environmental Assessment (MMA)
José Domingos Gonzale Miguez

General Coordinator for Global Climate Change (MCTI)
Márcio Rojas da Cruz

MMA Technical Team
Adriana Brito da Silva, Jaqueline Leal Madruga, Juliana Faria Nunes, Luiz Gonçalves da Motta, Mariana Egler, Nelcilândia Pereira de Oliveira Kamber, Pedro Christ

MCTI Technical Team
Andrea Araújo, Lidiane Melo, Ricardo Pavan, Sonia Bittencourt

Federal Government Institutions participants of the National Adaptation Plan to Climate Change

ANA	National Water Agency
CAISAN	Inter-ministerial Chamber for Food and Nutritional Security
Casa Civil/PR	Staff of the Presidency of the Republic
Cemaden	National Centre for Monitoring of Natural Disasters
EMBRAPA	Brazilian Agricultural Research Corporation
FBMC	Brazilian Forum on Climate Change
FUNAI	National Indian Foundation
FioCruz	Oswaldo Cruz Foundation
IBAMA	Brazilian Institute for Environment and Natural Renewable Resources
ICMBio	Chico Mendes Institute for Biodiversity Conservation
INPE	National Institute for Space Research
MAPA	Ministry of Agriculture, Livestock and Food Supply
MCTI	Ministry of Science, Technology and Innovation
MI	Ministry of National Integration
MCid	Ministry of Cities
MRE	Ministry of External Relations
MME	Ministry of Mines and Energy
MDA	Ministry of Agrarian Development
MDS	Ministry of Social Development and Combating Hunger
MDIC	Ministry of Development, Industry and Foreign Trade
MMA	Ministry of Environment
MPOG	Ministry of Planning, Budget and Management
MS	Ministry of Health
MT	Ministry of Transport
SFB	Brazilian Forestry Service
CPRM	Geological Survey of Brazil

State, civil-society and private-sector representatives also contributed to the drafting of this plan. See the complete list on the Ministry of Environment website.

Credits of Images: ASCOM/MMA, Paulo Hilst

International Publication Catalogue Data - CIP

B823p Brazil. Ministry of Enviroment.

National Adaptation Plan to Climate Change : volume 2 : sectoral and thematic strategies / Ministry of Environment.--. Brasília : MMA, 2016. 2 v.

295 p., il. (some colour.)

ISBN: 978-85-7738-284-2

1.National Adaptation Plan. 2.Climate risk. 3.Climate change. 4.Sectoral plans. 5.Mitigation and adaptation. I.Title.

CDU: 551.583(083.9)

Ministry of Enviroment
Library

Table of Contents

List of Tables

List of Figures

Introduction

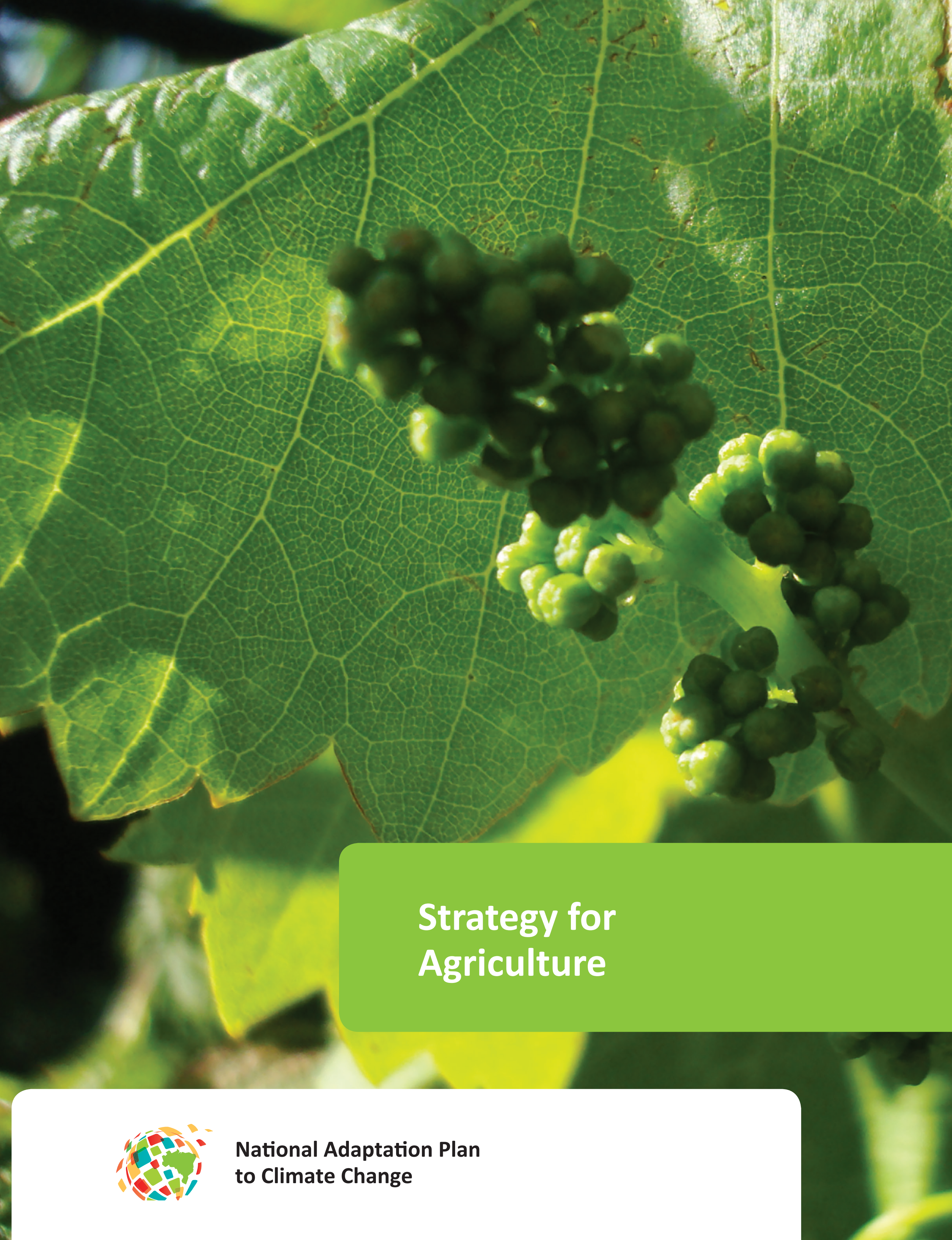
This volume is an integral part of the National Adaptation Plan (NAP). It is divided into 11 strategies for adaptation for sectors and themes considered priorities for national development and potentially vulnerable to climate change, namely: Agriculture, Biodiversity and Ecosystems, Cities, Disaster Risk Management, Industry and Mining, Infrastructure (Electric Power, Transport and Urban Mobility), Vulnerable Communities, Water Resources, Health, Food and Nutritional Security, and Coastal Zones.

The strategies discuss the main vulnerabilities, knowledge gaps, and management of each sector and topic, from a climate-change perspective and present current guidelines for implementation of adaptation measures targeted at increasing climate resilience.

During drafting of these strategies, efforts were concentrated on adoption of a systemic focus, based on the premise that inability of a given sector to fully exercise its normal activities, owing to the impacts of climate change, might directly or indirectly or to a greater or lesser degree, influence the functional stability of other sectors. Likewise, the scope of policies and actions targeted at fostering the adaptive capacity of a given sector may have repercussions on the resilience of others.

For example, deployment of adaptation measures for such sectoral and thematic strategies as recovery and conservation of river basins, rational use and reuse of water, and application of more technologically efficient irrigation systems, brings benefits not only in terms of ensuring future water availability, but also fosters positive outcomes for preservation of biodiversity, food production, urban water supply, industrial operations, etc.

In setting sectoral and thematic strategies of the NAP, the major bottlenecks identified for climate-risk management are: information and knowledge gaps relating to exposure and sensitivity of human, productive and infrastructure systems to climate change; identification and spacing of the potential impacts of climate change on Brazilian national territory; and decentralized dissemination of climate data and information in plainly understandable language. In this respect, initiatives that prioritize knowledge management, targeted at generating new knowledge and technologies, management and access to information are essential for fostering Brazil's sustainable development and economic competitiveness, within a context of climate change.



Strategy for Agriculture

National Adaptation Plan to Climate Change

1 Strategy for Agriculture

This strategy was prepared under coordination of the Ministry of Agriculture Livestock and Food Supply (MAPA) which is the focal point for this sectoral strategy, with participation of the Brazilian Agricultural Research Corporation (EMBRAPA); the National Institute of Meteorology (INMET), the Executive Commission of the Cocoa Farming Plan (CEPLAC), the Ministry of Agrarian Development (MDA) and the Ministry of National Integration (MI). Review and strengthening of the Adaptation Programme for Low-Carbon Agriculture (LCA) Plan[1] (BRAZIL, 2012) to be implemented in the 2016-2017 period, with ample public and private-sector participation and inputs from the productive sector, research institutions and civil society, will reflect the content of this strategy.

1.1 General Objective

The aim of an adaptation programme for the agriculture sector is to foster a secure environment for decision-making on the part of farmers and public-policy managers faced with climatic uncertainties, through efficient access to information, technologies and production processes for the establishment of sustainable production systems.

This Chapter aims to examine vulnerabilities of the agriculture sector to climate change; to provide support for deployment of actions that promote resilience of agro-ecosystems; to foster technology transfers; and to provide inputs for a review of the Low-Carbon Agriculture Plan, in particular its adaptation programme, and for actions to be carried out by 2020.

1.2 Introduction

Brazilian agriculture comprises a great diversity of production systems that play a prominent role in the national economy, both through supply of local markets and maintenance of rural livelihoods, and through contributions toward national wealth. The farm sector accounts for 23% of Brazil's Gross Domestic Product (GDP) or roughly R$ 1.1 trillion and generates 35% of jobs. Some 5 million farms contribute to production of food, fibre and energy for domestic consumption and to meet demand from international markets. Since 2008, Brazil has been the world's third largest overall exporter of agricultural produce and the leading exporter of various products. Farm-sector exports have consistently been the main contributor to Brazil´s positive trade balance (BRAZIL, 2015b) thus underscoring the nation's importance as a supplier of food for the world (FAO, 2012).

1 Available at: <www.agricultura.gov.br>.

Farming, as an economic activity, is influenced by environmental factors and highly dependent upon weather conditions (MOORHEAD, 2009). The climate is variability should be considered the main risk factor for agriculture. It has been estimated that roughly 80% of the variability in agricultural yields stems from seasonal and inter-annual climate variability, whereas the remaining 20% is associated with economic, policy, infrastructure and social issues (BRAZIL, 2015; NAKAI *et al*., 2015)

Agricultural activities are subject, directly and indirectly, to weather conditions: temperature, sunlight, rainfall, air humidity, wind speed, and to the availability of water in the soil. Oscillations in such weather variables affect the growth, development, yields and quality of agricultural crops and livestock, in addition to their effects on other components of agro-ecosystems, such as insects and other pollinators or predators, microorganisms, aquifers, etc. (GHINI, *et al*., 2011; HOFFMANN, 2011).

Aside from direct impacts on crop yields and farm animals, changes in climate patterns also impact the vectors of some diseases and insect pests and of pollinators, and may contribute toward the spread of weeds that undermine production (GHINI, *et al*., 2011; HOFFMANN, 2011). There are studies[2] underway to assess the entry of certain diseases not currently present in Brazil, but which could pose threats to Brazilian agricultural production.

2 Available at: <www.macroprograma1.cnptia.embrapa.br/climapest>

Variability within climate patterns is an intrinsic factor in the planning of food production. However, climate projections for Brazil, considering possible scenarios projected in international reviews (IPCC, 2014) raise concern as to the prospect of a rise in average temperatures and of reduced rainfall (MARQUES *et al*., 2013).

Studies show that the frequency of days with extreme (high or low) temperatures, and a lower day-night temperature gradient will have major consequences for plant metabolism and animal well-being, with major impacts on production capacity (HOFFMANN, 2011; BRAZIL, 2015). Moreover, projections point to seasonal changes in rainfall distribution, with a greater concentration of high-intensity rains in the short run, replacing a more diverse spatial distribution of rains during production seasons (HOFFMANN, 2011). Such phenomena are likely to negatively impact production systems given that, in Brazil, only 5% of the area under cultivation is irrigated (BRASIL, 2015; NAKAI *et al*., 2015). In other words, 95% of the area under cultivation is subject to natural rainfall variations, both in terms of quantity and of seasonal distribution. Such changes in rainfall patterns are likely to exacerbate negative impacts, either by increased potential runoff erosion, or reduced rainfall during critical periods of the production cycle.

Climate change in Brazil poses increased agro-climate risks, stemming from reduced availability and increases in the consumption of water for agricultural crops (owing to higher temperatures). Some studies point towards a decline in areas of low climate risk for all crops (BRAZIL, 2015). It has been estimated that such a decline may vary from 3% to 40%, depending upon the crop and climate scenario considered. Such a decline in average water availability will lead, among other impacts, to lower yields.

The economic impacts of reduced agricultural production capacity are of grave concern. Estimated losses for the Brazilian farm sector caused by higher temperatures may amount to as much as R$ 7.4 billion by 2020, and these could leap to R$ 14 billion by 2070, thus deeply altering the geography of Brazilian agricultural production (DECONTO, 2008; ASSAD *et al*., 2013). In view of the importance of the farm sector for the national economy, the social impacts of such losses. Family farming, an important segment of domestic food production, plays a major role in generating income and quality of life for thousands of rural families. According to the latest agricultural census (IBGE, 2006) family agriculture accounts for 48% of national gross production value. This highly diversified segment has been identified as being particularly vulnerable to climate change.

The inability to produce on the part of certain agricultural systems may have negative impacts on local and regional lifestyles and economies; compromise food and nutritional security; generate social insecurity; and lead to other problems. Losses of agricultural production capacity are also likely to cause higher prices for some products, especially basic foodstuffs, such as rice, beans, meat and by-products (DECONTO, 2008; ASSAD *et al*., 2013). If, on the one hand, the decline in agricultural yields can be offset by a fall in agricultural production costs, it is nonetheless likely to have a negative impact on the population's capacity to consume such basic products, not to mention on the general behaviour of the Brazilian economy, including higher inflation rates (HOFFMANN, 2011; BEDDINGTON *et al*., 2012; IGNACIUK & MASON-D' CROZ, 2014; MARQUES *et al*., 2013).

Changing climate patterns may have an accentuated negative impact on future potential agricultural production, when compared with current production conditions. There is a growing concern as to the nation's capacity to supply food to meet burgeoning domestic demand and that of international markets (MOORHEAD, 2009; FORESIGHT, 2011; HOFFMANN, 2011). Historically, agriculture has demonstrated an intrinsic capacity to adapt (MOORHEAD, 2009). Development and adoption of technological innovations in Brazil has kept pace with socio-environmental change. Substantial investment in agricultural research has enabled Brazil to assume a position of prominence in worldwide food production. Such research and technological-innovation capacities must now respond to the challenge of developing alternatives that will enable agro-ecosystems to adapt to new climatic conditions (MOORHEAD, 2009; BEILIN, SYSAK & HILL, 2012).

Notwithstanding the flexibility of agricultural systems and the supply of technological information, there remains the challenge of facilitating access to information and adoption of currently-available technologies, processes and systems, in forms that enable attainment and maintenance of expected outcomes (MOORHEAD, 2009). There is a need to strengthen public policies that offer the productive sector instruments that enable adjustment of production systems, making it possible for them to maintain production capacity and adjust to climate-change patterns (MOORHEAD, 2009; BEDDINGTON *et al*., 2012; BEILIN, SYSAK & HILL, 2012; IGNACIUK & MASON-D' CROZ, 2014; MARQUES *et al*., 2013). Such instruments need to focus not only on motivating farmers but, above all, on fostering a secure environment capable of accommodating the necessary adjustments and enabling maintenance of sustainable and resilient agricultural production systems.

To promote national development, food security, adaptation to and attenuation of climate change while, at the same time, seeking to attain their commercial goals in coming decades, Brazilian farmers will need significantly to increase yields in areas devoted to food-production and livestock systems. Concurrently, the farm sector has responsibilities toward reducing its greenhouse-gas emissions and deforestation pressures, while restoring millions of hectares of degraded pasture land and protecting areas under environmental preservation.

1.3 Institutional and legal framework

A variety of regulatory policies and instruments apply to the management of climate variability and its effects on the farm sector. Moreover, intense research is underway with the aim of providing alternative technologies, processes and technical arrangements targeted toward environmental adaptation and sustainability.

Among the highlights is the Low-Carbon Agriculture (ABC) Plan[3], one of the sectoral plans that comprise the National Plan for Climate Change (PNMC). Launched in 2011, the ABC Plan features instruments, such as an exclusive line of credit for fostering activities targeted at increasing the area under sustainable agricultural production and thereby enabling a reduction of greenhouse-gas emissions by the agriculture sector. In addition to its commitment toward reducing greenhouse-gas emissions (GHGs) the Plan aims to encourage, motivate and support the farm sector in deploying actions to foster adaptation, where necessary, by mapping sensitive areas, increasing the resilience of the agro-ecosystems, development and transfer of technologies (especially those with proven potential for reducing GHGs) and adaptation to the impacts of climate change.

In addition to the ABC Plan, there are a number of public policies and instruments that currently address climatic uncertainties and their influence on the farm sector, many of which are already contributing toward its adaptive capacity.

[3] Available at: <www.agricultura.gov.br>.

These instruments need to be reviewed in the light of the most recent information on climate change, through discussion of their timeliness and relevance, in line with the contextualization of specific goals. Below are some highlights:

Agricultural Climate-Risk Zoning - an agricultural-policy and risk-management instrument, whereby studies that seek to mitigate climate risks are periodically updated. Information thus made available enables targeting of decisions as to the most suitable strains for planting in each region and the best time for planting, taking into account prevailing soil conditions in each region and the capacity for crop cycling. Zoning is based upon quantification of climate risks that may cause production losses, thereby assigning low and high-risk areas and their respective sowing calendars. Such information is made available for each crop year, by municipality and by crop. Adaptation of the agricultural calendar to climatic conditions enables a lowering of loss risks in the field. As of the 2015/2016 harvest, it will be possible to access the Agricultural Zoning System for Agro-climatic Risk[4] (SISZARC) to obtain updated agricultural zoning[5] information.

The Agricultural Activity Guarantee Programme (PROAGRO)[6]- instituted by Law 5969/1973 and implemented by Agricultural Law 8171/1991, both brought into effect by Decree 175/1991, and Family Agricultural Activity Guarantee Programme (PROAGRO-Mais), instituted by Law 12058/2009, are targeted at ensuring financing and the payment capacity of farmers, in face of commodity-market price oscillations. Harvest Guarantees, including a specific modality of Agricultural Insurance targeted at Family Farming, comprise a productive-sector strategy that provides guarantees for farmers faced with harvest failure caused by climate events. For example, it offers special terms for family farmers in the semiarid Northeast region that historically has suffered crop failures owing to drought or excessive rainfall. Farmers that lose over 50% of their harvests are eligible to receive financial compensation.

Family Farming Insurance (SEAF)[7] - established within the scope of a programme known as PROAGRO-Mais, is designed to defray operational costs for family farmers and is linked to the National Programme to Strengthen Family Farming (PRONAF). SEAF was launched by the Federal Government to provide greater tranquillity for farmers in tending to their crops, in response to demands for insurance offering income guarantees. SEAF has undergone modifications targeted at attending to real needs of family farmers with regard to production security, encompassing sustainable production systems, such as agro-ecology, organic crops, agro-forestry systems, among others.

The Insurance Premium Subsidy Program (PSR)[8] - aims to facilitate access to Rural Insurance, as does the Catastrophe Fund,

[4] Available at: <http://www.agricultura.gov.br/servicos-esistemas/ sistemas/Siszarc)>.

[5] Available at: <http://www.agricultura.gov.br/politica-agricola/zoneamento-agricola>.

[6] Available at: <http://www.agricultura.gov.br/politica-agricola/zoneamento-agricola/proagro>.

[7] Available at: <http://www.mda.gov.br/sitemda/secretaria/safseaf/sobre-o-programa>.

[8] Available at: <http://www.agricultura.gov.br/politica-agricola/seguro-rural>.

launched on 26th August 2010 by Enabling Law (LC) 137, that has not yet been brought into effect.

Aside from these initiatives that feature specific approaches to climatic issues, certain other policies merit consideration for their contribution toward fostering sustainable rural development. In seeking to promote sustainability, various current initiatives are targeted at strengthening resilience to climate change of agricultural production systems of different types, by means of conservation agriculture through enhancing the natural environment (particularly soils, water and biodiversity), ecosystem services and best practices for farming and conservation. The aim of the National Policy for Agro-ecology and Organic Production and its respective Plan (PLANAPO) instituted by Decree 7794/2012, is to "coordinate and implement programmes and actions that foster transition to agro-ecology, organic farming and agro-ecological production as a contribution toward sustainable development, offering the population better quality of life through supply and consumption of healthy foods and sustainable use of natural resources".

The Law for Protection of Native Vegetation (Law 12651/2012) also provides policy guidelines for structuring sustainable agricultural production systems. It sets general rules for protection of vegetation and for Areas of Permanent Preservation (APPs) and Legal Reserve (RL); commercial forestry and provision of forestry raw materials, traceability of forestry products, control and prevention of forest fires, and economic and financial instruments are its objectives. Foremost among these instruments is the Environmental Regularization Programme (PRA) established by Decree 8235/2014, which sets procedures for regularization of APPs, RLs and Restricted Use (UR) areas, entailing processes of recovery, restoration, regeneration or compensation. It also orients rural landowners and freeholders on how to bring their properties into compliance with the PRA, beginning with registration on the Rural Environmental Register (CAR). Other related actions are foreseen in the National Policy for Integration of Farming Livestock and Forestry (ILPF) (Law 12805/2013) and the Agricultural Policy for Planted Forests (Decree 8375/2014).

The National Water Resources Policy (PNRH) and the National Water-Resources Management System (SINGREH) (Law 9433/1997) provide for decentralized and participatory multiple-use of water by Public Authorities, users and communities. They also aim to reduce climate risks inherent to agricultural activities, especially in regions susceptible to low or irregular rainfall distribution. Foremost among the management instruments provided for in the PNRH are Water Resources Plans, licencing of rights to use of water resources, and the National Water Resources Information System (SNIRH).

The National Irrigation Policy (Law 12787/2013) aims to encourage sustainable expansion of the area under irrigation in Brazil, to increase agricultural yields and, consequently, improve the competitiveness of Brazilian agribusiness while, at the same time, reducing pressures to bring new areas under cultivation. The law also characterizes the building of dams and dykes for irrigation as being of public utility. Among the basic premises of the policy is integration of sectoral policies for water-resources, agriculture, environment, electric-power, environmental sanitation, rural credit and insurance and their respective plans, with priority for projects that promote efficiency and multiple use of water resources. This includes the National Irrigated Agriculture Information System and the National Programme to Combat Desertification (PAN-Brasil) which identifies areas susceptible to desertification and establishes priorities for public and private actions.

In the light of average annual rainfall figures for most of Brazil's regions, incentives for water production and storage could ensure sufficient water supplies for human and livestock consumption, electric-power generation and for a significant increase in areas under irrigation throughout the country. Even in situations entailing the building of dams, when no other technical solution or alternative location is available, irrigated agriculture constitutes an economic, environmental and socially sustainable activity and is thus considered to be of public utility and social interest. The water crisis that has afflicted Brazil, and particularly its Central-West and Southeast regions in recent years, has been partially attenuated by a network of small reservoirs which, though insufficient to ensure minimum needs, have made it possible for various municipalities to reserve quantities for human water supply and livestock consumption. This includes reservoirs built for private irrigation projects which, nonetheless, have served as sources of public water-supply for communities in the direst situations. Reservoirs that supply public irrigation projects in the Northeast region often provide water supply for human and animal consumption in situations of water scarcity. Upon coming into effect, the Law for Protection of Native Vegetation ushers in a massive process of restoration of APPs and reforestation of riverbanks, with the aim of preventing silting of water bodies and improving drainage in river basins. A review of the legislation covering construction of small and medium-size dams and measures to cut through the bureaucracy for obtaining water-storage, water production, and water use rights is needed. In view of the importance of these measures, a partnership among farmers and federal, state and municipal authorities is needed to promote actions designed to induce water production in rural areas, by means of a sustainable policy for water management, production and storage.

The Agricultural Decision-Making Support System (Sisdagro[9] /INMET); the Simulation of Future Agricultural Scenarios (SCenAgri/EMBRAPA); and the Brazilian Agriculture Observation and Monitoring

[9] Available at: <http://sisdagro.inmet.gov.br:8080/sisdagro/app/index>.

System (SOMABRASIL[10] /EMBRAPA) are the main information and planning instruments used for these purposes and all take into account growing sensitivity to climate uncertainty, while seeking to furnish information to enable better decision making on the part of farmers and public-policy managers.

1.4 Qualitative vulnerability analysis

Agricultural systems, in view of their total dependence upon climate, are constantly developing strategies to meet challenges and minimize the impacts of climate variability. There are, consequently, a number of instruments available for assessment of the sensitivity of production systems to the vicissitudes of climate variation. Such instruments have been recalibrated to assess new potential scenarios and to orient research, policies and other instruments for fostering the sustainability and competitiveness of the farm sector.

The Agricultural Zoning Model for Climatic Risk and Vulnerability is a Brazilian public-policy instrument, launched in 1996, whereby each Brazilian municipality is assessed according to the probability of its achieving no less than 80% of an economically viable harvest.

Another important system is the Simulation of Agricultural Scenarios (SCenAgri) developed by EMBRAPA, which brings together information on climate, soils, water and the characteristics/needs of crops, based on field data collected throughout Brazil. The Agricultural Decision-making Support System (Sisdagro/INMET) provides farm-sector users with support for agricultural planning and management decision making. This system provides users with weather information gathered at the INMET weather-station network and data obtained from numeric weather-forecast models on such variables as: temperature, rainfall, relative humidity, wind speed and direction, and sunlight. This model is still under development and, in its second phase, is expected to incorporate climatology-based tools to enable functions such as analysis of the most favourable dates for planting. Another feature that the system will offer is predictions as to future development of harvests, based upon seasonal weather behaviour forecasts.

Notwithstanding the solidity of these systems, each instrument needs to be assessed and, if necessary, strengthened to operate in a context of climate uncertainty (VERMEULEN *et al.*, 2013). The number of crops analysed needs to be expanded, the impacts assessed in greater detail and, above all, evaluations need to consider close interdependence among productive elements. An evaluation of the negative impacts of climate changes on these systems is needed, as is also identification of the characteristics that imbue such systems with resilience.

The entire agricultural system depends upon and is exposed to vicissitudes of climate and of climate change. All elements of the system are susceptible

[10] Available at: <http://mapas.cnpm.embrapa.br/somabrasil/webgis.html>

to climate variability and are highly sensitive to climate change. It is therefore essential that adaptive capacity of the sector be reinforced, thereby enabling the productive sector to make better decisions for structuring production systems, making them sufficiently resilient to the effects of climate uncertainties. The proposed adaptation programme for the agricultural sector is focused primarily on reinforcing its adaptive capacity, through promoting of instruments, technologies and processes that enable farmers and other stakeholders to proceed with their activities with the necessary security.

1.5 Guidelines

The consequences of climate change on rainfall distribution, temperature and other factors that influence crop cycles may result in smaller harvests and lower quality products. Aside from causing great losses for farmers, these changes may jeopardise food security and the very presence of farmers on the land. Adaptation needs to be a component of public policies for facing up to climate change, strategies for which entail investing in greater agricultural efficiency, in promoting diversified systems and in the sustainable use of biodiversity, land, and water resources, in support of a process of transition, reorganization of production, guarantees of income generation, research (into genetic resources and cross-breeding, water resources, adaptation of production systems, identification of vulnerabilities and modelling) among other initiatives.

Thus, the Agriculture Adaptation Programme must aim to create a safe environment for decision-making on the part of farmers and public-policy managers, in response to the challenges of climate uncertainty, through efficient access to information, technologies and production methods so as to establish sustainable production systems in face of possible adverse scenarios for Brazilian agriculture over the coming decades. This programme, based upon the premises presented in this Strategy, needs to be assembled in a participatory manner, between 2016 and 2017, with the involvement of experts and representatives of civil society, within the context of a review of the ABC Plan (BRAZIL, 2012).

To guide construction and management of the Agriculture Adaptation Programme, the following **guidelines** shall be considered:

1. The Agriculture Adaptation Programme is to be coordinated by government ministries with the appropriate technical sectoral competence, and its implementation shall entail shared responsibility with other ministries and institutions related to the sector.

2. The Agriculture Adaptation Programme is an integral component of actions for responding to the challenge of climate change on the part of the farm sector, and is to take the form of coordinated and synergistic action for mitigation of concerns about GHGs targeted at jointly increasing sustainability of the sector, within the Sectoral Plan currently in place under the PNMC the ABC Plan

3. Adaptation measures shall attend to the needs of crops in face of the various possible changes in climate structure, including rising temperatures and higher thermal gradients, water intensity and distribution, etc. The first premise is that the sustainability of agricultural systems (in the broadest sense, encompassing agricultural crops, livestock and forestry, as well as various types of integrated systems) must be achieved and guaranteed through intensive application of knowledge for improvement of processes.

4. It is acknowledged that development of an adaptation strategy needs to be based upon the best available information sets and that its effectiveness depends upon how its implementation is structured and its continuity over time ensured, through constant review and improvement, with structured investments in science and technology.

5. The focus of actions for agriculture are initiatives and instruments that enable and motivate farmers to structure and maintain sustainable production systems, on a variety of scales, using various types of technology, labour and marketing arrangements. Aside from development of suitable technologies, two main actions shall be pursued: establishment of an Agricultural Climate Intelligence Centre, and development of the Monitoring and Agricultural Risk and Vulnerability Simulation System, based upon currently existing and deployed instruments.

6. Geographic Area of Implementation: National – agriculture is the most basic and central activity throughout Brazil, and is susceptible to changes in climate patterns. The Programme must thus entail discussion of structural and crosscutting actions at the federal level, while also establishing local action strategies.

7. Regional Strategy: specification of regional goals shall be based on mapping of vulnerabilities, opportunities and/or investments, and on the social profile of each region, with acknowledged priority for actions targeted at family farming. As with deployment of the ABC Plan, the specificities of each region and state need to be developed through construction and subsequent review of state-level LCA Plans, under the responsibility of State Management Groups, currently active in all states and municipalities, for purposes of local implementation and management of the ABC Plan.

8. Assimilation of risk management into sectoral policies: these already address issues relating to climate risk, which is considered an intrinsic factor for the agricultural sector. Assessment of such policies, in a context of climate change, needs to take place within the context of a more detailed discussion of the Agriculture Adaptation Programme, with a view to appraising its relevance, possible gaps and antagonisms, and strategies for strengthening its effectiveness.

A number of challenges must be met before these guidelines and the drafting and deployment of the Adaptation Programme for the Agricultural Sector can effectively be brought into effect. Some of these challenges stem not from issues of programme governance nor do they relate to the ministries responsible for implementation but, rather, demand a deeper understanding of the new agricultural production paradigm, induced by the threat of climate change and not as yet assimilated by the institutions concerned.

It is therefore important that consideration and debate should focus on selecting the best strategies for meeting the following challenges:

a. Prepare technicians and farmers to adopt systems and technologies that contribute toward adaptation to climate change;

b. Stimulate compliance of technicians and farmers, by showing the advantages of participating in the transition process for diversification of production systems and of adopting technologies which enable greater resilience and adoption and use of renewable-energy sources, from an economic, social and environmental standpoint;

c. Reduce the risks and minimize the impacts of climate change on agriculture by means of the National Plan for Reduction of Risks and Disasters, considering possibilities for contracting agricultural insurance and other agricultural-policy instruments;

d. Provide training and enhance skills, in the short and medium-term, with a focus on climate change and sustainability in agriculture;

e. Strengthen technical-assistance and rural-extension activities, with a view to preparing the productive sector for the effects of climate change, and provide guidance for adoption of adaptation measures that, preferably, also target mitigation of GHGs;

f. Strengthen actions for containment, reduction and prevention of desertification and dune formation, with a view to minimizing impacts and recovering the productive capacity of afflicted areas, by applying principles of soil conservation, sustainable management and use of water;

g. Develop and modify farming technologies so as to enable adaptation, ensuring that they are available to farmers;

h. Promote and develop diversified production systems, with a focus on increasing the resilience and efficiency of farming systems and the need to adapt to climate changes identified on vulnerability maps, with a view to fostering environmental sustainability, including control of GHGs (through synergistic adaptation and mitigation actions), income generation, and improved living standards;

i. Create production mosaics, based on integrated crop-livestock-forestry systems, in areas of production, forests, native vegetation and ecological corridors, resulting in an increase of regional resilience and in the use and conservation of natural resources (biodiversity, water, soil) in compliance with current legislation;

j. Establish and adapt procedures of financial agents to ensure they operate with modalities that incorporate adaptation/mitigation actions, including funding of diversified systems, sustainable use of biodiversity and of water resources, and sustainable energy generation and rational use;

k. Develop and make available technologies, by means of RD&I programmes that encompass integrated management of natural resources (biodiversity, water and soil), genetic resources, biological safety, renewable energy, and development of agricultural inputs and pesticides that do not degrade the environment, etc.;

l. Ensure access to federal, state and municipal agriculture-related climate information sources.

1.5.1. Development of the Agriculture Adaptation Programme

To achieve national development, food security, adaptation and attenuation of climate change, as well as its commercial goals over coming decades, Brazil must significantly increase food and grazing-crop yields while efficiently managing inputs and natural resources. Production increases must be achieved through improvements in sustainable production methods and higher yields while, at the same time, reducing deforestation, restoring millions of hectares of degraded pastureland and adapting to climate change.

Adaptation measures must incorporate advances in adoption of new agricultural production models and paradigms. Possible adaptation approaches include: a focus on decentralised production, solutions that better address local needs, diversification of local sources of food supply and greater attention to nutritional quality, genetic improvement to develop drought-resistant varieties, transition to more integrated production systems, expansion of access to efficient irrigation technologies, and management tools for conservation of natural resources.

Application of new agricultural management practices can contribute toward overcoming problems caused by extreme weather, for example, frosts that damage coffee plantations, or adoption of drought-tolerant varieties of non-irrigated crops. The development of new agricultural technologies, in addition to reducing GHGs, can result in higher yields.

Initially, the Agriculture Adaptation Programme will concentrate on actions already underway to assess their impact. The ABC Plan and its Adaptation Programme will undergo review during the course of the 2016/2017 growing season. This review, under coordination of the Ministries of Agriculture, Livestock and Food Supply (MAPA) and of Agrarian Development (MDA) through the National Executive Committee of the ABC Plan (BRAZIL, 2012) and with extensive public participation, will give continuity to the procedure used in drafting of the ABC Plan, with inclusion of more detailed assessments, definition of priorities, setting of more specific goals, targets, timeframes and distribution of roles.

This review of the Adaptation Programme shall take into account recently concluded surveys, weather-projection variables relating to agricultural production, and available information on vulnerability of the sector to projected climate forecasts. The starting point for this review and new proposal will be the content of the current ABC Plan (BRASIL, 2012) that will thenceforth incorporate new elements and priorities stemming from plenary discussions. The aim of these efforts is to generate, manage and disseminate basic environmental information and to facilitate access to the technological information necessary for expanding the array of alternatives and processes in support of farmers. The review is expected to last about one year, beginning in 2016, involving evaluation of actions in progress and subsequent discussion and proposal for actions targeted at strengthening new lines of action, and is due to be completed by early 2017.

The starting point of the work is the ABC Plan monitoring system and, in particular, the Multi-institutional Platform for Monitoring Agricultural Greenhouse-Gas Emissions (ABC Platform) established through a partnership between EMBRAPA and members of *Rede Clima*. It involves public research and teaching institutions engaged in the monitoring, reporting and verification (MRV) of mitigation and adaptation activities, including analysis of satellite images, as proposed under the ABC Plan (BRAZIL, 2012).

Actions from different sectors should be considered to enable the agricultural sector to climate change adaptation. Review of the Plan and efforts to strengthen its Adaptation Programme must focus on priorities to be pursued by 2020 under the next phase of the ABC Plan, when another evaluation of work fronts will be carried out. Structural and crosscutting approaches imbue the adaptation process with greater impact and merit priority, in view of the sensitivity of farming to weather conditions.

Two central features of the adaptation programme relate to the goals set for the farm sector, listed as NAP goals and reported in Volume I:

1. Establishment of the Climate Intelligence Centre for Agriculture that focuses on assessment of climate risk in the planning and development of Brazilian Agricultural Policies; and

2. Development and implementation of the Agricultural Risk and Vulnerability Monitoring and Simulation System.

These features have crosscutting effects in several areas and enable mapping of needs and setting of priorities for a diverse array of adaptive measures, thereby adding to the effectiveness of the Adaptation Programme. Both these features are under direct responsibility and governance of MAPA and EMBRAPA, respectively.

The following table shows goals and initiatives of the strategy for agriculture, as presented in Volume I of this NAP:

Objective 3. Identify and propose measures to promote adaptation and reduction of climate risk

Sectoral and Thematic Strategy: Agriculture

Goal 3.1	Initiatives	Responsible
Develop and deploy an Agricultural Risk and Vulnerability Monitoring and Simulation System.	Organize information collected from climate and agricultural observation systems.	EMBRAPA
	Enhance methods for modelling and estimation of climate risk.	
	Enhance the monitoring of impact on major production systems.	
	Develop the Agricultural Risk and Vulnerability Monitoring and Simulation System, utilizing and optimizing legacy systems.	
	Regional Vulnerability Analysis (development of indices, medium and long-term vulnerability indicators), climate-risk maps (local, regional and national), classification of the regions of Brazil in terms of climate risk for the main agricultural activities; propose a vulnerability scale; identify priority areas.	
	Identification of adaptation measures for efficient water use, phytosanitary management, integrated with development of methods and crops, with a view to increasing agricultural resilience in priority areas.	
Indicator/Monitoring:	Number and frequency of analyses undertaken.	
	Number of parameters evaluated.	
	Agricultural Risk and Vulnerability Monitoring and Simulation System deployed.	
	Number of systems and models made available.	
	Percentage of the territory classified by a vulnerability and climate-risk scale.	
Impact:	Ensure appropriate and effective investment of resources for adaptation of agriculture to climate change.	
	Collaborate with national food and nutritional security authorities in facing up to increased frequency of extreme events, improving readiness, adaptive capacity and resilience of farm sector.	
	Assist with the planning of exports.	

Sectoral and Thematic Strategy: Agriculture

Objective 3. Identify and propose measures to promote adaptation and reduction of climate risk

Goal 3.2	Initiatives	Responsible
Establish a Centre for Climatic Intelligence for Agriculture, for application of climate risk analysis in Brazilian Agricultural Policy.	Establish an inter-institutional working group involving the key players (INMET, EMBRAPA, MAPA, MCTI, MDA, MI, MMA, IPEA, IBGE, INPE, and ANA).	MAPA
	Integration of the Agricultural Risk and Vulnerability Monitoring and Simulation System with national monitoring and early-warning networks (CEMADEN and CENAD).	
	Draft a work plan: analyse current and potential scope for generation of information by existing monitoring networks; define technical requirements for the development of platforms and systems to guarantee compatibility with existing platforms; assess current demand for information; define methodologies, design flows and processes, etc.	
	Develop support systems for the inputting of secondary data.	
	Set up a system for spatial and integrated analysis of social, economic, environmental and institutional vulnerabilities.	
	Set up a system for prioritizing vulnerable regions and land-use planning.	
	Create the Climate Intelligence Centre for Agriculture – Communications and Early-Warning Network.	
	Develop Contingency Plans and provide support for Brazilian Agricultural Policy.	
Indicator / Monitoring:	Versions of the Agricultural Risk and Vulnerability Monitoring and Simulation System harmonised with other early-warning and monitoring networks.	
	Climate Intelligence Centre for Agriculture- Communication and Early-Warning Network consolidated.	
	Number of systems and models made available.	
	Percentage of the territory classified by the vulnerability and climate-risk scale.	
Impact:	Application of climate-risk assessment in planning of actions of Brazilian Agricultural Policy.	
	Establishment of a secure business environment for decision-making of farmers, government and investors.	
	Improve predictability of agricultural insurance planning.	
	Ensure appropriate and effective investment of resources for adaptation of agriculture to climate change.	
	Collaborate with national food and nutritional security authorities to face up to increased frequency of extreme events, and improve readiness, adaptation capacity and resilience of the farm sector.	
	Assist in the planning of exports and agricultural commodity negotiations with futures markets.	
	Support for agricultural zoning policies.	

1.6 Adaptation measures for the farm sector

The following Table presents adaptation measures proposed in the ABC Plan (BRAZIL, 2012) including actions already underway and some additional themes. There are seven major areas of activity that involve information systems targeted toward different publics (researchers, public-policy managers and the productive sector), land-use monitoring information, research in various fields, financial instruments, mechanisms for rural development and public policies for strengthening the sector in the context of climate change. The measures proposed are quite general and should be discussed, detailed and prioritized and responsibilities defined, by region and production system, in terms of phasing and execution timeframes, during review of the Agriculture Adaptation Programme.

Table 1. Adaptation measures proposed for drafting of the Adaptation Programme for Agriculture

Intensified acquisition and use of information
Establish basic environmental information systems, based upon currently used technologies and new technological options so as to promote resilience and adaptation to the negative impacts of climate change. Such systems should entail intensified acquisition and use of information, with actions related to networks, systems, platforms and other forms of data and information gathering for analysis and the developments proposed in other topics (i.e., biophysical components of the agro-ecosystem, water resources, and regional skills, among others). Moreover, systems are necessary for providing outcomes in terms of knowledge advancement and scientific and technological development for enhancement of production systems, using a broad concept of information management and universalization of access to developed or adapted knowledge.
Land use, zoning of risks and identification of vulnerabilities, modelling, simulation and design of integrated scenarios
Deployment of the Climate Intelligence Programme for Agriculture should be intensified, in conjunction with the National Plan for Reduction of Risks and Disasters, as provided for in the ABC Plan (BRAZIL, 2012). This Programme incorporates regionally-based climate behaviour studies with development of indices, climate-risk maps, and medium and long-term vulnerability indicators referent to different local, regional and national-level climate-change scenarios to serve as a basis for early-warning systems and contingency plans relating to extreme climatic events and their effects.
Research and thematic areas
Regard the advance of knowledge and scientific and technological development for improvement of knowledge-production systems, based upon a broad concept of information management and universalization of access to developed or adapted knowledge, as an innovative output in itself. Analyses and technical-scientific developments relating to specific themes seek to increase efficiency and resilience of production units and systems, with a view, under biotic and abiotic pressures arising from climate change, to increasing productivity and ensuring sustainable use of natural resources. The following themes are considered priorities for research and technological development projects:

Water resources and use of water in agriculture: Involve development and/or adaptation of technologies for sustainable use and increased efficiency of water use in agricultural production systems, especially efficient irrigation systems; increase abstraction, use and storage of water for agricultural use and reduce rainwater losses (water reservation bill - PL30/2015); promote soil and water conservation technologies in production systems and compliance with restoration and conservation standards for APPs and RLs, avoid pollution of water bodies and promote maintenance of rainwater in the system.

Combat desertification: By means of mapping of sensitive areas and technologies for addressing on-going desertification processes, and strategies for preventing new ones, with established goals and verification by competent agencies;

Pest and disease management: Develop prospective studies on risks of occurrence of pests and diseases as a consequence of climate change, including new management techniques and incorporation of new pest and disease emergence projections, through the Pest Risks Analysis (ARP) system, alongside aspects of animal health and well-being, biological-control strategies, and other approaches with little or no environmental impact.

Genetic resources and improvement: To provide diversity and production alternatives for farmers, a greater variety of species, crops and breeds must be identified, researched and adapted to new climate circumstances and threats. Possible actions involve: strengthening of collection programmes, conservation and sustainable use of genetic resources and plant and animal enhancement, with emphasis on adaptation to the biotic and abiotic factors prevalent in forecast warming and water-shortage scenarios; structuring of the national network of phenotype platforms to streamline genetic research, with a focus on adaptation to address various crops, the geography of Brazilian agricultural species and forests, and establish a long-term network of experiments to identify and quantify the combined abiotic stresses (heat and drought) effects of higher CO2 concentrations and possible interactions with native plant species, in representative areas of the various Brazilian biomes, among others. Such actions must encompass not only activities conducted by research institutions, but also field work and grass-roots initiatives.

Adaptation of production systems for economic, social and environmental sustainability: Evaluate the efficiency, resilience and adaptive capacity of current systems and, consequently, promote their economic, social and environmental sustainability; conduct (attributional and consequential) life-cycle analyses of the main Brazilian agricultural products; evaluate inclusion of production systems in the global production environment from a systemic and agroindustry perspective, taking into account items such as diversification and use of native and natural materials directly related to risk and insurance management, supply chains and warehousing systems, including assessment and prevention of losses and logistics, among others.

Financial instruments: Two major working approaches should be developed, as provided for in the ABC Plan (BRAZIL, 2012). Initially, coordinate with financial agents to attend to the financial demands of the different Brazilian regions and their priorities, in accordance with the mapping/identification of vulnerabilities. Another important approach is improvement and expansion of rural insurance coverage and of other instruments for prevention and compensation of agricultural climate losses in support of adaptation actions, through integrated and synergic approaches for reducing sectoral greenhouse-gas emissions.

Rural development (technology transfer and technical assistance): An important working approach entails formulation and structuring of models or new rural-development elements that include innovation and transfer of new technological options that promote resilience, adaptation and sustainability in face of the deleterious effects of climate change. This approach is based on strengthening of technology transfers derived from the outcomes of actions proposed in the previous topics, among others. More significant than technology is the scope of this approach, i.e., the tools and information technology transfers that provide means of access to developed and adapted technologies. To this end, the development of user-friendly information systems shoulod be pursued, along with strengthening and restructuring of the Rural Technical Support (ATER) system and training of its technical staff.

Public policies and normative instruments: Adaptation measures should also include development of public policies targeted toward fostering a secure environment, in favour of sustainable development of the Brazilian farm sector, promoting efficiency and environmental, social and economic sustainability of national farm production. These are essential for ensuring food security in face of new challenges imposed by climate change. Current public policies need to be strengthened and, whenever possible, integrated. Discussions on regulation frameworks for payment to the farm sector for environmental services need to be pursued, so that appropriate instruments can be deployed. Among the trends provided for in the ABC Plan (BRAZIL, 2012) is a review of rural insurance, in view of potentially negative impacts of projected climate changes. There is also a need to inform the general public, through awareness-building campaigns, of the contributions of agriculture to adaptation to and mitigating of climate change, and of efforts and outcomes of the adaptation plan, as a means of broadening its acceptance, and also campaigns for promoting consumer awareness.

1.7 Interdependence with other sectors

Maintenance of the productive capacity of Brazil's farm sector directly impacts its capacity to ensure food security for Brazilian society. Warehousing and distribution policies are conditioned by the sector's productive capacity which, in turn, is impacted by the choices and behaviour of consumers (mostly losses). Access to food of sufficient quality or quantity is directly related to sanitary aspects of agricultural systems that have a direct impact on social resilience, and are an essential requisite for public health. The contribution of agricultural systems to health also takes the form of environmental services provided by farms.

The establishment of sustainable production systems contributes to the maintenance of biodiversity. Enactment of the Forestry Code (*Codigo Florestal*) marked a highpoint in efforts of the productive sector to ensure conservation, especially through establishment of Legal Reserve (RL) and Permanent Protection Areas (APPs) that are certain to have a positive impact on maintenance of natural resources, especially water availability. Moreover, related legislation is likely to stimulate the adaptive capacities of the sector. Also of importance are regulations and standards that govern access to genetic resources and research into new cultivars, breeds and productive varieties. Access to the outcomes of such research is of special importance in order to ensure new areas for agricultural development, necessary for maintenance of productive capacity.

The farm sector is highly dependent upon water availability in various stages of the production cycle. It is reliant upon water-resources regulations, abstraction quotas, and licences for storage and sustainable use - including the reuse.

Transport logistics and infrastructure, including the quality of highways and other transport modes, strongly impact farm-sector decision-making, as they affect access to inputs, the cost of moving harvests to markets, the final quality of products and the prices offered to consumers.

Adaptation of the agricultural sector is heavily impacted by and has strong impacts upon other related sectors, including industry, energy, among others.

Strategy for Biodiversity and Ecosystems

National Adaptation Plan to Climate Change

2 Strategy for Biodiversity and Ecosystems

2.1 Foreword

The Secretariat for Biodiversity and Forests (SBF) and the Secretariat for Climate Change and Environmental Quality (SMCQ) of the Ministry of Environment coordinated the drafting of the biodiversity strategy of the National Adaptation Plan and are the focal points for coordination of actions under this sectoral strategy. Specialists and researchers of the Bio-climate Network (*Rede Bioclima*) also collaborated and provided support during drafting and review of this Strategy.

The objectives of the strategy for biodiversity and ecosystems are: to analyse the impacts of climate change on biodiversity in Brazil and assess potential adaptation measures for reducing vulnerabilities; to assess the role of biodiversity and ecosystems in reducing socio-economic vulnerabilities through provision of ecosystem services.

Actions and public policies for management of biodiversity are undertaken by various component bodies of the National Environment System (SISNAMA), mostly at the federal and state levels. At the federal level, these are: the Ministry of Environment (MMA), the Secretariat for Biodiversity and Forests (SBF), the Department for Combating Deforestation (DPCD), the Secretariat for Sustainable Rural Development (SEDR), the Brazilian Institute for Environment and Renewable Natural Resources (IBAMA), the Chico Mendes Institute for Biodiversity Conservation (ICMBIO), the Brazilian Forestry Service (SFB), and the Botanical Gardens of Rio de Janeiro (JBRJ).

Other institutions, such as the Ministry of Fisheries and Aquaculture (MPA) and the Ministry of Agriculture Livestock and Food Supply (MAPA) also participate in these activities. State-level environmental bodies also play an important role in promoting and overseeing activities for conservation of biodiversity.

2.2 Introduction

The Convention on Biological Diversity (CDB) states that "biological diversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems" (CDB, Art. 2, BRAZIL/MMA 1992, p. 9).

Climate is a determining factor for the distribution of living organisms on the Planet. Since the early 20th century, studies have assessed the influence of weather variations and climatic variability on species (PARMESAN, 2006). More recently, recording of the impacts of climate change associated to global warming has become more frequent and extensive (HUGHES, 2000, MCCARTY, 2001, WALTHER *et al*., 2002 and WALTHER *et al*., 2005 *apud* VALLEY *et al*., 2009). Most of the records, however, have concentrated on North America, Europe and Japan, and there are large gaps for South America (PARMESAN, 2006; VALE *et al*., 2009). In Brazil, the first papers on future impacts of climate-change scenarios on biodiversity were published in 2007, and focused on climate models and their effects on biodiversity (MARENGO, 2007; MARINI *et al*., 2010; MARINI *et al*., 2010b; MARINI *et al*., 2009a, VIEIRA *et al*., 2012) "publisher": MMA, "publisher-place:" Brasília-DF)".

Such studies are no substitute for observational approaches, which are as yet incipient and few, and causal links between decline of a species and climate change are hard to prove scientifically (PBMC, 2013). This is because it is difficult, scientifically, to prove that weather variations that may already be impacting species are caused by climate change, notwithstanding the consensus that climate change is already happening and may reach critical levels in coming decades (IPCC, 2014). The expected effects of climate change, such as changes in the behaviour of climate variables, compound a series of threats that already affect conservation of biodiversity and ecosystems in Brazil.

2.3 Analysis of the vulnerability of biodiversity to climate change

2.3.1. Exposure, sensitivity and potential impacts on biodiversity and ecosystems

This topic examines the vulnerability of biodiversity on three levels, as defined in the CDB:

a. Ecosystems (terrestrial and aquatic)

b. Species/populations

c. Genetic diversity within species/populations

The approach to vulnerability discussed in this Chapter is in line with the methodology of the 3rd and 4th IPCC Assessment Reports (IPCC AR3, 2001 and AR4, 2007). AR3 (IPCC, 2001) presents vulnerability resulting from factors of exposure, sensitivity and adaptation capacity of natural and human systems.

2.3.2. Terrestrial Ecosystems

Ecosystems are represented by vegetation types or phyto-physiognomies, organized as biomes. The Brazilian Institute of Geography and Statistics (IBGE) classifies Brazilian biodiversity into six biomes (Amazon, Caatinga, Cerrado, Mata-Atlântica, Pantanal, Pampa), which encompassing general vegetation types distributed in characteristic landscapes.

The most important climatic parameter that influences vegetation types is the number of dry or cold months, affecting vegetation subclasses; and also average temperatures that interferes in altitudinal assemblages (submontane, montane and upper montane). Each vegetation type has a different sensitivity to climate change, since some are more dependent on moisture than others (ombrophilous). Changes in climate-pattern parameters (strong variations in quantities and concentration of rainfall, or in the duration of dry periods or extreme events) may, to some degree, impact phyto-physiognomies.

The study of the Brazilian Climate Change Panel (PBMC, 2013) foresees an incremental increase in average temperatures throughout Brazil, but of varied intensity, mainly affecting the Amazon, Caatinga, Cerrado, Pantanal and northern Mata-Atlântica biomes. It also foresees lower average rainfall in the Amazon, Caatinga, Cerrado, Pantanal and northern Mata-Atlântica, and higher rainfall in the southern Mata-Atlântica and Pampa biomes.

Table 2. Projected temperature and rainfall changes in Brazilian biomes

Biome	Rainfall (%)			Temperature (°C)		
	By 2040	2041-2070	2071-2100	By 2040	2041-2070	2071-2100
Amazon	-10	-25 to -30	-40 to -45	+1 to +1,5	+ 3 to +3,5	+5 to +6
Caatinga	-10 to -20	-25 to -35	-40 to -50	+0,5 to +1	+1,5 to +2,5	+3,5 to +4,5
Cerrado	-10 to -20	-20 to -35	-35 to -45	+1	+3 to +3,5	+5 to +5,5
Mata-Atlântica (Northeast)	-10	-20 to -25	-30 to -35	+0,5 to +1	+2 to +3	+3 to +4
Mata-Atlântica (Southeast/ South)	+5 to +10	+15 to +20	+25 to +30	+0,5 to +1	+1,5 to +2	+2,5 to +3
Pampa	+5 to +10	+15 to +20	+35 to +40	+1	+1 to +1,5	+2,5 to +3
Pantanal	-5 to -15	-10 to -25	-35 to -45	+1	+2,5 to +3,5	+3,5 to +4,5

Source: Adapted, with data from the PBMC (2013).

The sensitivity of each of these biomes to climate change is different. Future scenarios of medium temperature rise and rainfall reduction points towards points toward greater impacts on ombrophilous physiognomies, i.e., those most dependent on moisture (Table 2).

Domains of ombrophilous forests are mostly located in the Amazon and Mata-Atlântica. An increase in temperature in these biomes may increase evapotranspiration, causing and/or exacerbating incremental dry conditions that would affect some species (BEAUMONT *et al.*, 2011). Extended dry periods may increase susceptibility to forest fires and consequent mortality of plants. Moreover, sensitivity of high altitude vegetation assemblages would increase, leading to possible changes in the appearance and composition of theses phyto-physiognomies. According to Beaumont *et al.*,(2011), the greatest impact of climate change on ecosystems relates to primary productivity, i.e., the rate at which plants produce biomass (BEGON, 2006). Such productivity may increase or decrease, depending on the new rainfall patterns.

Few studies have been conducted on the effects of gradual decline in rainfall and of higher temperatures on ecosystems of arid and semi-arid climates (e.g. seasonal forests and savannahs). However, the impact is likely to include loss of resilience of original ecosystems, especially for climatic niche species. In the Caatinga, such impacts may exacerbate currently observed desertification, associated mainly with higher rates of loss of vegetation cover caused by land-use changes. In the Cerrado, a reduction of forest formations is likely, alongside an increase in open formations, with reduced size of trees and density of wooded areas.

Aside from the terrestrial ecosystems covered by this phyto-physiognomic classification, Brazil has large and diverse areas of wetland and aquatic ecosystems, including freshwater ecosystems (rivers, ponds, wetlands and floodplains), coastal ecosystems (mangroves, sandbars, saltmarshes, sand dunes, estuaries, rocky shorelines and lagoons) and marine ecosystems (coral reefs), which provide various essential ecosystem services, while sustaining economic livelihoods and guaranteeing human well-being.

Increases in water temperatures cause changes in chemical and biological processes, such as reduced concentration of dissolved oxygen in water, affecting the capacity of water bodies to cleanse themselves and to sustain aquatic communities. Changes in flow levels of rivers directly affect the maintenance of aquatic ecosystems, since rivers depend on minimum flow levels (known as ecological flows) for maintenance of the biota and the functioning of the ecosystem. In smaller rivers and streams the effects of lower rainfall on flow levels is even greater, making such environments even more susceptible to climate change, since changes in the frequency and volume of rainfall can reduce the flow levels below the required minimum. Lower flow levels may affect water quality and lead to increased pollution and undesirable consequences for aquatic species. Higher nutrient levels in water bodies, caused by longer-duration and higher-intensity rains, lead to the growth of algae, which can alter aquatic ecosystem, causing death of fish and changes in the food chain.

2.3.3. Coastal and marine ecosystems

This section addresses key ecosystems in the Brazilian Coastal Zone and Marine biomes, considering their associated biodiversity and ecosystem services provided.

- Mangroves, saltmarshes (*apicuns*, *marismas* and *salgados*) and sandbars
- Coral reefs
- Estuaries and Dunes
- Coastal lagoons

The effects of climate change on coastal and marine ecosystems occur through the rise in sea levels, higher water temperatures and consequent expansion and acidification of water, and changes in salinity, associated with changes in rainfall patterns and air temperature. In the 20th century, ocean levels rose between 12 and 22 cm and forecasts indicate that they will continue rising (SILVA BEZERRA *et al.*, 2014).

Sediment transport and deposition will be affected both by higher sea levels and by changes in the patterns of storms and marine currents, resulting in reduced progradation and retraction of coastlines. Thus, for the future, in addition to rising sea levels, more dynamic coastal landscapes are predicted, forcing the limits of adaptation capacity for biotic communities, destruction of some stretches, and formation of new areas for colonization by living organisms in others. However, if rises in sea levels take place very quickly, biological systems may lack sufficient resilience to the impacts and thus fail to adapt.

Analysis of the impact of climate change on coastal ecosystems illustrates the importance of maintaining and restoring areas for displacement or mobility of such ecosystems. With the increase in average temperatures it is expected that mangrove ecosystems migrate to south regions of Brazil, beyond their current climatic limits that nowadays extend down to State of Santa Catarina.

The main impact on coral ecosystems is the well-documented bleaching of coral reefs and loss of symbiodium algae, due to higher temperatures and rising sea-water acidity. Studies have detected that, thermal anomalies of as little as 0.25°C for two weeks on the northern coast of Bahia and of 0.50°C in the Abrolhos archipelago led to bleaching in 10% of corals (Leao, *et al.*, 2008; Leao, *et al.*, 2008b). A gradual shift in the area of occurrence of corals and of certain species of fish toward higher latitudes has also been documented (PARMESAN, 2006) whereas species commonly found in warmer waters are likely to suffer from higher temperatures.

Estuaries and coastal lagoons are of key concern, in view of their vulnerability to various stress factors and the importance of ecosystem services they provide, especially for fisheries and the livelihoods of traditional populations. Dunes and rock coastlines play an important role in reducing the intensity of climate events in coastal areas. Coastal lagoon environments are highly sensitive to climate factors such as salinity and water-temperature changes. Many lagoons are cut off from the sea by only a sandbar and the influence of sea changes on these environments is highly significant. Rising sea levels can result in increased salinity in coastal lagoons, caused by percolation of seawater, leading to changes in environmental conditions that have negative effects on the biota.

Changes in rainfall patterns, with increased frequency of extreme events, may result in alterations of depths of coastal lagoons over the year. Such ecosystems tend to be shallow, meaning that a significant portion of the water column may be affected by higher air temperatures. This elevation in the air temperatures associated with changes in depth have consequences on the increase of water temperatures. This may lead to changes in biogeochemical processes, such as decay of organic matter and emission of greenhouse gasses that may result in changes in microbial metabolism, fauna, and ecosystem services.

2.3.4. Species and populations

Species are the second level of biological diversity according to the CBD definition. Emergence and extinction of species are part of the natural dynamics of evolution. However, climate change may accelerate the rate of extinction, thereby reducing the diversity of species.

It is estimated that Brazil's diversity of species accounts for between 10% and 20% of the Planet's biological diversity (BRAZIL, 2011; BRAZIL, 2006). Climate change may have a direct or indirect influence on species. Climate conditions, such as changes in temperature and rainfall may directly hinder their development, reduce mobility, hinder reproduction rates, increase mortality, affect immunity to diseases, etc. Some species are sensitive to lower temperatures; others to excessive heat or drought. The limits of climatic parameters within which species best perform define their climate niches. The smaller the climate niche, the more sensitive the species.

Aside from average climate parameters, extreme events, most notably floods and extensive droughts that leave environments vulnerable to forest fires, may cause significant impacts on species level. Climate change will also affect microhabitats, i.e., where a species lives in a very specific ecosystem, for example, underground habitats, tree canopies or in water (CLOSEL & KOHLSDORF, 2012). Some aquatic species inhabit temporary ponds that rely on seasonal rainfall for their maintenance. An example is the group of annual fish, which many of them are already listed on the "National Official List of Endangered Fauna Species – Fish and Water Invertebrates".

Biotic interactions are an important factor for analysis, since species form biotic communities with relations of great interdependence. Most of the impacts of climate change on biodiversity, according to Parmesan (2006) have been observed through the phenology of species, i.e., seasonal and inter-annual variation in such life-cycle events as flowering, fruition, or shedding of leaves, or even date of migration or of birth of offspring. Such impacts are of particular importance, as they affect synchrony between a species and its food sources (HARRINGTON *et al*., 1999, VISSER & BOTH, 2005, *apud* PARMESAN, 2006).

Climate change will affect the distribution of species and communities, and alter biotic interactions, such as predation, competition, dispersal, pollination, and mutualism, which, in turn, influences the communities in significant and unpredictable ways (HARLEY, 2011; HILLERISLAMBERS *et al.*, 2013). Such effects will be more intense among tropical communities and, in view of the higher degree of specialization of tropical species, consequent rearrangements may have serious consequences for communities (SHELDON *et al*., 2011).

Moreover, when the areas of occurrence of species change, their displacement to new areas may be retarded or accelerated by the presence of other species (HARLEY, 2011; HILLERISLAMBERS *et al*., 2013). It is also possible that a species that is not sensitive to climate change may be impacted by effects upon another species that is. Exposure to such changes in relationships among organisms living in an ecosystem is not easy to assess and entails monitoring over several years.

Species may adapt to climate change by means of the following: 1) changing their area of occurrence (expansion, retraction or displacement); 2) persistence in the current area of occurrence with a change of microhabitat; and 3) change of phenotype, phenology or behaviour (change of food source, of flowering period or of shedding of leaves, exploitation of more temperate microenvironments, altering of daily activity schedules, migration periods, etc.).

Fragmentation of landscapes poses challenges for the movement of species. In a context of climate change, in naturally fragmented landscapes, dispersion capacity alone may not be sufficient:, and efforts must be made to improve connectivity among suitable habitats to support species' dispersion occurrance (VALE, *et al*. 2009).

In synthesis, the major impacts of climate change on species and populations can be summarised as follows: changes 1) in phenology; 2) in biotic interactions; 3) in extinction rates; and 4) in distribution of species.

2.3.5. Genetic diversity

Genetic diversity have been exposed to climate change. Genetics sensitivity depends on how each species is affected, given that a drastic reduction in the abundance of a species may lead to severe genetic problems. Certain genetic features may become less viable in the light of climate change, while others may become more favoured.

One way of understanding how climate change will affect a species' genotypes is to examine its evolutionary past, where changes in climate may have enabled processes of specialisation and diversification, aside from causing extinction of many species and reducing their genetic diversity. (ALEIXO *et al*., 2010).

An important aspect of genetic and biological diversity relates to diversity between domesticated species and their wild relatives, which represent a source of genetic variability capable of providing material for improvement of agricultural adaptive capacity. Likewise, associated traditional knowledge is constantly being confronted by new ecological conditions, which may threaten the ability to produce results at the local level, even jeopardizing survival.

Genetic diversity, in itself, represents an adaptive capacity of the biodiversity to environmental changes and it is favoured by a number of biological mechanisms. To prevent loss of genetic diversity, all species must retain feasible size populations (numbers of which vary from one species to another) implying a need to conserve favourable territories of a minimum size. For example, the area needed to ensure survival of a viable population of pumas (at least 500 reproductive adults) in the long term for pumas is 31,250 km^2; and for jaguars, 21,186 km^2 (OLIVEIRA, 1994 *apud* BEISIEGEL, 2009). Thus, the maintenance of large areas under conservation is important for maintenance of the diversity of certain species, especially large predators and rare trees.

The process of genetic diversity loss resulting from climate change does not appear to be well documented in Brazil, where incipient studies have focused on the ecosystem and species levels. However, in situations where populations of species have been drastically reduced by habitat loss, losses of genetic diversity have also occurred and in some cases was registered.

2.4 Synthesis of future vulnerability of Brazilian biodiversity and ecosystems to climate change

2.4.1. Non-climatic exposure factors

In addition to impacts associated with direct exposure of ecosystems and species to change in climate variables, the sensitivity of an ecosystem is affected by “non-climatic” variables that include: conversion of forest cover and fragmentation of ecosystems, wildfires, gaps in the monitoring of vegetation cover, and weaknesses of governance and institutional arrengements.

Land-use changes increase fragmentation of biomes and threaten the maintenance of fauna populations owing to lack of contiguous areas to ensure the viability of populations. Fragmentation amplifies border effects which reduce resilience of ecosystems to impacts. Such impacts are exacerbated by climate change which increases the occurrence of fires, reducing climatic niches and altering the distribution of species and phyto-physiognomies.

Fragmentation and pollution of rivers and changes in flows, caused by different uses of water resources, directly impairs aquatic ecosystems and the life cycles of species that depend on such environments.

Thus, adaptation measures for biodiversity must include actions to reduce exposure to non-climate factors, especially recovery of native vegetation and establishment of protected areas, measures to promote consideration of future climate-change scenarios during development and planning of biodiversity-conservation policies.

Table 3 presents a synthesis of elements that increase the vulnerability of terrestrial and marineecosystems to climate change. Exposition to climate-change considered variation in average temperature and rainfall patterns, and changes in the number of dry months. Factors that affect sensitivity included timber harvesting landscape fragmentation, wildfires, water stress. Sensitivity is regarded as a component of vulnerability analysis that measures the extent to which a system is directly or indirectly affected, positively or negatively, by climate change.

Table 3. Synthesis of elements that contribute towards the Vulnerability of Terrestrial, Coastal and Marine Ecosystems, based on AR 4 models applied to Brazilian Biomes (PBMC, 2013).

Terrestrial Ecosystems										
Vegetation Types	Biome	Exposition			Sensitivity Components		Possible impacts - 2050			
		T°C	Rainfall.	N° Dry months	Climate Conditions (dry months)	Other factors	Water stress	Fires (heat source)	Others	Tendency to change
Ombrophilous forest	Amazon	↑↑	↓↓	↑↑	Up to 4 months	Timber harvesting Fragmentation	Yes	Yes	Increase in tree mortality	Reductiom in forest cover in the eastern Amazon region
Ombrophilous forest	Northern Mata-Atlântica	↑↑	↓↓	↑↑	Up to 4 months	Timber harvesting Fragmentation	Yes	Yes	Increase in tree mortality	Reduction of forest cover
Ombrophilous forest	Southern Mata-Atlântica	↑↑	↑↑	↓↓	Up to 4 months	Timber harvesting Fragmentation	No	No	-	Maintenance of the area favourable to the ecosystem
Seasonal semi-deciduous forest	Northern transitions	↑↑	↓↓	↑↑	4-6 months	Fragmentation	Yes	Yes	Increase in tree mortality	Displacement and expansion
Seasonal deciduous forest	Cerrado	↑↑	↓↓	↑↑	4-6 months	Fragmentation	Yes	Yes	Increase in tree mortality	Reduction of forest cover and replacement by savannah
Seasonal deciduous forest	Mata-Atlântica	↑↑	↑↑	↓↓	4-6 months	Fragmentation	No	No	-	Maintenance of favourable ecosystem areas
Mixed Ombrophilous forest (with araucaria)	Southern Mata-Atlântica	↑↑	↑↑	↓↓	Up to 4 months	Fragmentation	No	No	-	Maintenance of favourable ecosystem areas
Savannah	Cerrado	↑↑	↓↓	↑↑	Up to 6 months	Fragmentation	Yes	Yes	Increase in tree mortality	Expansion and displacement of forest cover Reduction in tree vegetation cover

Table 3. (CONTINUED) Synthesis of elements that contribute toward the Vulnerability of Terrestrial, Coastal and Marine Ecosystems

Types of Vegetation	Biome	Exposition			Sensitivity Components		Possible impacts - 2050			
		T (°C)	Rainfall	Dry months	Climate (dry months)	Other factors	Water stress	Fires (heat source)	Others	Tendency to change
Terrestrial Ecosystems										
Savannah steppe	Caatinga	↑↑	↓↓	↑↑	6+3 months	Fragmentation Desertification	Yes	Yes	Increase in tree mortality	Displacement
Steppe	Pampa	↑↑	↑↑		3 months cold[11] and 1 month dry	Pasture	No	No	-	Greater tree coverage and possible expansion of forests
Coastal/marine Ecosystems										
Mangrove/ Salt water swamp	Northern Mata-Atlântica	↑↑	↓↓		Minimum temperature of 15°C Elevation of the sea level	Deforestation Areas for expansion	Yes	No	Death by drowning Absence of migration areas in some locations	Penetration into the continent with more salt water swamps
Mangrove/ Salt water swamp	Southern Mata-Atlântica	↑↑	↑↑		Minimum temperature of 15°C Elevation of the sea level	Deforestation Areas for expansion (human occupation and terrain)	No	No	Death by drowning Absence of migration areas in some locations	Penetration into the continent and expansion to the South, with more mangroves
Mangrove/ Salt water swamp	Caatinga	↑↑	↓↓		Minimum temperature of 15°C Elevation of the sea level	Deforestation Areas for expansion	No	No	Death by drowning Absence of migration areas in some locations	Penetration into the continent with more salt water swamps

11 Average temperature below 15°C

Table 3. (CONTINUED) Synthesis of the elements that contribute to the Vulnerability of the Terrestrial, Coastal and Marine Ecosystems, based on IPCC AR 4 models (PBMC, 2013)

Coastal/marine Ecosystems (CONTINUATION)										
Types of Vegetation	Biome	Exposition			Sensitivity Components		Possible impacts - 2050			
		T°C	Rainfall	Dry months	Climate (dry months)	Other factors	Water stress	Fires (heat source)	Others	Tendency to change
Mangrove/ Saltmarsh	Amazon	↑↑	↓↓		Minimum temperature of 15°C Elevation of the sea level	Deforestation Areas for expansion	Yes	No	Death by drowning Absence of migration areas in some locations	Displacement into the continent with more saltmarsh
Tidelands	Southern Mata-Atlântica	↑↑	↑↑		Minimum temperature of 15°C Elevation of the sea level	Deforestation Areas for expansion (human settlement and use)	No	No	Death by drowning Absence of migration areas in some locations	Retraction to the South
Beaches, sandbanks and dunes	Mata-Atlântica	↑↑			Elevation of the sea level	Deforestation Areas for expansion (human settlement and use)	n/a	n/a	Death by drowning Absence of migration areas in some locations	Displacements
Coral reefs	n/a	↑↑	n/a	n/a	Elevation of the sea level Acidification and warming of the water	Fishing and tourism	n/a	n/a	Bleaching	Displacement, reduction in the area of coral reefs
Coastal lagoons	Mata-Atlântica	↑↑			Elevation of the sea level, extreme rainfall events	Eutrophication, silting, human settlement on shorelines	n/a	n/a	Warmer and more saline environment, unfavourable for some species	Displacement, change in the composition of communities

A summary of potential changes in Brazilian biomes in response to climate change, disregarding factors that affect sensitivity of systems, such as fragmentation, increased incidence of fire, etc, is presented above (PBMC, 2013):

In the Amazon and Mata-Atlântica biomes, given the predominance of Ombrophilous phyto-physiognomies, a reduction in area is foreseen;
In the Cerrado, which consists predominantly of savanna vegetation, expansion and displacement of coverage may occur, with a reduction of forest assemblages. Fragments of seasonal semi-deciduous forests will tend to be replaced by savannah;
In Mixed Ombrophilous Forests (Araucaria) an expansion of suitable coverage area is expected;
In the Caatinga (steppe/savannah) an increase in tree mortality is foreseen, with reduction/ displacement of coverage area;
In the Pampas (steppe) there may be an increase of wooded components and expansion of forests;
In mangroves and saltmarshes of the Mata-Atlântica, displacement towards continental areas and expansion to the south are foreseen, with an expansion of the area suitable for mangroves and retraction of southern tidelands (*marismas*);
For coral reefs, reductions and displacements of their original areas of occurrence is expected;
For inland aquatic ecosystems, there appears to be a trend toward increased flows in river basins of the South and Southeast regions, and of reduced flows in basins of the North and Northeast.

2.5 Conservation of biodiversity and relationships with other sectors

In general feedback on public awareness and perceptions of measures for conservation of biodiversity, maintenance of ecosystem services, and increasing the adaptive capacity of biodiversity and of the society to the impacts of climate change has been positive.The role of ecosystems in climate mitigation and regulation, and provision of important ecosystem services is fairly well acknowledged (Fundação Grupo Boticario, 2014). It is generally accepted that ecosystem services provide (directly and/or indirectly) benefits (MEA 2005) in the following categories: provision support, regulation, and cultural services. (FIGURE 1)

In recent years, a new approach for addressing impacts associated with climate change, known as Ecosystem based Adaptation (EbA) that relies on the use of ecosystem services to reduce human vulnerability to climate change, has gained ground among managers and researchers.

Ecosystem based Adaptation (EbA) approaches is based on the use of management, conservation and recovery of ecosystems to enhance ecosystem services that enable society to adapt to impacts of climate change.

Benefits of EbA strategies include reduction of the vulnerability to gradual and extreme events maintenance of the ecological integrity of ecosystems, carbon sequestration, greater food security, sustainable water-resources management, and an integrated approach to territorial management, all of which generate multiple economic, social, environmental and cultural benefits for society.(Fundação Grupo Boticario, 2015).

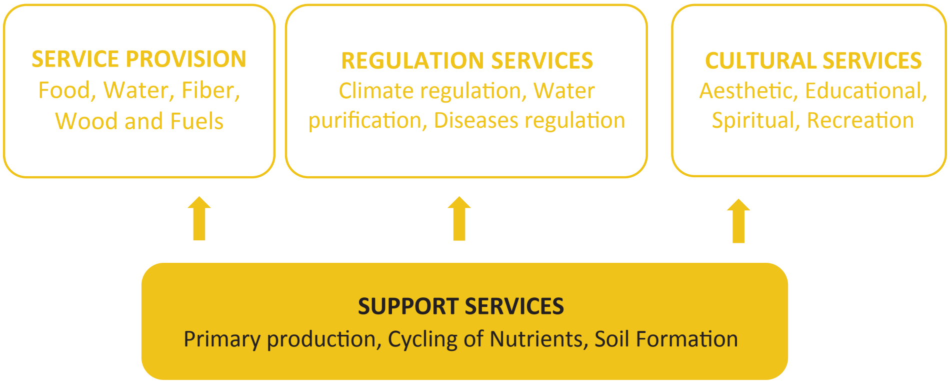


Figure 1. Categories of ecosystem services

Services related to reducing vulnerability to climate change generally and may support and regulation of ecosystem services and may contribute to adaptation in almost all sectors and activities.Knowledge gaps relating to methodologies tested and applied for identification, quantification and evaluation of ecosystem services remain to be filled. Gaps also includes the need of appropriated and tested guidelines for development of EbA measures and activities

A study entitled Ecosystem-based Adaptation, published by *Fundação Grupo Boticario*, identifies opportunities for integration of EbA principles into public policies and the sectoral and territorial actions of public and private institutions (FIGURE 2).

1. A better understanding of EbA among policymakers and support for its integration into the policy-formulation frameworks is needed.

2. Awareness must be stimulated between actors from diverse economic sectors of the importance of integrating of EbA approaches as cross-cutting themes for all policies, actions, plans and strategies, especially on those sectors more vulnerable to change or dependent upon ecosystem services.

3. Development of economic and modelling evaluation support tools is recommended, to ensure adoption of EbA decision-making strategies.

4. Prioritization must be applied to identify adaptation measures that generate represents no regret measures and provides environmental, economic and/or social benefits, notwithstanding uncertainties associated with forecasts (i.e., no-regrets measures).

5. Finally, from a governmental perspective, efforts should concentrated upon strengthening funding opportunities and current funding sources. Support must also be provided for drafting of legislation on economic incentives (ICMS Ecológico, Environmental compensation, and others) to stimulate the inclusion of EbA approaches in calls for research proposals and funding for science investments

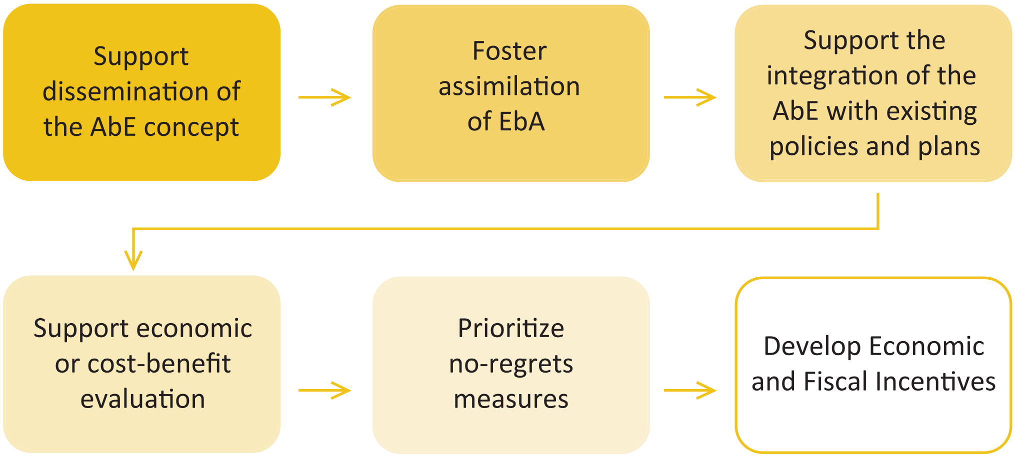


Figure 2. Framework for incorporation of EbA measures into sectoral adaptation policies

Table 4 presents a summary of ecosystem services related to certain sectors of the Plan. Ecosystem services are important for long-term sustainability and resilience to climate change under this Plan, and for such economically important sectors as Energy, Agriculture, Industry, Infrastructure and Urban Development. Other areas affected include Food Security, Disaster Relief, and Health.

Table 4. Summary of key ecosystem services for development of EbA approaches and sectors benefited

Biodiversity unit	Ecosystem service	Effect	Sector
Forest Ecosystems and Native Vegetation Formations	Regularization of the hydrological cycle, Preservation of the shorelines, Filtration of sediments and pollutants, Provision of weather services	Conservation of water quantity and quality; Self-regulation of hydrological flow dynamics	Economic activities dependent on water resources such as: Energy, Agriculture, Industry, Waterway Transport, Tourism Urban Development Human Well-being: Health, Water and Food Security, Vulnerable Populations
	Control of flows; Increased permeability of basins	Reduced flooding	Disaster risk reduction Sustainable urban development Vulnerable populations
	Reduced exposure of bare soil	Reduced erosion and landslides risk on hillsides	Reduction natural-disaster risk Urban sustainable development Vulnerable populations
	Protection of the dry-land with typical semiarid vegetation	Reduced desertification	Agriculture and Food security, Vulnerable populations
	Weather services in urban areas	Reduced heat-wave effect, Mitigation of temperature rises, Reduction of urban heat-island effect	Development and urban mobility, Vulnerable populations, Health, Well-being

Table 4. (CONTINUED) Summary of key ecosystem services that can be used in the development of EbA measures and sectors benefited

Biodiversity unit	Ecosystem service	Effect	Sector
Fauna and flora individuals	Conservation of species	Maintenance of ecosystem processes	Biodiversity and all economic sectors that depend direct or indirectly on ecosystem services
	Pollination	Viability of cultivation and reproduction of wild species	Agriculture and Food security, Industry, Vulnerable populations and Biodiversity
	Diversity of genetic resources	Genetic manipulation of species of commercial interest	Agriculture and Food security, Industry, Vulnerable populations and Biodiversity
		Diversification of diets	Food security, Vulnerable populations
	Vector species and wild disease reservoirs	Exposure of human populations	Health, Human well-being, Vulnerable populations
Mangroves	Protection of coastal regions; Control of river flow fluctuations in the coastal and estuary regions; Control of erosion and shifting coast lines	Reduced vulnerability to higher sea levels, storms and extreme events	Reduction of disaster risks, Urban development and mobility, Industry, Coastal and transport infrastructure, Coastal zone territorial profile
	Protection of vulnerable populations; Reinforcement of mitigation measures	Contribute towards preservation of lifestyles of traditional populations; Increased carbon sequestration	Vulnerable peoples and populations
	Nurseries for conservation of marine biodiversity	Conservation of fish stocks	Food security, Aquiculture, Vulnerable populations, Coastal zone territorial profile
Corals	Protection of coastal regions	Reduced vulnerability to storms and extreme marine and coastal events	Reduction of risks of disaster, Urban planning, Industry, Coastal and transport infrastructure, Coastal zone territorial profile
	Nurseries for conservation of marine biodiversity	Conservation of fish stocks	Food security, Aquiculture, Vulnerable populations, Coastal zone territorial profile
Continental aquatic ecosystems	Filtering and natural water treatment; Erosion and flood control; Maintenance and bio-geochemical cycles including of nutrients; Primary Production	Conservation of water quality; maintenance of fertility of floodplains; stability of food chains	Water resources and user sectors: Health, Water and Food security, Vulnerable populations, Disasters

2.6 Guideline and actions for adaptation

Besides assessment of vulnerabilities to climate change, the Biodiversity and Ecosystems strategy of this National Adaptation Plan also proposes some initial actions for reducing such vulnerabilities. To this end, guidelines are presented and some actions proposed for reducing the impact of non-climate threats (no-regrets measures). Moreover, proposals are presented to increase adaptation potential of current public policies[12], through consideration of climate change as a crosscutting component in all planning and policy decisions (in a approach referred to as a climate lens).

2.6.1. Guideline for incorporation of information on climate change into planning and implementation of public policies for conservation, recovery and sustainable use of biodiversity

In practice, this implies integration of information on climate change into policies and programmes for conservation, restoration and sustainable use of biodiversity and, when necessary, review and updating of current policies and programmes. Knowledge is also needed for implementation of EbA measures, including maping social and economic vulnerability within the territory, and guidelines for implementation of EbA activities.The main goal is to make policies effective within a future scenario of climate change. Foremost among the actions to be achieved by this guideline are:

[12] At the end of the chapter there is a list of the programmes and projects mentioned in the text, with the institution in charge and a link to more information.

1. Produce and disseminate information on the impact of climate change on biodiversity and promote its integration in public policies for conservation, recovery and sustainable use of biodiversity and for reducing deforestation, so as to reduce vulnerability (e.g. Rural Environmental Register (CAR), Creation and Management of Conservation Units, National Biodiversity Goals for 2020; Priority Areas for Conservation of Biodiversity; Economic Ecological Zoning; Plans of Action for endangered species; *ex situ* Conservation Measures; Plan for Combating Desertification);

2. Implement monitoring of biodiversity for evaluation and *in situ* monitoring, modelling projections of changes in the distribution of species and in local patterns of occurrence in response to climate change; support updating of conservation measures;

3. Develop plans of action to combat fires for each biome, and especially for Conservation Units (UCs), which are especially sensitive as they contain significant concentrations of biodiversity, integrating information about climate change into measures and actions for prevention and control of wildfires and burning;

4. Develop studies for assessment of vulnerability of people and of productive sector in support of drafting of an EbA strategy, covering local and regional scales;

5. Develop studies for identification of potentially vulnerable areas for implementation of EbA measures, focused on extreme events such as floods, landslides, droughts and dry periods;

6. Deepen knowledge on EbA methodologies in support of incorporation of EbA into policies and actions for reducing vulnerability among the various sectors covered by this NAP, especially disaster relief and prevention;

7. Update lists of endangered species considering information on sensitivity to climate change; review *ex situ* conservation measures so as to include species threatened by climate changes and strengthen measures for conservation of species.

Most of the measures proposed herein are for activities and monitoring on landscape and ecosystem scales. Foremost among the measures for species-level conservation are incorporation of climate-change information into plans of action for endangered species, *ex situ* conservation, and fisheries management.

2.6.2. Guideline for no-regrets measures

No-regrets measures for reducing the vulnerability of biodiversity to climate change are, in part, based upon strengthening and expansion of current approaches for conservation of biodiversity. There follows a list of such no-regrets approaches:

1. Strengthen measures for conservation, recovery and sustainable use of biodiversity, aimed at increasing connectivity between remnants of ecosystems and consolidation of Conservation Units, with a view to promoting integrated landscape-scale forest management and reducing the vulnerability of biological resources;

2. Implement deforestation monitoring programmes for all Brazilian biomes, with disclosure of data at least once a year, along the lines of the Project for Monitoring the Deforestation in the Amazon (PRODES) and the System for Real Time Detection of Deforestation in the Amazon (DETER); conclude implementation of the Plan to Combat Deforestation in the Caatinga (PPCaatinga) and draft and implement similar plans for other biomes;

3. Extend Land Use Monitoring Programmes, such as TERRACLASS, to all Brazilian biomes;

4. Strengthen policies and actions for conservation of aquatic ecosystems, providing maintenance of connectivity among such environments and suitable flow-level regimes for ecological processes of dependent species;

5. Expand coastal and marine Conservation Units, covering the diversity of existing environments and conserving their ecosystem services;

6. Strengthen fisheries management for conservation and sustainable use of fish stocks, considering the vulnerability of fish species associated with coral, mangrove and estuary environments;

7. Implement monitoring of coastal and marine ecosystems and associated information systems, so as to accompany the impacts of climate change on such systems.

Establishment of new Conservation Units must prioritize adaptation to climate change in the Caatinga, Cerrado, Pantanal and Pampa biomes, and in coastal and marine zones, and especially in mangrove and coral ecosystems, since fulfilment of international and national goals related to protected areas in these environments is behind schedule.

2.6.3. Guideline for institutional arrangements

Challenges of institutional nature are among those that need to be addressed by the guidelines proposed in this Chapter. Efforts must be concentrated on building an institutional coordination structure, capable of integrating the various actions and policies for biodiversity management, including reduction of deforestation, conservation of biodiversity and recovery of native vegetation, and dissemination of information on the impacts of climate change. It is desirable that the proposed institutional arrangements enable a central governance structure to integrate and monitor implementation of measures under this Plan, while respecting the attributions and different responsibilities of each of the institutions involved. This coordination arrangement should be supported by integrated information and monitoring systems.

2.6.4. Guideline and actions for knowledge management

This guideline addresses the need for management and production of knowledge Definition of its priorities is based on identification of knowledge gaps by researchers and experts of environmental agencies that participate in *Rede Bioclima*. Expected results include a review of guidelines for funding opportunities for research proposals and development of new climate and biodiversity knowledge-management systems.

1. Promote creation and deployment of information management systems which integrate information on deforestation, land use, recovery of native vegetation and of biodiversity; on integrated information platforms, combining the databases of environmental agencies, data from research institutions and information on climate change (e.g. Information System on Brazilian Biodiversity (SiBBr), the Biodiversity Portal, and others);

2. Raise the numbers of funding opportunities for research proposals and observational studies and for analysis of species-level relations between climate and biodiversity;

3. Increase the number of climate parameters modelled under regionalized scenario efforts;

4. Create specific grants of research and funding opportunities for research applied to assessment of ecosystem services and for case studies testing oEbA methodologies;

5. Issue long-term research proposals on climate change and biodiversity, to enable researchers to collaborate with monitoring initiatives; undertake efforts perpetuate current and new research initiatives for monitoring biodiversity and environmental data;

6. Guide research towards groups of target populations, such as species of commercial interest (fish stocks, lumber and agricultural pests), endangered, invasive and endemic species, and groups that perform ecosystem services, such as pollinators and seed dispersers;

7. Promote research for improvement of techniques for recovery of native vegetation in less-studied non-forestry ecosystems, with a view to achieving greater efficiency and lower cost;

8. Evaluate biological indicators such as water stress levels in vegetation as an indicator of the impact of climate change on biodiversity at the ecosystem level;

9. Increase numbers of research and of reference centres working on recording and collecting genetic information on endangered and domesticated species, wild relatives and varieties, landraces and species of commercial interest in *in situ* collections, alive or in gene banks.

2.6.5. Priority Goals and Actions

In Volume 1, several consensual priority goals of the NAP were identified for various sectors. Such goals orient actions, implementation and effectiveness of which depends upon the planning and institutional capabilities of the various sectors. For the biodiversity strategy, three contagion and no-regrets measures were selected as priorities for implemention during the current phase of the Plan:

1. Drafting of a strategy to deploy EbA measures in areas at risk of extreme events and other impacts of climate change.

2. Development of modelling studies of the impact of climate change on biodiversity for use in public policies for conservation, recovery and sustainable use of biodiversity.

3. Implement a monitoring programme in 50 federal conservation units for *in situ* assessment and monitoring of the impacts of current and future climate change on biodiversity.

The goals are directly or indirectly covered by no-regrets and contagion measures and the knowledge management strategies listed earlier in this Chapter. The table below presents details of these goals.

Objective 3. Identify and propose measures to promote adaptation and reduce climate risk	Sectoral and Thematic Strategy: Biodiversity and Ecosystems		
	Goal 3.3	**Initiatives**	**Responsible**
	Preparation of Ecosystem- based Adaptation strategy measures in areas at risk of extreme events and other climate change impacts.	Establish a working group.	MMA
		Identify potential areas for implementation of Ecosystem- based Adaptation (EbA) measures.	
		Prepare a strategy in conjunction with governmental bodies, private sector and civil society.	
	Indicator/Monitoring:	Percentage of the strategy drawn up.	
		Criteria for implementation of EbA measures in high-risk areas defined.	
	Impact:	Strengthen current government policies for recovery and conservation of ecosystems and native vegetation.	
		Support for reduction of disaster risk.	
		Support for reduction of vulnerability to climate change of the general population.	
		Foster identification, promotion and conservation of ecosystem services.	
		Foster increased resilience to climate change of cities and metropolitan regions, especially to impacts of flooding and landslides.	

Objective 3. Identify and propose measures to promote adaptation and reduce climate risk

Sectoral and Thematic Strategy: Biodiversity and Ecosystems		
Goal 3.4	**Initiatives**	**Responsible**
Modelling of the impact of climate change on biodiversity for use in public policies for conservation, recovery and sustainable use of biodiversity	Identify the impact of climate change on biodiversity.	MMA
	Promote incorporation of climate risk into current policies for conservation, restoration and sustainable use of biodiversity.	
Indicator/Monitoring:	Number of scenarios and maps available in an appropriate format as inputs for public policies on biodiversity.	
	Number of public policies for biodiversity management that incorporate climate modelling.	
	Number of staff of governmental and non-governmental agencies trained.	
Impact:	Foster incorporation of information on climate change into the policies of sectors involved.	
	Integrate information on climate change into the process of drafting actions for biodiversity management, thereby enhancing the effectiveness of such instruments.	
	Increase Brazil´s capacity to face up to the negative aspects of climate change, and particularly impacts that affect biodiversity and provision of ecosystem services, while fostering a climatic standpoint for such policies.	

Objective 3. Identify and propose measures to promote adaptation and reduce climate risk

Sectoral and Thematic Strategy: Biodiversity and Ecosystems		
Goal 3.5	**Initiatives**	**Responsible**
Deployment of monitoring in 50 federal Conservation Units, for evaluation and monitoring of the impacts of climate change on current and future biodiversity.	Develop and implement an programme for monitoring biodiversity in terrestrial ecosystems in 40 Conservation Units (CUs), covering different biomes, and in 10 CUs located in coastal marine ecosystems, with emphasis on critical ecosystems such as coral reefs and mangroves.	ICMBIO
Indicator/Monitoring:	Number of Conservation Units with monitoring implemented and maintained per year.	
	Number of biodiversity diagnoses in monitored CUs.	
	Number of reports and trend analyses on relationships between biodiversity and climate, including reports on specific formations/taxons.	
	Early-warning system deployed and number of warning reports issued since its deployment.	
Impact:	Systematic gathering of information on monitoring of endangered species and biodiversity in CUs, as inputs for analysis of the relationship between climate and biodiversity.	
	Enable evaluation of the contribution of CUs to mitigation of the effects of climate change.	
	Increased capacity for local response - since monitoring is carried out in a participatory manner, at a local level, involving numerous institutions, thereby enabling adoption of adaptation measures at a local level, with rapid responses.	
	Increased capacity for response on a regional and national scale – since the initiative works in articulation with several others, such as the Brazilian Forestry Service (inventory grid); the Rapeld system; RedeLep, and entails a dataflow, storage and distribution system.	

List of authors and collaborators who have supported the preparation of the Chapter on Biodiversity and Ecosystems

Coordination: Ministry of Environment	***Karen Silverwood-Cope*** Director for Environmental Licensing and Evaluation of the Secretariat for Climate Change and Environmental Quality (SMCQ) ***Pedro Christ*** Deputy-Director of Environmental Licensing and Evaluation of the Secretariat for Climate Change and Environmental Quality (SMCQ) ***Carlos Scaramuzza*** Director of the Secretariat for Biodiversity and Forests (SBF)
Authors:	Ronaldo Weigand Junior (Consultant) Mariana Egler (MMA) Joao Arthur Seyfarth (MMA) Adriana Brito (MMA) Jennifer Viezzer (MMA)
Collaborators:	Rafael Loyola (UFG) Ana Luisa Albernaz (MCTI) Marina Zanin (MPEG) Rafael Luis Fonseca (Consultant) Daniela America (MMA) Christiane Holvorcem (GIZ) Lara Cortes (ICMBio) Juliana Faria (MMA) Paula Pereira (MMA) Martin Becher (GIZ) Mario Soares (UERJ) Guilherme Karan (Fundação Grupo Boticario) Juliana Baladelli (Fundação Grupo Boticario) Eduardo Canina (WWF) Fabio Scarano (UFRJ/FBDS) Katia Torres Ribeiro (ICMBIO) Rodrigo Silva Pinto Jorge (ICMBIO) Ana Elisa de Faria Bacellar (ICMBIO) Vinicius Scofield (MMA/SBF) Bianca Chaim Mattos (MMA/SBF) Armin Deitenbach (GIZ)

Strategy for Cities

National Adaptation Plan
to Climate Change

3 Strategy for Cities

3.1 Introduction

Formulation of public policies for cities based on integrated approaches is a recent development, in response to the challenges of applying coordination and synergic approaches to an array of sectoral actions and programmes and their impacts on the dynamics of use and transformation of urban space. The Ministry of Cities (MCid), focal point for the current Strategy for Cities under the National Adaptation Plan, was created with the mission of improving the drafting, implementation and management of public policies targeted at urban territorial planning. In practice, MCid aims, through its programs and actions, to make cities more humane, socially and economically just, and environmentally sustainable, by means of democratic management and integration of public policies for urban planning, housing, sanitation, urban mobility and accessibility, and traffic through coordinated efforts with federal, state and municipal bodies and civil-society organizations.

Urban development policies are, potentially, among the more effective means for bringing about adaptation to climate change in cities, especially by means of systemic approaches that address current issues while, at the same time, anticipating future problems. Such integrated approaches become more viable as scientific knowledge advances and uncertainties with respect to climate change decline.

There is a general consensus that cities that offer participative urban planning processes which ensure democratic management, decent housing, basic sanitation (safe drinking-water supply, sewerage, street cleaning, solid waste management, stormwater management), high-quality roadway systems and public safety and civil defence, are inherently more resilient to most of the impacts of climate changes (OLIVEIRA AND MOREIRA, 2006).

Nonetheless, urban-planning flaws, such as inadequate housing, infrastructure and services, especially when exacerbated by informal settlement in unsuitable areas, contribute toward increased climate-change risk in urban areas. In many Brazilian municipalities, such deficiencies are associated with uncoordinated urban growth, which undermines the capacity of local administrations to cope with the impacts of climate events, owing to the difficulty of providing suitable and affordable urban infrastructure and public services to a majority of the population (UN-HABITAT, 2009).

Most Brazilian cities already face socio-environmental problems associated with accelerated growth and transformations of urban space. Climate change tends to exacerbate the effects of existing hazards, such as flooding, landslides, heat waves and water shortages.

Historically, issues relating to changes in climate patterns and extreme weather events have generally been overlooked by government at the three levels and, consequently, themes such as urban development, risk management and adaptation to climate change have usually been treated separately. In recent years, Brazil has advanced in the implementation of public policies for urban development that combine urban planning and risk management within a prevention perspective. Recently, it has been incorporating considerations on climate change.

Among the effects of climate change discussed in Volume I of this NAP that are of greatest relevance to cities are the increase in Earth's average surface temperatures. Depending on the climatic scenario considered, these may rise by between 2 and 4°C in some regions of Brazil by the end of the 21st century. Such increases in temperature may modify moisture flows and create atmospheric conditions that are more susceptible to extreme events. There is thus increased risk of a rise in the frequency and intensity of extreme rainfall events in the more urbanized and populated regions of Brazil, especially the South, Southeast and along the Brazilian coast.

This, combined with other evidence from studies on a global scale, indicate that climate variability already poses a significant challenge and that future climate change seems inevitable. This makes it imperative to develop strategies for adaptation, in view of the issues of ethical and social justice these entail.

Although everyone will, in some way be affected, the impacts of climate change are inordinately heavier for the poor. Some precarious communities and settlements, because they are concentrated in high-risk areas with limited access to services and resources, are already under climatic-variability stress (Marengo, 2009) and particularly vulnerable to extreme events. Under such conditions, problems are exacerbated owing to a lack of resources that is reflected in lower capacity to respond to crises, thereby increasing their vulnerability to severe weather conditions expected under more intense climate-change scenarios. Addressing such challenges requires inter-institutional and joint collaboration, social-policy formulation strategies, and effective long-range integrated nation-wide adaptation programmes. Thus, the NAP acquires importance not merely as a tool for directing guidelines and actions, but also as the nexus for inter-sectoral and intergovernmental coordination.

A crucial aspect for implementation of national urban development policy relates to consonance of the actions of federal authorities with those of the states and municipalities, other Branches of government (legislatures and judiciary), and participation of civil-society in coordination and integration of investments and actions for Brazilian cities, targeted at reducing social inequality and strengthening environmental sustainability.

This Chapter thus aims: to apply a climate lens to the framework of public policies for urban planning and development and to identify no-regrets actions that contribute directly to reducing vulnerability to climate change and to development of resilient cities.

This sectoral strategy will examine the main characteristics of Brazilian cities, as well as current federal-government actions and policies targeted at addressing the latest climate-change assumptions, with a view to setting basic guidelines for adaptation to climate change in the context of urban development and related themes.

3.2 Main vulnerabilities of Brazilian cities to climate change

The vastness of Brazil's territory underscores the great variety of geographic, environmental and climatic characteristics which, in turn, affect and correlate to an array of economic, social and urban-development issues among Brazilian municipalities. The history of Brazil's development also reflects the diversity of its urban settlements, especially between micro and macro-regions of great social and economic heterogeneity.

Such heterogeneity has repercussions on the resilience of municipalities and their ability to adapt to climate change, which also relates closely to aspects of governance and democratic management (OLIVEIRA and MOREIRA, 2006). From an urban standpoint, local administrations are better able to deal efficiently with issues of infrastructure and essential public services for public well-being, and more capable of regulating and exercising control over the local-level actions of individuals and companies (SATTERTHWAITE *et al*., 2007).

Prospective impacts from climatic hazards also vary throughout Brazil, making the analysis of risks even more complex, especially when considering current and likely future effects of climate change.

As a means for guiding discussion of the next items, Table 5 presents a summary of the main relevant characteristics of Brazilian municipalities for the drafting of adaptation guidelines, based upon an assessment of current urban risks in the context of climate change. An array of approaches is required to promote adaptation in different Brazilian cities, bearing in mind that the risks inherent to climate events vary in a number of respects, and that specific knowledge of major determining factors is needed when defining municipal-level adaptation measures. However, the broad outline of this adaptation strategy will focus on a national approach, leaving local-level planning and decision-making to municipal managers and private-sector players.

As stated earlier, municipal characteristics are of crucial importance when assessing how climate change may affect a given urban system. Indeed, when defining guidelines for adaptation it is relevant to note that, according to the 2010 census (IBGE, 2011) municipalities with populations of over 100,000 account for a mere 5%, or 283, of the total of number of Brazilian municipalities (5.565) but, nevertheless, are home to more than half of the Brazilian population (54.7%, or 104.4 million).

In the light of this concentration, investment of public resources in such municipalities, which include major cities, can enhance expansion of access to improvements in urban infrastructure, including basic sanitation services and housing which, in principle, would greatly help reduce risk exposure of the most vulnerable groups. This observation notwithstanding, the need for public investments in medium and small municipalities must also be addressed in order to overcome infrastructure deficiencies, especially when the micro and macro-regions in which they are located is considered, in view of the duty of the State to reduce inter and intra-regional inequalities.

In the larger cities, social inequality and the impetus to maximize property gains during recent decades have greatly exacerbated exposure of a major portion of the population which, lacking resources and other alternatives, has been forced to settle in high-risk areas. When faced with the array of threats posed by climate change, the risks of living in such improvised urban settlements become even worst.

All too often, these same cities also have high population densities which, it is generally acknowledged, significantly increases the potential for damage, especially in informal settlements (UN-HABITAT, 2003; UTZINGER and KEISER, 2006). As a matter of location, such settlements are often exposed to hydro-meteorological disaster risks, such as landslides and flooding (NATHAN, 2008; BERTONI, 2006; COLTEN; ZAHRAN *et al.*, 2008)

Vulnerability, in such cases is specifically related to questions of health, food insecurity, insufficient access to livelihoods, lack of basic services and poor capacity on the part of managers to foster progress and initiatives for adaptation in an extensive, preventative and inclusive manner (IPCC, 2012).

The following table presents a categorization of Brazilian cities, based on size, and on major components of exposure to climate change and vulnerability. Though not exhaustive, its objective is to illustrate and guide the drafting of guidelines for adaptation and future studies to complement this still incipient knowledge.

Table 5. Characterization of Brazilian municipalities, demographic aspects (Census, 2010) and urban risks, in climate-change context

Size	Population	Municipality		Population		Geographical location	Major vulnerabilities	Exposure
		Qty.	%	Population million	%			
Small size	< 50,000	4957	89.07	64.01	33.6	North, Semiarid part of the Northeast and much of the Central-West region, northern and north-eastern of MG, south of BA, interior of PR and south of RS	Fewer resources for infrastructure and basic services. Development limitations and high socioeconomic vulnerability. Poverty. Sanitation problems	Mainly to droughts and floods. Some abrupt severe flooding. Waterborne diseases. High growth rates that can increase exposure to other dangers
Medium size	50 to 100,000	325	5.84	22.31	11.7	SP, RJ, central-south of MG, west of PR, SC and RS, north of RS, much of the coast from RS to CE, route between DF- Palmas (TO)- Belem (PA) – Manaus (AM). Scattered regions of MA, MT and RO, some capitals and metropolitan regions	Very variable. Generally, they have more resources than small municipalities. The larger the municipality, the greater the compliance with urban planning instruments. Some problems of drainage and sanitation.	Housings and economic activities in disaster-risk areas (floods and landslides) featuring different degrees of exposure, such as land use limitations. Contagion from waterborne diseases and depending on the case, of respiratory diseases
Large size	100 to 500,000	245	4.40	48.57	25.5			
	50,0000 to 1 million	23	0.41	15.71	8.2	Some capitals and industrial and development hubs, especially in the Southeast, South and Northeast.	They have more resources and capacity to deal with structural and basic services problems. Strong social inequality and consequent housing problems normally linked to sanitation. Inadequate Drainage System due to intense sealing. Resulting in contamination of the water resources	High exposure to abrupt flooding, flash floods and inundation; landslides and water crises linked to urban supply. Respiratory diseases, thermal discomfort, worsening of health conditions and the spread of some waterborne diseases
Metropolis	> 1 million	15	0.27	40.16	21.1	Capitals of SP, RJ, BA, CE, MG, AM, PR, PE, RS, PA, GO, MA and DF and another two cities in São Paulo		

A broad variety of observed urban-settlement behaviours have a direct influence on risks associated with climate change. Urban development of valley floors and channelling of rivers are common features observed in Brazilian cities. In medium and large-size cities, urban expansion has often extrapolated the original river floodplains, producing neighbourhoods with high population densities and few green areas. Suppression of vegetation results in high temperatures on constructed surfaces and, at the same time, greater susceptibility to flooding, owing to sealing of the soil (PMSP, 1999a; DAEE, 2009). In such locations, the risk of disasters is exacerbated by inability of the soil to absorb water from intense rainfall events, resulting in abrupt flooding during which roadways become the main exit routes for runoff, where floodwaters are liable to drag people and even vehicles along with them, despite relatively shallow depths (DAEE, 2009).

With respect to roadway infrastructure and urban drainage, Brazilian urban planning was much influenced by the concept of river channeling. The consequence is that watercourses are often enclosed, with a view to shifting downstream surplus flows caused by sealing of soils. Such watercourses end up receiving excess surface flows and pollution loads, including those arising from shortfalls in other urban services, e.g., urban solid wastes and poorly channelled wastewater. (NASCIMENTO *et al*., 2006; BAPTISTA and NASCIMENTO, 2002).

On the other hand, data shown in Table 5 indicates that smaller municipalities are most often located in regions with lower urbanization rates (North, Northeast and the Central-West, in this order) and that, consequently, they have different characteristics. In such municipalities, fewer public resources are available and other basic sectoral development demands (i.e., health and education) have priority. These are among the roughly 90% of municipalities that account for one third of the Brazilian population.

For these municipalities, exposure of the population relates to gradually evolving climatic processes, such as droughts and flooding, that affect more extensive areas. In such cases, risk factors do not stem from a specific urban planning problem, but rather, from land-use, settlement and migration processes taking place on a regional scale. In these areas, socioeconomic vulnerabilities tend to be more pronounced and may exacerbate already existing problems relating to poor sanitation, infrastructure and housing. The Special Report on Managing the Risks of Extreme Events and Disasters to Advance to Climate Change Adaptation (SREX) (IPCC, 2012) emphasizes that climate change is an additional factor which contributes to impacts relating to such events, and that local vulnerabilities pose the main determinant risk factors.

For smaller municipalities, adaptation needs to be promoted primarily as a means of reducing vulnerabilities, especially those of a socioeconomic nature, and providing opportunities for sustainable development in its broadest sense. Such an approach can prepare these municipalities to advance toward a future with better planning and layout of urban spaces, and in which local resilience to climate threats that have historically afflicted them has been sufficiently assimilated so as to enable them to minimize the impacts of climate change.

In terms of growth and recent urban expansion, two processes related to adaptation are of concern to urban planners: fragmentation and verticalization. Areas for urban expansion in towns with high growth rates, especially smaller-size towns in the North, Northeast and Central-West, tend to suffer increasing fragmentation and dispersion. This causes encroachment into the countryside and onto productive farmland and areas with important environmental functions, such as buffer zones for protection of water sources, hillsides and aquifer-replenishment areas. Such pressures may contribute toward greater social inequality and environmental degradation.

In areas where towns are more consolidated, as is the case in many medium and large-size cities, increasing verticalization takes place in central and more affluent regions, while population densities rise on the peripheries. This leads to loss of socio-environmental quality, greater compaction and loss of soil permeability and subdivision of properties (PBMC, 2014).

In summary, many of the current risks present in urban regions will tend to be exacerbated in a future scenario of climate change. However, impacts can be minimized or avoided through adoption of no-regrets adaptation measures targeted at reducing current risk factors and introduction of more robust urban-planning and development guidelines and policies.

3.3 Overview of urban-development policies and potential adaptation actions

This section presents a summary of the main urban planning and development actions and instruments in effect or foreseen in public policies. The objective is to present aspects of government activities that contribute toward reducing some of the aforementioned vulnerabilities.

3.3.1. General Aspects

Under Brazil's federative structure, the Union, the states and the municipalities are autonomous bodies, with competencies defined in the Federal Constitution (CF). The Union (or Federal Government) has the power to set guidelines for urban development, including basic sanitation and urban transport (Art. 21, XX). The Federal Constitution states that it is the competence of the municipalities to provide services of local interest. In this respect, municipalities are responsible for implementation of urban development policies, with a view to organizing full development of a town's social functions and ensuring the well-being of the population (as defined in the caption of CF, Art. 182).

To enable implementation of these constitutional provisions, the Cities Statute (Law 10257/2001) establishes general guidelines for urban policies. One such guideline establishes a guarantee of the right to sustainable cities, meaning the right to housing, environmental sanitation, urban infrastructure and transport, among other services (Art. 2, I). These guidelines are convergent with basic premises for adaptation in urban centres and provide support for reducing risks and mitigating many of the vulnerabilities related to climate change, while contributing toward making cities more resilient.

In view of this normative framework, intergovernmental cooperation and coordination becomes indispensable. This is especially the case when the solution to large and complex urban issues depends upon shared management and administrative cooperation measures, as is the case of management of river basins, conurbations and sprawling metropolitan regions. The Metropolis Statute (Law 13089/2015) sets guidelines for planning, management and execution of public functions of common interest in metropolitan regions and conurbations within states and establishes general standards for integrated urban-development planning and other instruments for shared governance, defining criteria for federal-government support for governance actions in the field of urban development.

In consonance with the aforementioned constitutional provisions, and to ensure alignment of the main current planning instruments, integrated urban and environmental planning and management systems need to be adopted. These include: Municipal Master Plans, River Basin Plans, Municipal Environment Plans, the Local Agenda 21, Integrated Shoreline Management Plans, Municipal Integrated Solid Waste Management Plans, Municipal Basic Sanitation Plans, Municipal Disaster Risk Reduction Plans, Mobility Plans and Local Social Housing Plans. Such integration is of utmost importance, since all sectoral plans targeted at ensuring and enhancing the quality of life in urban contexts, also serve as environmental-planning instruments of immense importance for reducing the vulnerability of municipalities to future climate-change impacts and for increasing their adaptative capacity.

3.3.2. Federal Government sectoral policies for cities as tools for fostering adaptative capacity

One of challenges that the Cities Statute has posed for government is reversion of a widespread characteristic of Brazilian cities, also common in many cities throughout the world, namely: spatial segregation. Affluent neighbourhoods that have leisure areas and modern urban facilities, coexist alongside immense outlying neighbourhoods and slums, marred by precariousness or total lack of infrastructure, irregular land tenure, flooding and landslide risks, shoddy building standards and degradation of areas of environmental interest.

Creation of the Ministry of Cities, in 2003, signalled the Brazilian Government's commitment to transforming this scenario. This Ministry received the mission of supporting states and municipalities in the formulation of a new urban-development model that contemplates housing, sanitation, mobility, accessibility and urban renewal programmes.

Throughout Brazil, the Ministry of Cities concentrates efforts on four major areas that contribute directly to reducing current vulnerabilities and, more indirectly, toward mitigation of future climate-change threats.

The first of these areas is urban planning and implementation of the Cities Statute, by means of dissemination of methodologies and support for public participation in the drafting and implementation of Municipal Master Plans, through promotion of the National Campaign for Participatory Master Plans. A Municipal Master Plan (PD) instituted by a municipal law, is the main municipal planning instrument for urban expansion and development throughout the territory of the municipality (Cities Statute, Law 10257/2001), All municipalities with populations greater than 50,000 must have a Municipal Master Plan.

The second area of intervention of MCid is social housing. To tackle housing issues, Brazil currently has three instruments that contribute toward reducing vulnerability to climate change: 1) actions for urbanization of precarious settlements, as a strategy for redeeming social liabilities relating to an accumulated housing deficit; 2) large-scale production of social housing, as a strategy for settling the housing deficit and assuaging future demand for housing; 3) regularization of land-tenure issues in the social interest.

The Programme for Urbanization of Precarious Settlements seeks to provide improved housing conditions for people living in high-risk areas. Actions under this programme are covered by the Growth Acceleration Programme (PAC) to which the states, the Federal District and municipalities may submit proposals for addressing urban-planning, housing, land-tenure, social and environmental issues. Projects for urbanization of precarious settlements must provide solutions for all diagnosed needs in the area, and especially those relating to mitigation of risks and adoption of measures for reducing population densities through reordering of settlement patterns. Projects submitted must encompass deployment of basic infrastructure, containment and stabilization of hillsides for elimination or mitigation of landslide risks, recovery of degraded areas, construction of public facilities, improved roadway systems, and control of subdivisions, with a view to enabling access to public utility and emergency services, land-tenure regularization and social-welfare services.

Moreover *Minha Casa Minha Vida* (PMCMV) a programme that promotes home ownership for low-income families, distributes deeds to decent housing, served by basic infrastructure and services in urban and rural areas of Brazilian municipalities. Through integration among sectoral policies and coordination with other urban-planning and economic-development instruments, the PMCMV is an important instrument for refurbishing degraded, environmentally-fragile and headwater areas, through promotion of settlement of empty urban spaces and better planned urban expansion. The programme prioritizes families living in high-risk or unhealthy areas, or that have been left homeless owing to states of emergency or public disaster.

The third area of intervention, whereby MCid contributes toward reducing vulnerability to climate change is environmental sanitation. The main elements of the National Basic Sanitation Plan (PLANSAB) approved in December 2013, are universal provision of safe drinking water, and access to wastewater collection and treatment. According to data from the National Sanitation Information System (2013) the greatest deficiencies in sanitation relate to sewage collection, since only 56.3% of Brazil's urban population is connected to wastewater networks.

In order to promote full access to basic sanitation services (i.e., safe drinking-water supply, collection and treatment of wastewater, storm drains, street cleaning and urban solid-waste management) and to achieve universalization goals, initiatives have focused on structural measures (principally strengthening of management and planning capacities) and support for local interventions of states and municipalities. Such interventions include sustainable urban drainage works and projects targeted at reducing flood risks, improvement of wastewater infrastructure and of environmental safety in municipalities; deployment of water-supply and wastewater systems in urban areas, and support for street cleaning and urban solid waste management.

MCid's participation in sanitation-sector activities is targeted at municipalities with populations of over 50,000 and those that comprise Metropolitan Regions and Integrated Development Regions. In smaller municipalities and rural areas, sanitation activates are carried out under the auspices of the Ministry of Health, through the National Health Foundation (FUNASA).

Urban development actions often intersect with risk-management and disaster-response activities. These are addressed by the National Plan for Risk Management and Responses to Natural Disasters, launched by the Presidency of the Republic on 8th August 2012. (For further details, see the Strategy on Disaster Risk Management). Within the framework of this Plan, MCid conducts initiatives for risk mitigation, through support for structural works for containment of hillsides, urban drainage and flood control, and measures for mitigating the effects of prolonged drought in semi-arid regions through construction of infrastructure for collection, distribution and storage of drinking water. Such initiatives and interventions, whenever possible, should focus on reinforcing capacities for adaptation to climate change, in consonance with the principles of Ecosystem-based Adaptation (EbA).

MCid maintains close ties with the Geological Survey of Brazil (CPRM) which, aside from its main attribution of conducting basic geological surveys, also promotes knowledge on risk areas and conducts zoning exercises for municipalities, through preparation of geotechnical maps showing areas suitable for urban settlement and of vulnerability to disasters, in 821 priority municipalities.

For containment of hillsides, MCid engages in three types of activities: planning (Municipal Risk Reduction Plans (PMRR); projects; and engineering works. In view of their contribution toward reducing urban risks and addressing vulnerabilities relating to the lack of infrastructure and of adequate urban-planning instruments, such actions need to be reinforced and expanded in the coming years.

Finally, the fourth area in which the MCid intervenes in urban development is urban mobility. The National Urban Mobility Policy (PNMU) in conjunction with similar policies and strategies at state and municipal levels, seeks to ensure socially-inclusive and sustainable democratic access to towns and cities, prioritizing collective and non-motorized transport. From the standpoint of this NAP, however, the theme of urban mobility is examined in greater detail on the sectoral strategy for infrastructure.

3.4 Priority guidelines for adaptation

In pursuit of adequate urban development, the investment plans of Brazilian cities seek to incorporate strategies for adaptation to climate change and reduction of vulnerabilities. Such planning entails careful evaluation of climate risks and requires integrated land-use and settlement guidelines for installation of the necessary infrastructure. Moreover, adoption of concepts that reinforce urban sustainability, with lower consumption of natural resources, can greatly contribute to the adaptative capacity of cities.

The main objectives of these proposed guidelines are to rank efforts for fostering the resilience and adaptation capacity of municipalities and to prioritize no-regrets measures and actions for urban development which contribute, directly or indirectly to reducing vulnerability to climate change. There follows a summary of these guidelines.

1. Promote coordination among the three levels of government with a view to fostering cooperation for reducing vulnerability to climate change through integrated territorial planning and management by states and municipalities, especially in areas of public interest in metropolitan regions and conurbations;

2. Consider adaptation to climate change in processes of rehabilitation of consolidated and degraded urban areas, with a view to fostering urban diversity and limiting urban expansion and exposure of the population to risks arising from inadequate land-use and settlement patterns;

3. Consider adaptation to climate change during processes for promoting urbanization of precarious settlements, with the aim of improving housing and living conditions of the population through integrated approaches such as installation of urban infrastructure, housing improvements, land-tenure regularisation, environmental restoration and social-welfare;

4. Consider adaptation to climate change during large-scale projects for production of social housing, ensuring conveniently-located housing for low-income families living in situations of vulnerability, through decent and resilient infrastructure, with access to urban, social and cultural goods and services and leisure opportunities;

5. Strengthen urban planning integrated with policies and practices for prevention of disasters and risks, through specific urban-expansion projects, setting standards for urban land-use, settlement and land subdivision procedures, with a focus on adaptation to and mitigation of risks posed by climate change;

6. Promote engineering works for containment of hillsides and formulation of Municipal Disaster Risk-Reduction Plans (PMRR), increase the number of municipalities benefited, particularly those listed on the National Register of Municipalities with Areas Susceptible to Landslides, Floods or related Geological or Hydrological Processes (CadRisco) as foreseen in Law 12608, of 10th April 2012;

7. Incorporate measures for adaptation to climate change into actions for implementation of the National Basic Sanitation Plan (PLANSAB);

8. Strengthen actions for Sustainable Urban Drainage targeted at reducing flooding, through works and services including containment basins, heavy-runoff control structures, seepage-drainage systems, riverside parks, recovery of floodplains, restoration of floodplains, and other related measures. Such sustainable drainage actions, whenever possible, should comply with Ecosystem-based Adaptation (EbA) principles;

9. Support implementation and improvement of water-supply and wastewater services, taking into account socio-economic, public-health, ecological and infrastructural aspects of measures adopted, so as achieve health and environmental benefits directly associated with such systems seeking, in particular, decontamination of water bodies, multiple use of water, greater energy efficiency, and use of biogas from wastewater and urban solid-waste treatment, and other renewable energy sources;

10. Support actions for improvement of street cleaning and management of solid wastes, with the aim of expanding pre-sorting in municipalities, appropriate disposal of tailings and eradication of landfills, since more intense rainfall arising from climate change may exacerbate outflows of slurry from dumps that contaminate water bodies, exacerbating the effects of inadequate waste disposal on watercourses, in dumps and in densely populated urban areas, aggravating flooding risks;

11. Support the management and dissemination of information related to climate changes, as inputs for the drafting of diagnostic studies and development of strategies for adaptation, in synergy with urban planning;

12. Support studies on the impacts of climate change in different cities, as inputs for development of adaptation methodologies for urban infrastructure within urban development policies;

13. Support capacity building for human resources and dissemination of information management technologies, to assist in implementation of strategies and methodologies;

14. Incorporate adaptation to climate change into enhanced urban planning models, with a view to fostering management of land-use and settlement through approaches that respect environmental preservation and mitigate disaster risks;

15. Support coordination of initiatives for review of regulations and technical standards for buildings and urban-planning, with a view to promoting resilient buildings and urban infrastructure.

Strategy for Disaster Risk Management

National Adaptation Plan to Climate Change

4 Strategy for Disaster Risk Management

4.1 Introduction

In Brazil, Civil Defence is organized under the National Civil Protection and Defence System (SINPDEC) comprising various federal, state and municipal bodies, community-based and voluntary organizations. This Chapter was prepared by the National Secretariat for Protection and Civil Defence (SEDEC), focal point for its implementation, in coordination with the Secretariat for Climate Change and Environmental Quality of the Ministry of Environment. Other collaborators include the Ministry of National Integration (MI), the National Centre for Monitoring and Early Warning of Natural Disasters (CEMADEN), the Brazilian Geological Service (CPRM), the Ministry of Planning, Budget and Management (MPOG), the Ministry of Cities (MCid) and the National Institute for Space Research (INPE).

The impact of climate change is regarded as one of the contributing factors to increased disaster risk. Risks stem from the intersection of three factors. Firstly, threat stemming from extreme weather conditions, exacerbated by current climate-change trends. Secondly, vulnerability of populations to disasters, i.e., their capacity to prepare and recover effectively in the aftermath of a disaster. Vulnerability has a multidimensional characteristic, linked to underlying factors such as poverty, schooling levels, risk perception, sensitivity to damage, susceptibility, low capacity to adapt and low resilience. Thirdly, exposure of human systems and settlements in areas susceptible to phenomena such as flooding and landslides, referred to as "risk areas".

Widespread unplanned urban expansion over the past 60 years has resulted in concentration of vulnerable populations in risk-prone areas. Such populations are thus exposed, both to sudden disasters, such as landslides, floodwaters, etc., and to gradual natural processes, such as drought and flooding. Increases in the number of disaster events, in recent decades, can be attributed to the sum of those three factors. Furthermore, it has been scientifically documented that the climate extremes that trigger such disasters are occurring with greater frequency and, all too often, with increasing intensity.

The Intergovernmental Panel on Climate Change (IPCC) Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX - IPCC, 2012) highlights that there is high confidence in asserting that the intensity of extreme climate and weather events and exposure to them tend to be factors more commonly associated with damage caused in major disasters than to vulnerabilities of human systems. However, for less extreme events (with greater probability, less intensity) the vulnerability of elements exposed plays an increasingly important role in explaining the level of the impacts. Thus, vulnerability is one of the main causes of the increase in adverse effects of non-extreme events, i.e., small-scale recurrent "disasters", which generally attract less attention at the national or local level (MARULANDA ., 2008b, 2010, 2011; UNISDR, 2009a; CARDONA, 2011; UNISDR, 2011).

According to the SREX, even discounting the effects of climate change, disaster risks will continue to rise in many countries, including Brazil, as more people and vulnerable assets (e.g., on the outskirts of large cities or scattered over semi-arid areas) are exposed to natural climatic variability. On the other hand, evidence based on historical series dating back to 1950 suggests that climate change has already altered the magnitude and frequency of some extreme weather events related to climatic conditions in certain regions. Nonetheless, it remains very difficult to attribute individual events to climate change alone.

In this respect, climate change means an additional stress factor for each type of disaster. This Chapter presents information and inputs for this debate, with the aim of outlining strategies for reducing risk and promoting adaptation, in line with Brazilian priorities and needs.

There is a pressing need to invest in scientific knowledge relating to all dimensions of disasters, in line with new 21st century knowledge-society paradigms. In this context, the new post-2015 Sendai Framework for disaster risk reduction, agreed between the UN member countries at the Third World Conference on Disaster Risk Reduction, is based on the following four areas of priority action:

1) understanding of the disaster risk; 2) strengthening of governance; 3) investment in reducing disaster risk and increasing resilience; and 4) improved preparation for disasters.

The main objective of this Strategy is to promote actions targeted at developing capacities for reduction of risks and preparation and response to disasters in the context of climate change.

4.2 Disasters in Brazil and vulnerabilities related to climate-change

Disasters of different types in Brazil are almost always related to hydro-meteorological and climatological events, in which rainfall (shortage or in excess) is principally responsible for triggering physical processes that jeopardise populations and livelihoods. In view of its vast size and environmental, climatic and geological diversity, Brazil is susceptible to a broad array of disasters. These disasters are directly related to socioeconomic and urban vulnerabilities combined with distinct exposure scenarios.

Table 6 provides a summary of these different types of disasters, listing significant aspects to guide proposals for adaptation presented at the end of this Chapter. It is based on data from the Brazilian Atlas of Natural Disasters

(UFSC, 2013) and provides percentages of people affected and reported deaths, by region, caused by adverse events, as a proportion of the total of such events in Brazil, between 1991 and 2012.

Table 6. Regions of Brazil and principal features of disasters

Region	Main types of disasters	% of people affected 1991-2012	% of deaths CEPED (2013)	Relevant and determining characteristics of disaster risk
South	Great diversity, highlighting droughts and dry periods, sudden floods and windstorms / cyclones	22.68	13.43	Severely affected by storms, gales and hail. The only Brazilian region ever hit by cyclones (coastal zone). Affected by many weather instability systems and atmospheric blocking. THREAT is a crucial vector for intensification of current and future risks.
Southeast	Landslides, floods, flash floods and inundation. Droughts in the north and northeast of Minas Gerais State.	22.17	66.56	High population density combined with unplanned settlement in risk areas (high exposure). Great social disparities and high vulnerability of different social groups. The highest numbers (roughly 28.50) deaths/ million pop. The SE region accounts for 79% of recorded landslides in 1991-2012, with the State of MG accounting for 60%.
Central-west	Diversified. Gradual flooding, droughts, flash floods and erosion and recurrent forest fires.	4.09	0.41	Agricultural vocation, low population density (lower exposure). Few historic series for identification of disaster patterns. Merits attention in view of recent development with introduction of new vulnerabilities and increased exposure.
Northeast	Mostly drought,. Flooding (gradual or sudden) causing major impacts.	44.09	15.84	High inter-annual rainfall variability and low water storage capacity pose limitations for local development (threat). Metropolitan regions highly exposed and vulnerable to flooding, displacing many people and causing significant numbers of deaths. Region with the largest numbers of people affected by disasters (47.63%)
North	Flooding (gradual and sudden) and drought	6.97	3.80	Riverside populations strongly affected by flooding (exposure) with associated health risks (social vulnerability). Livelihoods directly impacted by drought (exposure and economic vulnerability)

The events that most afflict humans are flooding and landslides caused by extremely heavy rainfall. Findings of a survey (UFSC, 2013) reveal that, between 1991 and 2012, these two types of disasters alone accounted for 73.79% of disaster deaths in Brazil. The South and Southeast regions lead the ranking of these disasters. The Southeast region, which features large population densities, is also the region with a highest percentage of disaster-related deaths in the 1991-2012 period, accounting for 66.56% of the total reported, and the highest ratio of deaths per million population (roughly 29.5 deaths/million pop.).

On the other hand, a major portion of Brazil is affected by climate events that lead gradual physical processes, such as drought and seasonal flooding. As they tend to cover large areas for longer periods, such events may affect the lives and livelihoods of great numbers of people. The occurrence of these events tends to be cyclic, if not in regular progressions, they often develop incrementally, with gradually worsening effects. In some cases, seasonal climate events are part of natural regional-climate dynamics, for which local populations are capable of preparing, thereby reducing their exposure to the intensity of impacts.

The region most affected by drought and extended dry periods is the Northeast where, all too often, these impacts impose restrictions on local economic development. The North, Central-West, and Northeast combined accounted for roughly 20% of such deaths between 1991 and 2012, but had the largest portion (55.15%) of affected people (UFSC, 2013). The Northeast region alone accounted for 44.09% of the nearly 29 million people affected by such events between 1991 and 2012.

Changes in seasonal weather patterns, especially in rainfall (excess or shortage), anthropogenic factors, and the vulnerability of human systems may induce, facilitate and accelerate the onset of disasters, thereby contributing toward intensification of their impacts. The influence of anthropogenic (non-climatic) factors is variable for each type of disaster. This makes an analysis of the influence of climate change on the increased occurrence of such disasters a complex task and emphasises the need for further knowledge on characteristics of the relationships of their temporal and spatial repercussions.

This rationale and conceptual framework is important for clarification of the role of various factors that increase disaster risk linked to vulnerabilities not associated with climate-change variables. In this context, climate-change effects are considered an additional factor in the disaster risk management. Table 7 presents the relationship between extreme events, climate change, and the occurrence of different types of disaster in Brazil. It also provides information on confidence levels as to each of the impacts of climate change relating to extreme events (threats) and with respect to uncertainties of future climate projections for assessment of disaster typologies, in the light of existing vulnerabilities.

One factor that complicates analysis of the data presented in the Table below is the relatively small number of historical climate change and extreme event studies in Brazil.

Table 7. Synthesis of information on issues relating to types of disasters that afflict the Brazil, extreme events and climate change

[1]	[2]	[3]	[4]	[5]	[6]	[7]	8	9
Type of disaster	**% of people affected**	**% of deaths**	**THREAT triggering climate events of (1)**	**Effects of CC on THREATS presented in (4)**	**Degree of confidence in the response in (5)**	**Probability of effects (5) for future projections**	**Major anthropogenic interferences and vulnerabilities that trigger impacts of the process presented in (1)**	**From analyses of (5), (6), (7) and (8), the relationship between climate change and occurrence of disasters (1)**
Landslides	1,79	15,6	Extreme events of rainfall (those that occur in a few hours as well as those that occur during several days	Increase in the frequency and magnitude of the extreme events listed	HIGH regarding extreme events. LOW for the occurrence of landslides and inundations (little evidences)	HIGHLY PROBABLE	Irregular slope profiles, erosion processes at the base of the slope, deforestation of hillsides, poorly planned storm water systems, overload due to construction in risk areas, among others	Unlikely. However, it is considered very difficult to separately assess due to the various anthropic constraints and also the vulnerabilities because both are temporally and spatially variable. There are few registers and metrics (indicators) to do such an analysis with conclusive results. The increase in exposure is also considered a key-factor for the two types of disasters.
Sudden flash floods, flooding and inundations	20,66	58,15	Extreme events of rainfall over short periods of time (especially in a few hours)				Deforestation of APPs, suppression of ecosystem services (i.e. reduction in the infiltration potential, increase in surface drainage, etc.) degrading land use, deficient storm drains, large surfaces sealed, among others	
Gales and cyclones (wind effects)	7,07	3,74	Storms accompanied by strong winds, sometimes with hail	Increase in the frequency and magnitude of the extreme events listed	LOW (lack of data, complex analysis)	PROBABLE	No direct relation, the anthropogenic effects of GGE emissions and changes in land use and vegetation cover, which are related to the global and regional/ local climate changes	Probable. Even with the uncertainties. The unprecedented occurrences in the South region during the past decade are significant evidence (intensification in the THREAT vector)
Droughts	51,31	7,57	Dry periods, poor distribution of the rain, increase in the temperature (increase in evapotranspiration)	Intensification of the ENSO events, TSM anomalies in the Tropical or Subtropical Atlantic (reduced rainfall) displacement of humidity flows and increase in surface temperatures	MEDIUM for the dry season and LOW for the rainy season. (lack of data and inconsistencies)	HIGHLY PROBABLE for the NE and western Amazon, mainly in the dry season. Note: Highly probable that inter-annual variation is controlled by ENSO events	Changes in land use and vegetation cover. However, "drought" in the context of a disaster, depends much more on VULNERABILITIES of the social groups affected than on climate conditions (Castro, 2002). Degrading land use is also seen as a factor that favours, indirectly, storage of water in the soil and can contribute to this scenario.	Unlikely. But the change in temperature and rainfall patterns from observations and modelling, has been coherent with theoretical understanding of the hydrological response to the global warming, where dry regions become even drier and the humid ones more humid, in a warming world. It is still necessary diligently to evaluate the evolution of disasters to reach significant conclusions.
Heavy rainfall	12,04	13,4	Increase in rainfall in the seasonal regimes	Intensification of the ENSO events, TSM anomalies in the Tropical or Subtropical Atlantic, causing changes in the seasonal rainfall regime (increase)	LOW (lack of data and inconsistencies)	HIGHLY PROBABLE for the South of Brazil and Western Amazon	Engineering works that can either favour or contain (dykes and reservoirs) interferences in the environment, especially changes in land use and vegetation cover that do not appear clearly in the historic registers	

Further studies and evidence are needed to establish a clear link between climate change and the disasters that cause the greatest numbers of deaths (sudden floods and landslides). Although records point to an increase in the number and frequency of extreme events, studies carried out in Brazil show a greater correlation to rising population densities than to climate change (UFSC, 2013). Increasing occurrence of disasters may be a consequence of greater exposure stemming from rapid urbanization patterns and their associated social inequalities and socioeconomic vulnerabilities. In conclusion, adequate land use and planning are the essential elements for reducing disaster risks.

In some cases, it must be acknowledged, exposure to certain types of events cannot be avoided. Territorial planning and sound decision-making as to the location of settlements and economic activities, in such cases, needs to be accompanied by other structural or non-structural approaches to preventing or reducing risks (UNISDR, 2009a; ICSU-LAC, 2010a, b). Approaches of this type that have been pursued in Brazil in recent years are examined in greater depth in the Chapter on the Strategy for Cities.

Droughts and flooding are mainly attributable to El Niño Southern Oscillation (ENSO) events, which are likely to intensify with climate change. For drought, especially in the Northeast of Brazil, climate predictions derived from climate modelling (Volume I of this NAP) indicate a trend toward more extended periods without rain. Indeed, increased desertification is yet another of the inherent risks of climate change. However, the occurrence of disasters is not conditioned solely to climate factors, but also to local vulnerabilities. Thus, initiatives that foster economic and social development, sustainable land use practices and installation of adequate infrastructure are essential for reducing the climate risk.

Regionalized climate models provide an approach for reducing uncertainties relating to analyses that rely on global climate models for evaluation of extreme events and their relationship to disasters. Such models are capable of presenting the peculiarities of continental atmospheric phenomena in greater detail, thereby considerably improving assessments of rainfall variability. For the Third National Communication to the UNFCCC, a study was conducted to assess, from a climate-change perspective, the vulnerability of Brazilian municipalities to the two types of disasters that cause the greatest numbers of deaths in Brazil: 1) sudden floods, storm runoff, and flooding; and 2) landslides.

This study postulated that, by the end of the 21st century, vulnerability to climate change is likely to rise in many places current considered at high-risk of disasters. Its analysis focused on the increase in frequency and magnitude of extreme events, from a climate change perspective, while keeping other variables constant.

Among the findings of the study were that, for the risk of sudden floods, the South and Southeast were the regions where vulnerability most increased, followed by virtually the entire Brazilian coastline between Rio Grande do Sul and Ceará. For landslide risk, the greatest vulnerabilities can occur: in the States of Paraná and Santa Catarina (especially the Vale do Itajai); in the Serra do Mar and Serra da Mantiqueira; in southern and south-eastern Minas Gerais; followed by certain locations in the Northeast region.

4.3 Overview of the main disaster-risk management initiatives for adaptation

The terrible disaster that hit the hills (*Região Serrana*) of the State of Rio de Janeiro in January 2011 contributed to important changes on disaster-risk management in Brazil. It shifted the public-policy focus from response, post-disaster recovery and reconstruction, to more preventative approaches, targeted primarily at safeguarding human lives. Reflecting this change, the National Plan for Risk Management and Response to Natural Disasters (2012-2014) has allocated 85% of its funding for prevention, targeting:

(1) structural construction works; (2) better understanding of risks, through mapping; and (3) foreknowledge of disaster risks, through the upgrading of the national monitoring and early-warning network.

The National Plan for Risk Management and Response to Natural Disasters (PNGRRD) entrusts coordination and monitoring to the *Casa Civil* (SAM/CC) of the Presidency of the Republic and with representatives of the following federal public institutions: the National Secretariat for Protection and Civil Defence/MI and its National Risk and Disaster Management Centre (CENAD/SEDEC/MI), the National Centre for Monitoring and Early-Warning of Natural Disasters (CEMADEN/MCTI), the Ministry of Cities (MCid), the Brazilian Geological Service (CPRM/MME), the National Water Agency (ANA/MMA), the Ministry of Health (MS), the Secretariat for Planning and Strategic Investments (SPI/MPOG), the Secretariat of the Growth Acceleration Programme (SEPAC/MPOG), the Federal Budget Secretariat (SOF/MPOG), the Department for Control of Airspace (DECEA/MD), the National Treasury Secretariat (STN/MF), the Comptroller-General (CGU), and the Ministry of Communications (MC).

During preparation of the National Multi-Year Plan (PPA 2012-2015) the main agencies involved with the theme of disasters gathered to draft a programme focused on prevention, building upon past experience, academic contributions, civil-society mobilization and the other branches of the government. Based upon this decentralized approach, objectives, goals and initiatives were drafted for the 2040 Programme – Risk Management and Response to Disasters (www.planejamento.gov.br), involving the Ministries of National Integration; Cities; Science, Technology and Innovation;

Mines and Energy; and Environment, with participation of the Ministry of Foreign Affairs (MRE) for international advisory.

Programme 2040 represents a combining of forces on the part of the public administration to promoting integration of to databases and information formerly compartmentalised in different public institutions.

Targeting of actions under Programme 2040 entailed identification of municipalities considered most critically susceptible to disasters. Based on the Atlas of Natural Disasters (UFSC, 2012) 821 critical municipalities, accounting for 94% of deaths and 88% of people affected by disasters between 1991 and 2010, were identified. Of these, special priority was awarded to 286 municipalities that account for 89% of deaths and 55% of people displaced or made homeless (Figure 3).

Figure 3. Location of the 821 municipalities targeted for priority actions under the Programme for Risk Management of Risks and Response to Disasters (PPA 2012-2015)

This approach, involving an array of ministries has proven effective. Moreover, now under the title Programme 2040 – Disaster Risk Management, it was maintained in the Brazilian federal government's main planning instrument (PPA 2016-2019).

4.4 National Protection and Civil Defence Policy and System

The National Policy for Civil Protection and Defence (PNPDEC) brought into effect by Law 12608 of 10th April 2012, States that it is the duty of the Union, states, Federal District and Municipalities to adopt measures necessary for reducing disaster risks, and that these may be applied in collaboration with public, private or civil-society bodies.

The PNPDEC encompasses actions for prevention, mitigation, preparation, response and recovery, targeted at promoting civil defence. It provides for the National Protection and Civil Defence System (SINPDEC), comprised of federal, state and municipal administrations, and of public and private organizations with significant engagement in the field of protection and civil defence, as shown in Figure 4.

Figure 4. Overall organization of SINPDEC

The Table below describes some innovations that can promote adaptation to climate change and reduction of disaster risks brought in under the PNPDEC.

Integration of policies for territorial planning, urban development, health, environment, climate change, water-resources management, geology, infrastructure, education, science and technology and other sectors, with a view to promoting sustainable development;
A systemic approach to prevention, mitigation, preparation, response and recovery actions;
Closer coordination among federal, state and municipal authorities for reducing disaster risks and providing support for affected communities;
Drafting and implementation of Protection and Civil Defence Plans at the three levels of government;
Creation of the Disaster Information and Monitoring System;
Constant professional training and capacity building for civil defence and protection agents;
Creation of a national register of municipalities with susceptible areas to major landslides, sudden flooding or related geological or hydrological processes; and
Inclusion of the principles of civil defence and protection in elementary and secondary-school curriculums.

Such actions, though primarily targeted at management and reduction of disaster risks, will also help increase the capacity of Brazilian municipalities to adapt to climate change. Moreover, they are necessary for tackling pressing current problems in Brazil and should thus be reinforced, especially in the light of augmented risks foreseen in a context of climate change.

There follows a list of the main national policies and plans referred to in the PNPDEC of crosscutting and synergistic relevance to other sectors:

Cities Statute- Law 10257, of 10th July, 2001;
National Environment Policy - PNMA (Law 6938, of 31st August, 1981; Enabling Decree approved in 1990);
National Environmental Education Programme- PRONEA (2005);
National Education Plan- PNE (2012);
National Climate Change Policy- PNMC (Law 12187, of 29th December 2009);
National Water Resources Policy (Law 9433, of 8th January 1997);
National Regional Development Policy– PNDR.

4.5 Early-warning and monitoring system

The guidelines of the PNPDEC acknowledge that it has become essential to institute an early-warning and monitoring system that brings together scientific and technological expertise from various fields, including meteorology, hydrology, geology and disasters. To address this need, in 2011, the Ministry of Science, Technology and Innovation (MCTI) established the National Center for Monitoring and Early-Warning of Natural Disasters (CEMADEN). Considering that the quality of disaster warnings depends on the capacity to observe the natural phenomena that trigger them, founding of this Centre necessarily entailed implementation of a modern environmental observation network.

CEMADEN currently monitors 957 municipalities where it has mapped areas at risk of landslides and flooding. It also monitors over 1000 municipalities in the semiarid region of Brazil's Northeast for risk of crop failure and food production during extended dry seasons and periods of intense drought.

Current efforts are concentrated on development of numerical models for very short-term rainfall forecasting based upon data from meteorological radar, geotechnical and hydrological models for prediction of landslides, floods and flooding, and models for prediction of crop failure, of family farming in Brazil's semiarid Northeast region.

Within the scope of the PPA 2012-2015, institutional coordination of the CEMADEN with other agencies involved in disaster prevention (such as ANA and CPRM) within the National Protection and Civil Defence System has resulted in generation of new knowledge on the physical environment, processes that trigger major events and areas susceptible to disasters. Such knowledge is applied in the deployment of prevention strategies and shared, through CENAD, with other agencies that participate in the system.

CPRM is the body that provides the largest amounts of information on areas of risk, through mapping and classification of high and very high-risk areas in the 860 priority municipalities identified. In the field of water-resources management, CPRM also performs an important role in partnership with ANA, through operation of 76% of the National Hydro-meteorological Network and issuing of flood-risk forecasts and early-warnings of flooding. CPRM also operates the Groundwater Information and Monitoring Network (RIMAS) under which there is a programme for drilling wells, targeted at municipalities in the semiarid region. In terms of disaster prevention, through land-use management actions, within the scope of the National Protection and Civil Defence System, CPRM drafts maps of geotechnical susceptibility to landslides and flooding for priority municipalities. Moreover, in partnership with the Ministry of Cities, its geotechnical maps are used for determining the suitability of areas for urban settlement, from a disaster perspective.

The National Secretariat for Civil Protection and Defence, through its center

CENAD, consolidate risk-management information, such as data on the occurrence of natural and technological disasters and collateral damage. Management of such information makes it possible to support states and municipalities prepare for disasters and afford protection to more vulnerable communities. It also enables streamlining and optimization of responses and of cooperation with states and municipalities when disaster strikes. CENAD is also responsible for coordination with other technical agencies (e.g., in the fields of hydro-meteorology, geology, hazardous products, etc.) that work with forecasting and monitoring information, to obtain inputs for its protection and civil-defence activities.

4.6 Gaps identified

There follows an assessment of information gaps identified in the sectoral analysis. Filling such gaps is considered one of the main indirect measures for fostering adaptation, since it would enhance public-policy actions underway or foreseen for disaster risk management in the context of climate change:

Details for analysis of vulnerability: For risk management at the municipal level, the level of detail of information needs to be greater than that provided in the census. One alternative is to break down data to the urban-block level. Measurement at this scale is being tested by CEMADEN, in partnership with IBGE.

Implementation failures of the National Policy for Protection and Civil Defence (Law 12608): Though enacted in 2012, the PNPDEC has not been brought fully into effect. Consequently, several of its provisions lack clarity, thereby leaving scope for implementation gaps. Strengthening of SINPDEC, with a view to improving coordination and management of actions for preparation, prevention, mitigation, response and recovery, and protection and civil defence, is one of the benefits that could be achieved by an Enabling Law. The national registry of municipalities with areas susceptible to landslides and flooding has proven an important planning tool for actions targeted at these municipalities. Law 12608 foresees establishment of a Disaster Information and Monitoring System, an instrument of inestimable importance for filling gaps stemming from poor integration among databases on the occurrence of disasters. Gaps left after enactment of Law 12608 include: a) deficiencies in the management structure for coordination of actions provided for in the PNPDEC; b) failure to draft a National Plan and State-level Plans for Protection and Civil Defence, also foreseen in this Law; c) lack of continuity of actions for protection and civil defence, owing to disparities between agencies at the different levels, and d) failure to implement capacity-building strategies;

Actions relating to urban planning: some progress has been made in recent years with regard to urban planning and measures targeted at reducing disaster risks. Actions supported by the Ministry of Cities, such as drafting of geotechnical urban-development suitability maps from a disaster-risk standpoint, Municipal Risk Reduction Plans (PMRRs), hillside-containment projects, and other infrastructure investments, need to be reinforced. These, however, are covered in the urban-planning section of the Chapter on the Strategy for Cities.

4.7 Guidelines for promoting adaptation

This item covers the priority guidelines for adaptation of the context of this Strategy. At the federal level, significant progress has been achieved in terms of public policies, plans and programmes for prevention, mitigation, preparation, response to and recovery from disasters. These include the Multi-year Plans (PPA 2012-2015 and PPA 2016-2019) and the National Plan for Risk Management and Response to Natural Disasters. In line with these instruments, there follows an account of measures targeted at improving delivery of current initiatives and at developing new as-yet untried approaches for adaptation to climate change.

At the municipal level, there is still a predominance of inadequate land-use and settlement patterns, which exacerbate exposure threats and contribute toward the causes of disasters, thereby increasing the vulnerability of populations. As mentioned earlier, however, and for purposes of this NAP, approaches for dealing with these problems are presented in sections devoted to urban planning in the Chapter on the Strategy for Cities.

For Disaster Risk Management, the first guideline addressed in this Chapter is to bring Law 12608 on the National Policy for Civil Protection and Defence fully into effect. The PNPDEC provides guidelines which could directly promote reduction of disaster risks while, at the same time, fostering adaptation to climate change on a variety of time-frame and territorial levels.

Another guideline is was the establishment of a Federal Committee dedicated to management of disasters risks, comprised of representatives of federal government agencies with expertise in related fields. This Committee would, as its first mission, be entrusted with improving coordination and performance of the SINPDEC through better integration of management actions for protection and civil defence at the federal level. Improvements of this nature would lead to strengthening of governance, thereby contributing directly to implementation of other guidelines proposed in this NAP.

The National Policy for Protection and Civil Defence established that the drafting of the National Plan for Civil Protection and Defence is one of the responsibilities of the federal authorities, which should seek to determine measures for management of disaster risk, and for planning of short, medium and long-term risk reduction, to be carried out at the national and regional levels. Measures under this Plan should thus be considered from a climate-change perspective.

As presented in item 7.6, there is a pressing need for greater integration of databases and of systems used for assessing disaster risks. A number of bodies at the federal, state and municipal levels have their own systems for recording disaster events. However, there is a lack of integration among them, which compromises their capacity to share information. Progress in this area is essential: 1) for drafting of optimum strategies and targeted public policies; and 2) as inputs for studies and multi-year diagnoses for different regions and municipalities.

Another important guideline relates to fostering of studies on the application of Ecosystem-based Adaptation (EbA) measures for disaster-risk management. This approach is imminently suitable for tackling water-related issues such as droughts, prolonged dry seasons, flooding and landslides, since ecosystem services not only contribute toward reduction of disaster risk, but also to the adaptation strategies of other sectors. Environmental services relating to water production provided by forests increase soil permeability, thereby facilitating infiltration and reducing surface runoff. They also play a significant role in regulating the hydrological cycle in micro basins and in strengthening the stability of hillsides. These examples suffice to demonstrate the crosscutting nature and importance of EbA approaches to various sectors, such as water resources, cities, infrastructure, and transport, covered in other Chapters of this NAP.

Once such studies have been concluded, implementation of their recommendations needs to be evaluated by public authorities at the federal, state and municipal levels, with the participation of sectoral committees, organized civil society and research institutions, to adapt them to local needs and possibilities. It can thus be concluded that the conduct of specific EbA-related studies will provide scientific and technical inputs and contribute toward the design of better strategies for disaster risk management.

Adaptation strategies for reducing disaster risks that need to be pursued are: Monitoring of extreme climate events and of disaster precursor variables; accurate weather forecasting and prediction of disaster risks are measures that, alongside fostering of research on climate change themes and simulation of likely future climate and adaptation scenarios.

Moreover, disaster early-warning systems provide important inputs for assessment of climate risk and for reducing damage to vital physical infrastructures. The major infrastructure projects need to be carried out with awareness that, due to climate change, weather and rainfall series have become much less predictable. For planning of infrastructure for water supply, hydro-electricity, transmission lines, highways, wastewater systems, bridges, irrigation, aqueducts, oil and gas pipelines, and port terminals, effective adaptation measures are of vital concern, in view of the likelihood of more volatile climatic extremes and of their inherent risks.

Research also needs to focus upon promoting a better understanding of disaster risks and on reducing uncertainties of various types, with a view to identifying vulnerability hotspots where disasters are most likely to occur.

Incentives should be offered for climate-change studies that explore its relationship with extreme events on various scales. Other fields of study that merit support include: environmental change, modelling of socioeconomic scenarios, and the effects on various forms of vegetation cover. Also important is stimulus for formation of more research groups on such themes that have, as yet, received scant attention in Brazil, owing mainly to the small number of research institutes qualified to work with climatic projections. Support and encouragement needs to be provided for new postgraduate-level courses focused specifically on disasters. As a means of strengthening these guidelines, modelling data on future climate projections should be widely shared through inter-institutional technical cooperation agreements.

From a broader perspective it should be stressed that reducing social disparities is among the best approaches for reducing vulnerability to disaster risks. Reducing inequality needs to be considered as a crosscutting theme to all Strategies of this NAP, permeating all government planning and policies, targeted at increasing not only the resilience and adaptive capacity of specific groups, but also at reducing their vulnerabilities.

Table 8 presents a summary of the guidelines proposed in this Chapter, offering a preliminary timeframe, monitoring indicators, and suggestions for its adoption by institutions. SEDEC/MI and the CEMADEN/MCTI are the main focal points for promotion and implementation of these guidelines and are the bodies responsible for reporting to the NAP coordination.

Finally, the crosscutting nature of themes relating to disaster risk management must be stressed. Within the context of the actions proposed under this NAP, it is vital that effective integration and coordination be maintained with such other sectors as cities, health, infrastructure and urban mobility, water resources, agriculture, biodiversity, ecosystems, and coastal zones.

Table 8. Guidelines for Adaptation to climate change for the Disaster Risk Management sector

Adaptation Guidelines	Target vulnerabilities/ Opportunities	Agencies and executive bodies	Indicator	Status	Framework
Implementation of the National Policy for Protection and Civil Defence – Law 12608 and fulfilment of actions provided for thereunder.	Several improvements to the sector already provided for in the Law, highlighting: creation of a National Disaster Monitoring and Information System , national registry of municipalities with areas susceptible to landslide and flooding, promotion of State Plans for the Prevention of Disasters, among others	MI/SEDEC	Monitoring of guidelines specified in the Law 12608	To be implemented	Short term for implementation. Medium term for fulfilment of actions provided for.
Ecosystem-based Adaptation (EbA) Measures	Implementation of actions targeted at increasing environmental services provided by forest (replanting or preservation) and soil conservation, related to water and stability of hillsides	MMA, ANA, MCid, MI, State and municipal secretariats, basin committees	Number of EbA actions implemented. Number of beneficiaries. Hectares reforested, preserved and soil conserved	To be implemented Could be interconnected to municipalities and states with a pre-existing or on-going Payments for Environmental Services (PSA)	Long term
Consolidation of an Early Warning System	Reduction of the risk posed by climate threats by increasing disaster prediction capacity, raise awareness of risk and promote related studies.	MI/SEDEC, CEMADEN, INMET, CPTEC/INPE, ANA State institutions among others	Monitoring of the expansion of Brazil's observational network. Number of municipalities monitored	Consolidate and strengthen existing actions. Implement new actions	Short term Medium term
Mechanisms for insurance or transfer of risk	Transfer of risk of the most exposed and vulnerable population through payment of insurance premiums when impacted.	MI, MF, MMA, MCid, MAPA, State Secretariats	Number of policyholders. Total value of premiums paid	To be implemented	Long term
Stimulus for research focused on the understanding of disaster risk	Improve the capacity for research and understanding of disaster risks on different scales, especially at the local level. Indirect inputs for research related to the CCs as a means of reducing uncertainties	MI, MCTI, MEC, Research Institutes, Universities	Number of post-graduate lines of study. Number of Thematic Projects Number of publications	Consolidate the current situation and promote improvements	Short term Medium term

Strategy for Industry and Mining

National Adaptation Plan to Climate Change

5 Strategy for Industry and Mining

5.1 Introduction

The industrial sector can be divided into three broad categories: mining, manufacturing, and public-utility services. In 2013, the sector accounted for 24.4% of GDP and for 8.16 million jobs. In addition to its economic importance, industry contributed to society through incorporation of novel technologies and solutions, products and processes. In this respect, strengthening the adaptive capacity of industry and mining to climate change is an indispensable requisite for Brazil's sustainable economic development.

Founding of the Inter-ministerial Committee on Climate Change (CIM) in 2007, and launching of the National Climate Change Plan, introduced a framework for participation of the industrial sector in issues relating to the theme within the national public-policy agenda, culminating with enactment of Law 12187/2009, which instituted the National Climate Change Policy (PNMC).

The PNMC prepared the field for launching, in 2010, of the Climate Change Mitigation Plan for Industry for Consolidation of the Low-Carbon Economy in Manufacturing, and for Climate Change Mitigation and Sectoral Adaptation for Consolidation of the Low-Carbon Economy in Mining, in acknowledgement of the vital role played by manufacturing and mining activities in environmental, social and economic issues.

Initially, climate-change discussions within the sector were dominated by issues relating to reducing greenhouse-gas emissions in industrial processes of the aluminium, cement, paper and pulp, chemicals, iron and steel, limestone and glass industries; and in extraction, physical processing, pelletizing and internal transport processes relating to mining. Sectoral plans regarded adaptation as a co-benefit, stemming from improved efficiency of energy use and materials consumption.

The Industry Plan has a governance structure centred upon the Technical Committee for the Industry Plan (CTPIn-MDIC) comprised of government and private-sector representatives, with participation of the National Confederation of Industry (CNI). The Plan for Low-Carbon Mining is centred on the Secretariat for Geology, Mining and Mineral Processing of the Ministry of Mines and Energy (SGM/MME). These respective governance structures are the focal points for promotion of the goals and actions under the Plan and the relation to the Coordination Unit of the National Plan for Adaptation.

This Chapter was prepared under coordination of the Secretariat for Development of Production of the Ministry of Development, Industry and Foreign Trade (SDP/MDIC) and the Secretariat of Geology, Mining and Mineral Processing of the Ministry of Mines and Energy (SGM/

MME), with the support from the Ministry of Environment (MMA).

It aims to introduce concepts and basic guidelines to complement the approaches relating to adaptation to climate change in the Industry Plan and the Low-Carbon Mining Plan, highlighting the crosscutting nature of actions required and remaining gaps.

5.2 Vulnerabilities of the industry and mining sector to climate change

Resilience of the industry sector can be considered in terms of its sensitivity reduction and increased capacity of adaptation to potential impacts of climate change. When considering the adaptation capacity of industry, not only the direct impacts of climate variability and extreme phenomena, but also indirect impacts on the infrastructure upon which sectoral operations depend, and the resilience of territories where industry is present, must be taken into account.

The impacts of climate change on the industrial sector may also result in impacts upon local, regional and national economies, which underscore the relevance of public policies for adaptation of the sector. A study that examined such impacts from a broader perspective, which included not only direct losses traditionally associated with interruptions of production, but also indirect impacts upon associated local production chains, estimated losses caused by flooding in the City of São Paulo at R$ 108 million per year for the City itself, and at R$ 226 million for the Brazilian economy as a whole (Dos Santos & Haddad, 2014)[13].

The severity of impacts varies from one industry sector and geographical location to another, whereas adaptive capacity is influenced by size and by the quantity of resources available for investment in adaptation measures. Sectors that are highly dependent upon natural resources (e.g., pharmaceuticals, agroindustry and forest-based industries) are more susceptible to changes in biodiversity and agricultural cycles, whereas industrial parks and mines located in hilly areas prone to intense rainfall are more likely to suffer interruption of activities and supply chains, owing to landslides and flooding in lower-lying terrain.

Impacts can thus be categorised either as biophysical or socio-economic (Table 9). Examples of biophysical impacts are scarcity of raw materials caused by changes in biodiversity, agriculture or water supply that may directly affect availability of basic supplies for manufacturing. Examples of socioeconomic impacts include rising prices of raw materials, material damage to industrial facilities, interdiction of transport routes, and interruptions in electric-power supply and communications.

[13] Available at: <http://www.scielo.br/pdf/asoc/v17n4/a05v17n4.pdf>.

Table 9. Dimension of the evaluations and impacts for the industrial sector

Exposure	Vulnerabilities	Potential Impacts		Opportunities	Adaptation Actions
		Socioeconomic	Biophysical		
Extreme Climatic Phenomena	Industrial parks and mining companies located in regions of steep topography susceptible to landslides or on low ground, subject to floods	Reduced availability and quality of water	Increase in operational, investment and insurance costs	Development of new technologies, systems and equipment for prediction and monitoring of risks	Mapping of risk areas
		Reduced availability of raw material and inputs	Reduction or interruption of production	Development, implementation and strengthening of production models based on local potential	Availability of tools to access the data on the monitoring and early-warning network in management language
	Industrial parks and mining companies far from storage facilities	Reduced thermal comfort, quality and security of the working environment	Production loss	Strengthening of sustainable production systems	Investments in ecosystem services
	Industrial parks and mining companies with water supply dependent upon public distribution networks and poorly diversified energy mixes (highly dependent on distribution networks)	Compromised human resources	Competitiveness losses		Inclusion of "climate risk" in all the industry planning actions
		Damages to industrial infrastructure (mines, buildings, machinery etc.)	Reduced capacity to generate jobs and income		Investments in reuse, desalinisation and alternative water-supply and power sources
	Industries with low investment in adaptation of industrial facilities (buildings, and equipment) and research and development	Damages to logistic infrastructure (roadways, waterways and ports)	Compromised logistics		
		Damages to power and telecommunications infrastructure			

Table 9 (CONTINUED). Dimension of the evaluations and impacts for the industrial sector

Exposure		Vulnerabilities	Potential Impacts		Opportunities	Adaptation Actions
			Socioeconomic	Biophysical		
Extreme Climatic Phenomena	Elevation in the sea level	Industrial parks and mining companies located in the coastal zones	Potential loss in supply and quality of water			
			Rusting of metallic structures and equipment			
			Damages to port facilities			
	Change in weather patterns	Industrial parks and mining companies located in vulnerable regions or dependent on raw materials from agricultural, forests or biodiversity	Reduction or interruption of raw-material supplies			
			Reduced thermal comfort, quality and security of working environments			

5.3 Adaptation of industry and mining to climate change

5.3.1. Relevance of adaptation to the sector

The sensitivity of industrial and mining activities to climate variations stems from their direct dependence on raw materials derived from natural resources and the physical integrity of public or proprietary infrastructures (water-supply, wastewater, electricity, logistics and telecommunications). Uncertainties as to the links between current weather phenomena and climate change notwithstanding, evidence of economic and social damage caused by climate events in recent years (exemplified by the current water-shortage crisis in the Southeast) lends credence to the importance of adoption of appropriate adaptation strategies, targeted at improving the management of risks and opportunities for mitigation of economic losses, reinforcing climate resilience, and strengthening the industrial and mining sectors and their respective production chains.

In view of its technical and technological resources, its strong influence on supply chains, its capacity for innovation and to respond quickly to contingencies through effective actions for minimizing damage to people and the environment, industry has a crucial role to play in promoting resilience among other economic sectors and society as a whole.

Intrinsic characteristics of the industrial sector, such as its great heterogeneity and dependence on public infrastructure, make delineation of adaptation actions more challenging. Such actions must seek combinations of different response strategies, based upon the mapping of regional vulnerabilities and potential impacts, increased tolerance to risk, ecosystem services, and exploitation of other potential opportunities. Categorisation by size, sector of activity and geographic location facilitates identification of vulnerabilities and the adoption of appropriate adaptation measures.

The physical risks of climate change may affect industrial and mining activities in different ways, each demanding different strategies for adaptation, depending upon their capacity to influence the sector and the degree of engagement of production chains (Figure 5). Identification of business opportunities in the field of adaptation is important for strengthening the value chain. Vulnerabilities associated with core operations, value chains, or external factors require different adaptation strategies. Industry has considerable scope for implementing necessary adaptation measures relating to its core operations. It has less influence, however, when addressing broader value chains; and its influence declines dramatically in cases involving adaptation measures for external factors (public and private electricity and water-supply infrastructure) which demand coordination with the public sector and other economic sectors.

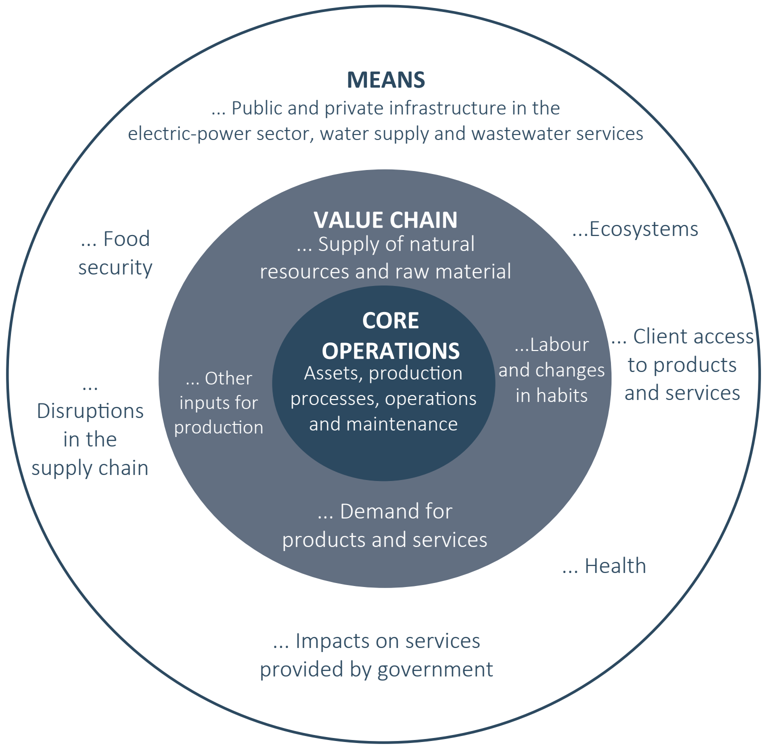


Figure 5. Influence zone of Industry on the Adaptation[2]

Climate change may also increase the exposure of industry to non-physical risks (i.e., reputational or market risks) as a consequence of higher investment, insurance and input costs, and decreased financial measures. Potential impacts on the sector may go far beyond economic and structural losses, and affect the capacity of industry to generate jobs and income.

[14] SUSSMAN and FREED, 2008. Self-adapting to climate Change: A Business Approach. Pew Centre on Global Climate Change. Adapted from the document "Primary Contributions of the Industry- CNI", available at the electronic address: http://www.mma.gov.br/images/arquivo/80182/Contribuicoes_Peliminares_PNA _ Sector% 20 industrial_CNI.pdf, accessed at 3/11/15.

5.3.2. The Crosscutting Nature of Vulnerabilities and Adaptation Measures

The impacts of climate change on other economic sectors also have repercussions upon industry and require preparation of combined adaptation strategies (Figure 6). Within the context of drafting of this NAP, reduction of exposure and vulnerability in the following sectors is of greatest interest to the business sector:

• **Water Resources:** water is among the key vectors of biophysical and socio-economic impacts. Changes in rainfall patterns or extreme events which affect availability or quality of water used by industry in its processes, demand preparation of short, medium and long-term adaptation strategies on different scales, as they could dramatically affect levels of industrial activity, generating higher costs and reducing the feasibility of certain water-intensive segments.

For facing up to these scenarios, it is imperative that support and encouragement be given to initiatives that target improved water efficiency in industrial processes and reuse of water.

- **Agriculture:** This sector provides basic inputs for an array of industrial segments, including paper and pulp; iron and steel; food and beverages; mining; chemical, etc. Changes in availability of such inputs can affect continuity of operations in these sectors.

- **Biodiversity:** A number of industrial segments, including pharmaceuticals, cosmetics, biofuels, forestry-based, chemicals, etc. are likely to be affected by reduced biological diversity and associated ecosystem services that are important for water and raw-materials production, climate regulation, nutrients cycles, pollination, seed dispersal, etc. Negative impacts on biodiversity and associated ecosystem services may generate economic risks, including fewer opportunities for generating value through creation of innovative products and increased competitiveness.

- **Coastal Zone:** A major portion of Brazil's industrial facilities are located in coastal areas that are susceptible to a rise in sea levels. Lower flow levels in rivers and higher sea levels may result in encroachment of saltwater, affecting the salinity of water used by industries in coastal areas, especially, those located in estuary areas.

- **Infrastructure (energy, transport, telecommunications, cities):** Reinforcement of the resilience of critical infrastructure is crucial for the effectiveness of initiatives targeted at industrial adaptation.

- **Health:** Extreme climate events present risks to the health and safety of workers, especially those involved in outdoor activities such as mining and construction. Higher temperatures are liable to affect recruitment, retention, safety and productivity of industrial workers, and to increase accident hazards.

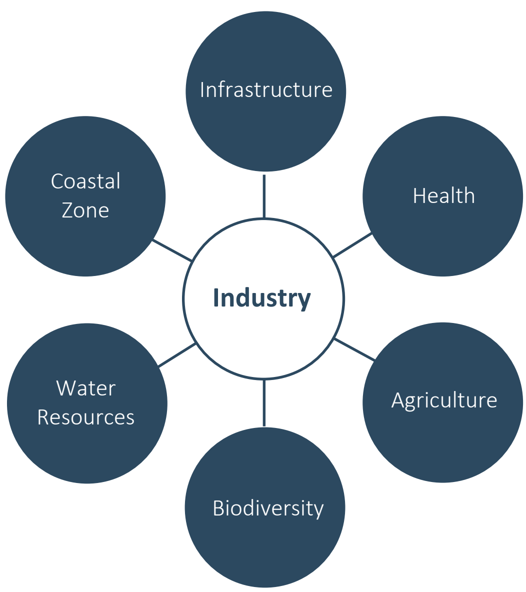


Figure 6. Crosscutting nature of adaptation measures

5.4 Guidelines

More than any other, the public sector has capacity to model the impacts of climate change and to ensure that the challenges of adaptation posed for society as a whole are adequately addressed.

The sectoral guidelines aim to foster the development of policies that facilitates adoption of adaptation measures by the private sector and to promote the consideration of an adaptation perspective into decision-making of public and private stakeholders, thereby enabling coordination and convergence with policies of other sectors.

During review of the Industry Plan and Low-Carbon Mining Plan, these guidelines will serve as a basis for formulation of a Plan of Action for Adaptation, to complement the respective mitigation initiatives proposed under these Plans.

In the light of preliminary contributions forwarded by the National Confederation of the Industry's Technical Chamber for Adaptation, discussions within the framework of the Working Group for Adaptation of the Inter-ministerial Committee for Climate Change (CIM) and inputs prepared by the Centre for Sustainability Studies of the Getúlio Vargas Foundation (State of the Art Mapping on the Topic of Adaptation in Brazil) the following guidelines were prepared:

1. Deepen knowledge on impacts and specific vulnerabilities on industrial subsectors: This guideline is to be developed jointly with initiatives that stimulate research into the impacts, vulnerabilities, opportunities and appropriate adaptive measures of companies of various sizes in each industrial subsector, with the aim of consolidating databases, defining indicators, downscaled mapping of risk areas and making information accessible for decision-making and formulation of prevention plans.

2. Establish an institutional framework to facilitate implementation of adaptation measures: Adoption of effective adaptation measures requires an institutional environment that promotes inclusion of an adaptation perspective to climate-risk management for companies without compromising competitiveness of the national economy. This guideline aims to stimulate organization of information on adaptation and consolidation of inter-sectoral discussion forums, promotion of joint adaptation strategies, and to facilitate access to sources and mechanisms for implementation of adaptation measures.

3. Develop decision-making support tools for Adaptation in Industry: Adoption of adaptation strategies will be facilitated by development of tools for incorporation of knowledge of impacts and vulnerabilities designed to assist with decision making at strategic and operational levels. Such tools may consist of fiscal incentives and tax credits; templates for adaptation strategies; and development of maps of likely short, medium and long-term impacts based on projected climate scenarios.

4. Raise awareness among micro and small businesses of adaptation topics within the sustainability agenda: Micro and Small Businesses form the largest contingent of industrial companies and are generally the most vulnerable and least prepared to adopt adaptation measures. It is therefore important to work jointly with small-business support institutions through targeted actions, training, funding for adaptation investments, and drafting of guidance manuals and business continuity plans for adaptation to disasters.

5. Introduce climate-risk considerations into sectoral policies and encourage consideration of such risks in corporate decision-making: Facing up to climate change requires progressive inclusion of climate-risk mitigation measures in public policies and introduction of climate scenarios into government planning. An adaptation perspective should also be incorporated into business decision-making when considering location of facilities, supply chains, logistics and communication strategies, to enable identification of impacts, analysis of vulnerabilities and implementation of adaptation measures.

6. Provide stimulus for the capital-goods segment so as to increase the resilience of society: The aim of this guideline is to orient formulation of targeted policies for development of the goods and equipment industry that favour adaptation and increased resilience, including equipament for reuse, water desalination, construction work, thermal comfort, automation of outdoor activities, etc.

7. Alongside the National Confederation of Industry (CNI), promote a strategy for collaboration among Labour Unions and Industrial Employers' Federations for development of joint strategies for climate-risk management in industries located in sensitive regions: The territorial dimension of adaptation imposes a need for extensive coordination among players at the municipal, state and federal levels. All too often, the role of coordinating the sectoral and local aspects is relegated to local-level players, making their role in evaluation and planning of adaptation activities of key importance, especially in sensitive areas.

8. Foster Ecosystem-based Adaptation (EbA) practices as tools for strengthening territorial and industrial resilience: Adaptation measures targeted at reducing vulnerability of territories to potential impacts of climate change also reduce, in a synergic way, industrial vulnerabilities. In this context, use of biodiversity and of environmental services as components of an adaptation strategy for addressing adverse effects of climate change may present an alternative for strengthening climate resilience of the industrial sector. For example, regional investment initiatives for river-basin management and recovery may contribute to preservation of headwaters, thereby ensuring sustainability of water supplies.

Strategy for Infrastructure

National Adaptation Plan
to Climate Change

6 Strategy for Infrastructure

6.1 Introduction

The term infrastructure encompasses a broad array of sectors, physical and operational integration of which are essential for functioning of a modern economy and society. This strategy covers the Transport, Urban-Mobility and Energy segments, all of which are of strategic importance for Brazil's development and receive substantial investment from the federal government, states, municipalities, and from the private sector. This Strategy was prepared jointly by staff of the Ministries of Transport (MT), of Cities (MCid), and of Mines and Energy (MME) which are the focal points for this strategy.

Transport, for purposes of this Plan, comprises the physical and operational infrastructure of various modalities of transport for moving people and cargo among Brazil's cities and regions, and encompasses federal highways, railways and waterways.

For Urban Mobility, the strategy covers an array of public and private, mass and individual, motorised and non-motorised transport modes used to move people and goods within cities and the physical infrastructure for provision of services, including routes, transfer points and systems.

For the Energy sector, the generation, transmission, and distribution segments are addressed. Energy is a vital input for practically all other economic sectors. In view of the high proportion of energy from renewable sources in Brazil's energy mix, the sector's greenhouse gas emissions are remarkably low by International standards.

Future climate projections indicate that Brazil is likely to be affected by various impacts of climate change, including increased occurrence of extreme events and rising sea levels, which may have numerous effects on all infrastructure segments.

Moreover, as a consequence of strong interdependence among the sectors covered in this Chapter, interruptions or reduced performance of one sector is likely to cause reciprocal and synergistic effects on others. Indeed, climate impacts may simultaneously affect infrastructure elements in more than one of these segments.

The objective of this Strategy is to assess impacts and vulnerabilities associated with climate change, from the standpoints of the Transport, Urban Mobility and Energy sectors and to propose guidelines for addressing them.

There are considerable interdependence among the factors that may affect these sectors, hence the need to adopt joint adaptation and planning approaches. Thus, the strategy proposes guidelines for adaptation, targeted at reducing vulnerabilities within the scope of each sector.

6.2 Transport

6.2.1. Introduction

The legal framework for Brazil's transport infrastructure is provided by the National Traffic System (Law 12379/2011 - SNV[15]) and encompasses the physical and operational infrastructure of different modalities of transport of people and goods, under federal, state and municipal jurisdictions. This strategy on adaptation to climate change for the transport sector focuses on highway, railway and waterway cargo transport in Brazil.

The National Plan for Logistics and Transportation (PNLT) developed by the Ministry of Transport is the main planning document for the transport sector in Brazil and assigns it a permanent management structure, based on a geo-referenced information system. The Plan provides for the main factors of interest to the sector, in terms of both supply and demand, with a view to adjusting the cargo-transport mix so as to stimulate use of the most efficient modalities.

The current Brazilian matrix of regional cargo transportation displays a high concentration of road transport which accounts for approximately 52% of total freight transported. In second place comes railway freight (30%), followed by coastal shipping (8%), inland waterways (5%), and pipelines (5%)[16].

In quantitative terms, the Brazilian road network extends for 1,720,755 km, most of which (78.6%) is unpaved. Paved roads account for 12.3% of the network; and 9.1% is planned but as yet unbuilt. Of Brazil's paved roads, 45.8% are under state jurisdiction; and 36.4% are federal highways.

The national railway network comprises approximately 28,000 km of track. The Brazilian inland waterway system stretches approximately 63,000 km through 12 river basins. Moreover, there are some 21,000 km of navigable waters of which, in 2012, 6,500 km were used by commercial shipping[17].

It can thus be perceived that Brazil has a strong transport matrix, the infrastructure for which is currently undergoing a renewed cycle of expansion and modernization. This underscores the importance of approaching climate aspects that could potentially expose the sector to impacts, both from the operational standpoint and from that of conservation of physical assets.

Within the context of the National Plan for Climate Change, in 2013, the Ministry of Transport published its Sectoral Plan for Transport and Urban Mobility for the Mitigation of Climate Change (PSTM) with

[15] The *National Transportation System* (SNV) comprises the Federal Transport System (SFV) and the transport systems of the states, Federal District and municipalities, including highway, railway and waterway systems.

[16] National Logistics and Transport Plan (2011)

[17] Strategic Waterway Plan (2013)

a view to demonstrating the Brazilian federal government's commitment to preparing for climate change, while maintaining competitiveness and conditions for economic and social-environmental development.

6.2.2. Impacts and vulnerabilities

Cargo transport infrastructure, like that of other sectors, may be affected by higher-temperatures, rainfall and wind-intensity scenarios, capable of causing direct and indirect impacts on the road, railway and waterway transport networks (MACARTHUR, 2013; FGV, 2013). Among such impacts, the most common are floods and landslides, many of which are consequences of extreme weather events (INPE, 2010). Intense rainfall events have caused flooding that seriously disrupts road and railway transport.

Unpaved roads, which account for 78.6% of the Brazilian road network, are highly vulnerable to a variety of climatic factors and especially to intense rainfall, which can lead to the interruption of transport routes (ARNDT; CHINOWSKYT, 2012). Such disruptions may even compromise interconnection between different transport modes, adding to transport costs by requiring additional safety measures or use of alternative routes which, generally, entail longer distances and hence higher costs (UNCTAD, 2009; UNECE & UNCTAD, 2010).

When saturated, the roadbeds of highways become subject to excessive pressures, causing deformation and cracking of asphalt surfaces. Under very intense rainfall conditions, structural changes may occur, causing damage to paved surfaces, increasing maintenance costs and demanding installation of additional structures and adaptations on the road transport system.

Table 10 lists climate variables and potential changes that may impact highway infrastructure, based on studies conducted in different countries.

Table 10. Impacts of extreme events on transport systems

Country	Climate Variable	Expected change	Expected impact of change climate variables
Canada	Temperature	Rise in maximum and minimum temperatures (especially in winter)	Increase in the frequency of freezing cycles – defrosting with deterioration in the pavement
	Rainfall	Increase in intensity and frequency	Increased presence of debris on roads, landslides, flooding and changes in sizing of bridges and culverts
	Sea level	Higher average levels	Flooding and damage to roadways, sidewalks and marine installations located in lowland areas
Holland/ United Kingdom	Rainfall	Higher in winter and lower in summer	Flood risk and associated damage from insufficient drainage capacity
	Sea level	Higher average levels and consequent rise in groundwater levels	Flooding, problems with light materials used on the base layers (EPS-Expanded Polystyrene), contamination by the leaching of ash used in the sub-base
Australia	Temperature	General rise	Changes in climate which, when drier, causes loss of asphalt binding and shortens lifespans of bituminous materials
	Rainfall	Lower intensity and frequency	

Source: Adaptation of *Technical Committee D. 2 Road Pavements* (2012) *apud* Project 2040 (SAE, 2015)

Increased rainfall and flooding events can cause erosion, damaging roadways and metal structures such as bridges. If such structures have older concrete components or lack maintenance, there is increased risk of moisture infiltration and corrosion (SOO HOO & SUMITANI, 2005). Highways may likewise become structurally unstable owing to subsurface erosion, resulting in increased maintenance costs (CNRA, 2009).

Another impact caused directly by increased rainfall or extreme storms, which are likely to occur more frequently, is runoff flooding that exceeds capacity of projected storm drains, overloading current drainage systems (SOO HOO & SUMITANI, 2005).

For terrestrial transport, the main foreseen impacts resulting from heavy rainfall or flooding are (OSWALD, 2009): (1) increased flooding of roadways, low bridges and tunnels; (2) increased frequency and severity of overflows from drainage systems; (3) increased flooding of evacuation routes; (4) delays and stoppages of vehicle traffic; (5) higher incidence of disasters on roads caused by landslides and erosion; (6) washout of bridge abutments and excessive moisture in crevices, causing deterioration of structures and slippage of slabs; (7) destruction highway and bridge signage. All these impacts would result in traffic-flow problems and interruption of journeys.

For inland-waterway navigation, the impacts of extreme rainfall events and increased numbers of days of rainfall could lead to higher water levels increasing the length of high-water seasons, leading to enforced stoppages of service for safety reasons, causing substantial economic impacts (MIDDELKOOP *et al*., 2001; KREKT *et al*., 2011).

By contrast, periods of drought, also foreseen to become more frequent, could cause drops in water levels, increasing the average annual number of days during which inland navigation is hampered or suspended, owing to limitations on waterway carrying capacity (MIDDELKOOP *et al*., 2001). Even if improvements to navigation channels are carried out, they will tend only partially to relieve such problems. Moreover, low water levels oblige vessels to use only part of their potential capacity, thereby considerably increasing costs for this transport mode (KOETSE & RIETVELD, 2007).

Changes in temperature will tend to impact transport infrastructure, such as bridges and railway tracks and to cause deterioration of roads and railways, thus requiring more frequent maintenance (SOO HOO & SUMITANI, 2005). An increase in the number of days with high temperatures raises the risk of premature deterioration of transport infrastructure caused by thermal expansion of bridge joints, increased deformity of paved surfaces and causing changes in periods of construction activity (IPCC, 2007; OSWALD, 2009).

Though materials used in assembly of metal structures permit a certain degree of plasticity allowing for contraction and expansion (MEYER, 2008) nonetheless, uncertainties relating to future climate change could pose threats related to tolerance of the various types of transport infrastructures to greater temperature variations (IPCC, 2007).

For example, on highways, degradation of paved surfaces is directly related to thermal stress, which can cause softening of asphalt layers when temperatures exceed projected limits (LAVIN, 2003). For inland navigation, excessive warming could lead to lower water levels and, consequently, reduced flow levels, caused by evaporation (LEMMEN & WARREN, 2010).

Higher sea-surface temperatures give rise to tropical-storm phenomena, causing strong winds to become more frequent (OSWALD, 2009). Such winds may: (1) reduce the stability of bridge decks, (2) lead to an increase in highway and railway journey interruptions, caused by blockage of lanes and tracks by falling trees and rocks, and (3) increase the probability of highway infrastructure flaws.

As mentioned earlier, variations in seasonal weather conditions, besides causing direct impacts, may have indirect impacts on transport and other economic sectors. For agriculture, problems arising from logistical bottlenecks could be exacerbated by the impacts of climate change on the transport sector, especially on highways (FGV, 2013).

It is likely that, as a consequence of natural disasters, transport costs will rise and that new alternative routes will be sought to carry produce to markets, thus disrupting traditional supply chains (BECKER *et al*., 2012). Increased frequency and intensity of extreme events may also affect the breaching of bottlenecks, by increasing maintenance costs of barges and wagons, thus causing delays and raising costs (IPCC, 2007; POTTER *et al*., 2008; UNCTAD, 2009).

An accumulation impacts on the transport network may result in loss of infrastructure assets, hampering the recovery capacity and resilience of the entire sector, given that transport infrastructure accounts for a substantial national investment.

For cargo transport, adaptation can be regarded as the sector's response to the impacts of foreseen extreme weather events. Brazil's social development and economic growth require constant investment in transport infrastructure. Such investment becomes even more necessary in a context of climate change, to maintain or reduce costs of goods and services, and to enable free circulation of people throughout the country.

Analysis of the adaptive capacity of transport system management to climate change often poses complex questions, since transport infrastructure is dependent upon and interconnected with numerous other systems. Moreover, potential impacts are not limited to a given geographical region, but have repercussions that extend to other transport modes.

However, in view of the need to re-establish or maintain the continuity of cargo-transport links among the various regions despite climate threats, the National Transport System (SNV) and National Transport Logistics Plan (PNLT) propose adaptation strategies, such as selection of an alternative route and switches of transport modality in the event of interruption of stretches of a major highway.

The main objective of the National Plan for Logistics and Transportation is to restore sectoral strategic planning. A geo-referenced database has been set up to enable modelling and assessment of long-term project outcomes.

Such projects encompass expansion of cargo-carrying capacity on strategic routes, filling of gaps in the national highway network, and construction of new sections to enable increases in efficiency, through redirection of cargoes from roads to railways and/or waterways. Furthermore, such logistical integration projects focus on reducing bottlenecks at strategic locations, such as cargo terminals of ports and airports.

The main aim is to promote stability of the Brazilian cargo transport matrix. This goal is linked to the strategy for ensuring capacity of the transport sector to respond to potential damage to infrastructure in areas or regions likely to be affected by extreme weather events, thereby making the system less vulnerable to climate change.

To complement the PNLT and further promote integration with other policy areas, the Ministry of Transport has launched the Strategic Waterway Plan (PHE) with the aim of enhancing waterborne cargo and passenger transport, especially on inland waterways.

6.2.3. Guidelines for adaptation

Some of the strategic issues related to reducing vulnerabilities to climate change in the transport sector are addressed by a strategy for promoting a more stable cargo-transport matrix. This could make the system less vulnerable while, at the same time, ensuring development of intermodal approaches, through improvements in access to port, railway and airport terminals. Such improvements in the flow of goods and passengers would be especially significant during occurrence of critical climate events.

Notwithstanding the attention that planning of the Brazilian transport system has received in recent years, further rationalisation of the transport mix will require institutional measures and significant investment.

There follows a set of guidelines to be adopted by the Transport sector, for addressing emerging needs for adaptation to potential effects of climate change:

1. Promote greater engagement of the transport sector in issues relating to adaptation to climate change, through capacity building and dissemination of information.

2. Take into account, as appropriate, issues relating to adaptation to climate change in institutional plans, programmes and projects of the Transport sector.

3. Prepare studies and research on the relationship between climate change and the vulnerability of transport infrastructures, as inputs for public policies, planning and identification of solutions for the sector, through Ecosystem-based Adaptation (EbA) approaches.

4. Evaluate possible co-benefits and synergies between mitigation and adaptation strategies relating to different alternatives applied to the transport sector.

5. Improve production and availability of information on extreme events relating to the transport system.

6. Increase the capacity of the transport sector to respond to extreme climate events by means of plans, action protocols and preventive measures.

The Ministry of Transport hereby assumes a commitment to assimilate the guidelines for regional public transport established in this NAP, within the scope of the Sectoral Plan for Transport and Urban Mobility for Mitigation and Adaptation to Climate Change (PSTM) as defined deadline setting by the Inter-ministerial Committee for Climate Change (CIM).

6.3 Urban mobility

6.3.1. Introduction

The guidelines of the National Urban Mobility Policy (PNMU) were established by Law 12587 of 3rd January 2012, commonly referred to as the Urban Mobility Law, which defines mobility as: *"the manner in which movement of people and cargo takes place within urban space"*. Such movement is essential for economic and non-economic viability of activities in cities, where roughly 84% of Brazil's population is concentrated (IBGE, 2010).

According to the Mobility Law, the National Urban Mobility System comprises an organized and coordinated range of transport modes, services and infrastructures that enable movement of people and cargo within the territory of a municipality. These include: motorized and non-motorized vehicles; urban passangers transport and cargo services; mass and individual, public and private transport; roads and other public routes; including underground railways; waterways and bicycle lanes; parking lots; terminals; stations and other transport hubs; stops, boarding and disembarking of passengers and cargo; roadway and traffic signage; equipment and installations; traffic control instruments; inspection; collection of fares and fees; and dissemination of information.

Urban mobility in Brazilian cities is subject to disruption arising from adverse weather conditions and climate events such as flooding, temperature variations, etc. (hereinafter referred to as climate impacts). The frequency and severity of such impacts may vary, depending upon projected climatic variations and the characteristics of each locality having potential to generate economic losses and jeopardise the well-being of the population.

Thus, for the urban mobility sector, adaptation is crucial for protecting the intrinsic value of transport infrastructure, ensuring the reliability of mobility systems, the feasibility of economic activities, and safeguarding the quality of life and safety of the population.

The activities of federal, state and municipal bodies on this theme must be aligned with provisions of the Urban Mobility Law. At the federal level, the Ministry of Cities is responsible for overseeing implementation of the instruments foreseen in the PNMU, such as the Urban Mobility Plan, deployment of which is mostly in the hands of local governments.

In consonance with PNMU guidelines, in June 2013, the Ministry of Cities launched the Sectoral Plan for Transport and Urban

Mobility for Mitigation and Adaptation to Climate Change (PSTM) within the context of the National Plan for Climate Change, upcoming review of which is outlined in this NAP.

6.3.2. Impacts and vulnerabilities

The effects of climate change will be unevenly distributed throughout Brazilian territory (see Volume I of the NAP) both in terms of gradual changes in weather patterns and temperature and rainfall levels, and in the behaviour of extreme events, with rising degrees of uncertainty.

Sea levels are expected to rise throughout this century, with effects exacerbated by extreme climate events of increasing intensity, such as storms and strong winds associated with low pressure, neap tides and high waves, posing risks to Brazilian coastal cities, as described on Strategy for Coastal Zones.

Vulnerabilities for urban mobility stem from interaction among various aspects, including weather conditions, degree of exposure, sensitivity, and associated adaptive capacity. The influence of such factors varies in accordance with locality and specific characteristics of each conurbation, and, consequently, the severity of impacts may vary greatly from one area of a city to another.

Exposure is associated with systems and the infrastructure characteristics of the various different transport modes potentially subject to climate impacts, and that may have reflexes in terms of damage to physical assets, reduced performance, or interruption of mass-transit or cargo-carrying capacity. Exposure may also directly or indirectly affect travel choices of the population, with repercussions of a socioeconomic nature.

Within the context of climate-change scenarios foreseen for Brazilian territory, the following climate aspects are likely to have an impact on urban mobility:

Higher average temperatures, heat waves and exacerbated “heat-island” effects;
Increased rainfall and occurrence of extreme events (storms, strong winds), causing flooding, floods, landslides, tree falls, higher groundwater levels, among other consequences;
Rise in average sea levels and high tides, associated with extreme events, sea swells and tidal storms, causing flooding in coastal areas, higher groundwater levels and salt-wedges in estuaries, among other consequences;
Reduced rainfall, lower flow and water levels in water bodies.

The following table illustrates the initial impacts of climate change and their potential effects on urban mobility, and other infrastructures.

Table 11. Potential impacts on infrastructure and urban mobility

Climate impact	Potential impacts on Infrastructure	Potential impacts on Urban Mobility
Rising temperatures, heat waves and aggravation of heat islands	Deterioration and deformation of paved surfaces and tracks; Deterioration and deformation of structural elements of bridges, viaducts and culverts; Fatigue in building materials; Instability on slopes; Overheating and overloading in equipment (engine cooling, air conditioning, electrical control systems, signalling and communications).	Reduced safety and / or performance of transport modes; Reduced comfort of passengers, pedestrians and cyclists; Increased travel time; Blocking of transport routes *; Restricted logistics for distribution of goods and services; Increased operational costs (maintenance and replacement of assets); Reduced participation of mass transport and non-motorized modes.
Increased rainfall and occurrence of extreme events	Damage to infrastructure owing to flooding on transport routes*, terminals, stations and special artworks; Corrosion and deterioration of structures; Instability on slopes, landslides and trees falling; Damage to equipment and electrical systems (air conditioning, control, signalling and communication systems); Damage to foundations of transport routes * (base / sub-base etc.); Overloading in drainage systems; Reduced of visibility and vehicle traction; Restricted navigability (headways under bridges etc.).	
Rising sea levels	Damage to infrastructure due to coastal flooding; Erosion and corrosion of structures and building materials; Damage to foundations of transport routes (base / sub-base).	
Reduced rainfall	Restricted navigability.	

Source: AUTCC – GIZ and EU Strategy, adapted from SEMOB/MCid.

* the term " transport routes " includes highways, railways, subways, waterways, cycle tracks and walking paths

Potential impacts on road and railway infrastructures share some similarities, including those associated with special engineering structures, drainage systems, roadbeds, stability of embankments, among others.

Certain systems have very specific sensitivities to temperature variations, such as propensity of rails to buckle and fatigue, of transmission lines to deform/snap, of paved surfaces to deform, of motors to overheat, etc. Weaknesses of this type may result in greater demand for cooling systems and add to the discomfort of users.

Ground-level systems tend to be more exposed to extreme events. Threats of this type may also degrade and affect access to underground stations and terminals. Moreover, impacts to isolated elements of transport systems tend to have repercussions throughout the network, especially when these lack flexibility, integration, scope, and redundancy capacity. Thus, not only events that shut down entire transport systems, but also those that could lead to reduced operational performance need to be considered.

Rising sea levels could cause devastating flooding of coastal areas, exacerbating sea-water encroachment and overflowing of inland water courses, saltwater intrusion, rusting of infrastructure elements, coastal erosion, etc.

Such climate impacts directly or indirectly affect the movement of people and distribution of goods and services within cities, and raise the probability of accidents. They also generate additional costs for maintenance, recovery and/or refurbishing of damaged or deteriorated assets. Some such damages are immediately visible, whereas others only become apparent in the medium or long term.

The severity of potential impacts in each city varies not only according to climate conditions, but also on biophysical and socio-economic attributes of the site.

In the case of extreme rainfall events, for example, susceptibility to floods, flooding and landslides depends on an array of factors, including: topography (declivity, depressions, and floodplains), presence of water bodies, land use (surface sealing, presence of vegetation), soil types, effectiveness of urban drainage systems, etc.

From a socioeconomic perspective, conditions of mobility (i.e., access to public-transport services, decent roads and sidewalks, etc.) in a given locality or neighbourhood have a direct influence on the magnitude of impacts. In practical terms, heavy rainfall may cause major disruption of mobility services for populations in poorly served areas. In consequence, they may have to walk longer distances in the rain or on inadequate roads, wait longer for transport, or simply be unable to reach their intended destinations.

Such restrictions on mobility may induce, or even require, adoption of alternative forms of transport, new routes, or altered timetables, implying changes in the behaviour of commuters. Choices and reactions to transport stoppages caused by adverse climatic conditions are often conditioned by factors such as schooling levels, income bracket, age group, and characteristics of the intended trip (distance, cost, motive etc.). Thus, different segments of the population will react differently to inconveniences caused by interruption of mobility services. Moreover, disabled people count as a vulnerable group in the context of this NAP, which reinforces the challenge of ensuring universal accessibility to urban mobility services.

Climate-related disruptions of infrastructures in other sectors, including fallen electricity cables, failure in communications and signalling systems, outages of electric-power supply for subway, light rail and tramway systems may also have repercussions on urban mobility. Sectoral policies that address climate-change adaptation in the fields of urban development, sanitation, urban solid wastes and telecommunications are also correlate to those for urban mobility.

Day-to-day experience in Brazilian cities has shown that adaptation is needed not only to address gradual climate changes but, more pressingly, the challenges of intense adverse weather events in the short term, often referred to as extreme events. These need not refer only to catastrophic events, but also to more moderate ones that nonetheless cause great inconvenience to the population.

With respect to extreme events, it is plainly impossible to totally eliminate all their impacts. However, the concept of resilience implies ways in which people and systems can react in order to minimize negative consequences, i.e., the capacity to anticipate, prepare, respond and recover, in adverse situations.

In the mobility sector, adaptive capacity and resilience are closely related concepts, covering an array of conditions necessary for development and implementation of adaptation measures. Such measures encompass institutional arrangements, technology, knowledge and economic management that relate to structures, resources, information analysis, availability of technologies, and the existence of programmes for mitigation and adaptation to climate change and urban-mobility planning. Moreover, the willingness of government, private-sector, academic and civil-society players to work together on this topic is also of fundamental importance for adaptive capacity.

The quality of public-transport systems is also an essential factor for gauging adaptive capacity, and entails aspects relating to coverage, capacity, integration and alternative modes and routes, which enable better management in the event of stoppages or loss of performance of one specific element of a system, minimizing impacts on commuter journeys.

Other examples of adaptive capacity include: (1) availability of technical solutions (drainage and pumping systems, weather-proofing of equipment, enhanced construction methods and maintenance technologies etc.); (2)

cooperation among the sectoral bodies responsible for transport and mass-transit systems, sanitation, and among federal, state and municipal administrations, especially in large metropolitan regions; (3) early-warning systems to promote readiness for extreme weather and public information systems to advise the population on how different transport modes will be affected, offering advice on alternative routes, etc.

The vulnerabilities of the urban mobility sector relate to a combination of current and projected climate impacts, to biophysical and socioeconomic characteristics, to the quality of installed transport infrastructure and systems, and to the commuting patterns of the population. All these factors need to be addressed when assessing current adaptive capacity, remembering that, the greater the adaptive capacity, the lower the vulnerability to impacts.

6.3.3. Guidelines for Adaptation

In view of the rates of population growth prevalent in Brazilian cities, it is important that new infrastructures and urban mobility systems incorporate an adaptation perspective. Adopting such a perspective requires a focus on planning of land-use and settlement patterns, integrated infrastructure projects that take into account climate risks assement, so as to avoid generating new exposures and vulnerabilities. Moreover, adoption of sustainable urban-planning, mixed land-use and density control principles, which minimize distances and/or commuting needs, can help reduce vulnerability of the urban-mobility sector to climate change while, at the same time, reducing greenhouse-gas emissions.

There needs to be a complete overhaul of existing transport infrastructure from an adaptation perspective, targeted at minimizing climate impacts, based not only on maintenance cycles, but also on reassessment and refinement of technical specifications.

In contrast to private automobiles, public mass-transit systems and non-motorized transport help reduce congestion and facilitate commuting. Improvements to mass-transit systems and promotion of non-motorized transport could create synergies between adaptation and climate-change mitigation goals while, at the same time, benefiting the public and the economy as a whole.

Technical solutions that imbue urban-mobility systems with greater resilience and that focus on prevention and minimization of the impacts of extreme events should be considered, with a view to facilitating transport of people and goods and reducing losses and recovery time in the event of stoppages. Efficient implementation of such solutions entails adoption of robust transport systems, prior identification of bottlenecks and prioritization of routes and infrastructures capable of operating even when such events are occurring, thereby providing an alternative to more vulnerable transport modes. Planning of such solutions must take into account rising demand, and be equipped with operational signalling and early-warning systems to orient passengers in the event of emergencies.

Demarcation of green areas, planting of trees, recovery and protection of natural streambeds and of lakeshores, i.e., Ecosystem-based Adaptation (EbA) measures, should serve as the basis for local-level programmes for fostering adaptation and resilience. Invariably, the effectiveness of adaptation strategies depends upon public and private-sector involvement and production of knowledge, both on the national and local levels, and its dissemination to the public. Although Brazil's municipalities are responsible for the planning and management of their local transport systems, the coordination function of the federal government reduces duplication and helps foster synergies, especially in metropolitan regions.

Measures for implementation of climate-change adaptation strategies should not be taken on an *ad hoc* basis, but rather, be intrinsically incorporated into the decision-making processes and policies of the sector, with a view to minimizing inconvenience and economic losses for the population.

There follows a set of adaptation guidelines for the mobility sector:

1. Inter-institutional coordination among government institutions, to harmonize national adaptation plans and policies with local planning and actions, involving private-sector, civil-society and academic players;

2. Consideration of urban-mobility vulnerability studies for preparation of local-level adaptation and resilience programmes, in coordination with relevant sectors;

3. Incorporation of adaptation and resilience to climate change into urban-mobility plans, in coordination with urban land-use planning and in line with Ecosystem-based Adaptation (EbA) principles;

4. Strengthening of mass-transit infrastructure and popularisation of non-motorized individual transport, through facilitation of intermodal integration and flexibility in the system;

5. Stimulus to studies on the need to review technical standards, both for planning and maintenance of urban mobility infrastructure, incorporating an adaptation perspective;

6. Building awareness of climate change and its impacts on mobility, encouraging the population to prepare and contribute toward mitigation and adaptation measures;

7. Disseminate information on urban transit networks;

8. Support innovative projects for reducing carbon emissions and increasing capacities for adaptation to climate change.

6.4 Energy

6.4.1. Introduction

Renewable energy is considered a priority and diversification of sources a fundamental principle of Brazil's energy matrix. A number of mechanisms provided for in legislation are targeted at meeting diversification goals.

Given the importance attributed to renewable energies and their wide distribution throughout Brazilian territory, an assessment of the degree to which climate change may impact such facilities is needed to identify threats and potential means of reducing vulnerabilities.

When assessing vulnerabilities of the energy sector to impacts of climate change, the electric-power sector, broken down into the generation, transmission and distribution segments is the first point of focus in the context of this NAP. This is a complex sector, as it involves energy derived from a variety of sources, including both fossil fuels and renewables.

The main energy source for the National Electricity Grid is hydropower, whereas other renewable and fossil-fuel energy sources complement the system. Thus, the Brazilian eletric power Matrix is characterised by much lower greenhouse-gas emissions than systems of similar size in other countries of the world. An Interconnected Transmission Network links generation facilities installed in a variety of river basins located throughout the country and reserve non-hydraulic generating capacity for use when water shortages affect hydroelectric generating capacity.

Figure 7 shows the composition of the energy sources that feed the Brazilian Electric Power Matrix:

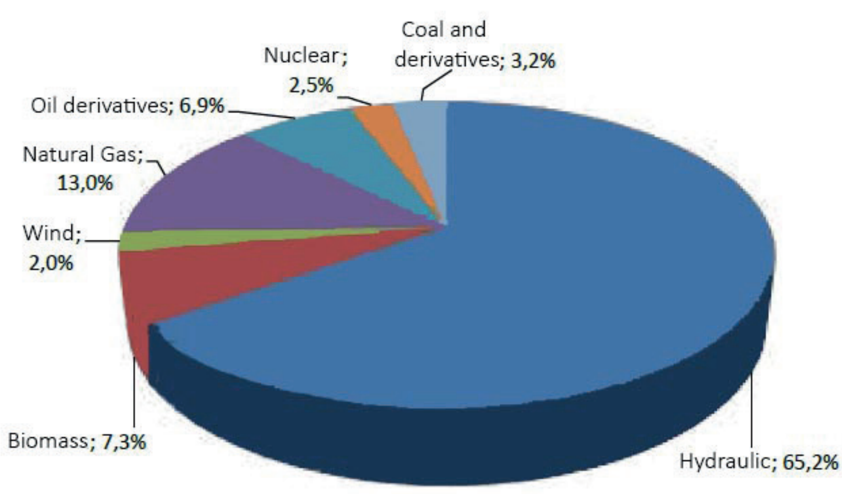


Figure 7. Brazilian Electric Power Matrix
Source: National Energy balance sheet, base year 2014

Hydroelectric power is distributed throughout Brazilian territory. The main reservoirs and hydroelectric power plants for generation are located in the central-south of Brazil. There are, moreover, a number of basins where hydroelectric potential has not yet been exploited, especially near borders in the North region and on rivers in the Amazon Basin.

Brazil also has great potential sources of wind power, mostly concentrated in central and coastal areas of the Northeast, Southeast and South regions. The map in Figure 8 shows the most promising areas for exploitation of Brazil's wind power potential:

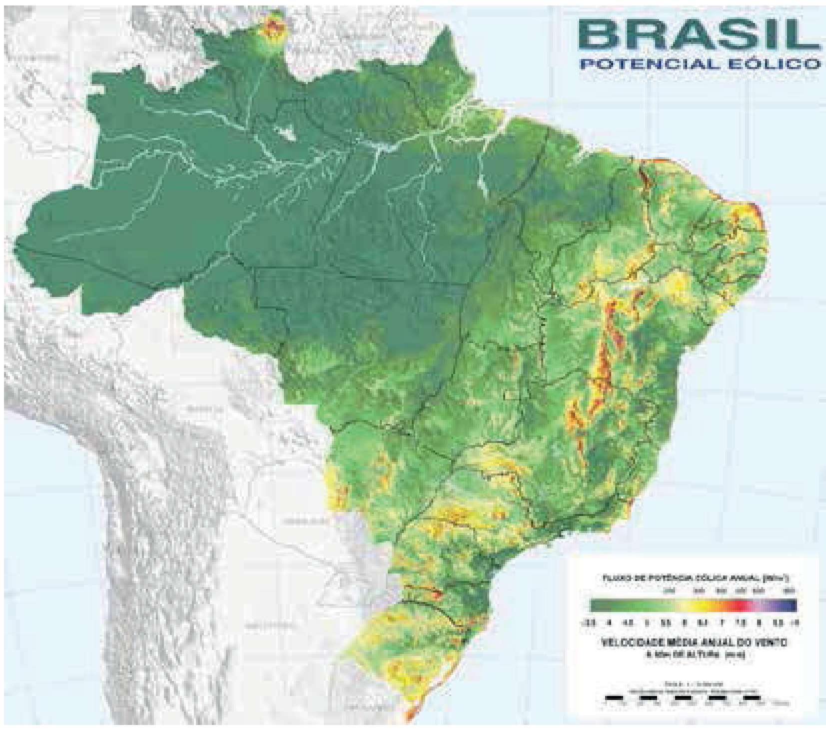


Figure 8. Brazilian Wind Farm Potential
Source: Centre of Research- CEPEL

Biomass provides another significant renewable-energy source for generation of electric power from thermal power plants, fuelled by sugar-cane bagasse, located alongside sugar and ethanol mills. The Southeast and Northeast regions of Brazil have the greatest potential for this form of electricity generation and ethanol production.

Another potential power source for electricity generation is solar power, as currently collected and converted into electricity by photovoltaic arrays, and, in the future, through solar-thermal power plants. Though solar power currently contributes only a small component of Brazil's electricity matrix, this is likely to grow significantly in coming years.

Brazil has high solar radiation potential, fairly evenly distributed throughout the country, as is shown in Figure 9.

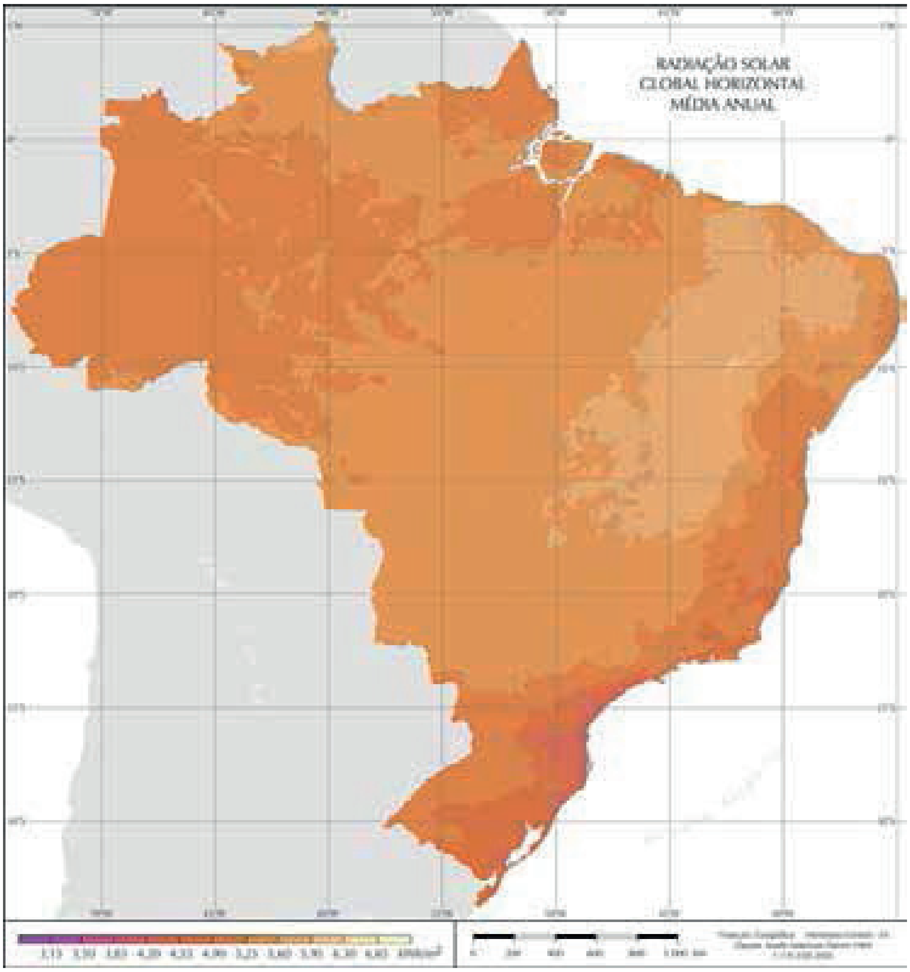


Figure 9. Solar radiation in Brazil
Source: Brazilian Atlas of Solar Energy- INPE/2006

A network of transmission lines interconnects power plants in different river basins, thereby optimising availability of water resources in the various reservoirs throughout the country. Vast quantities of water stored in the reservoirs of hydroelectric power plants serve to regulate downstream flows, storing water for use in periods of low rainfall.

To enhance the effectiveness of this system, a centralised body, the Electric System National Operator (ONS) issues orders[18] for discharges of each plant and for operation of the transmission line network, with a view to optimising supply. Figure 10 shows a diagram of the National Interconnected Transmission System:

[18] *Dispachos* – orders issued by the Electric System National Operator, determining which plants should operate and which should be on standby so as to maintain, permanently, a production volume equal to consumption, taking into account plants of lower cost. In general terms, these orders initiate power generation from the hydroelectric plants and when necessary, generation by the lower-cost thermal plants, provided the plant is in technical conditions and has fuel.

Figure 10- National Interconnected System – NIS

Source: Electric System National Operator – ONS, 2014.

A further component of the electricity system is generation reserve, i.e., large thermal-electric plants powered by fossil fuels that spend much of the time on standby, to fill gaps when hydropower sources are in short supply.

Energy security remains one of the main objectives of an adaptation programme for the electricity sector. In this regard, fossil fuel power plants, notwithstanding their greenhouse-gas emissions, fulfil an important role by ensuring stability to the system.

Moreover, the need for maintenance on hydroelectric power plants also makes necessary an expansion of thermal-generation capacity. However, technological criteria and selection of fuels for such plants must prioritize low greenhouse-gas emissions and seek to strike a balance between mitigation and adaptation.

Thus, an assessment of the vulnerabilities of the electrical sector should extend beyond a focus on individual river basins and contemplate the network as a whole, taking into account the array of energy sources, operation of the system, and its reserve-capacity structures.

6.4.2. Impacts and vulnerabilities

There is a consensus among the scientific community that climate change is taking place and that it is highly likely that Brazil, like the rest of the world, will suffer ever more impacts in the next few decades. Regardless of the accuracy of these predictions and doubts as to which scenario will prevail, it is probable that electric-power generation will in some way be affected.

Of the climate parameters most likely to affect the sector, higher average temperatures that increase evapotranspiration of lakes and water courses and changes in rainfall patterns are of greatest concern. Rainfall, in conjunction with evapotranspiration, affects the calculation of the water balance, which is an important conditioning factor for maintenance of river flows.

Other weather parameters also influence electricity production, including cloud cover that reflects solar irradiation, and changes in wind regimes that have a direct effect on generation from wind turbines.

When considering the effects of climate change on electricity generation, other anthropogenic factors also merit consideration. Surface Characteristics and settlement patterns, for example, may interfere in regional wind dynamics. Consumptive[19] uses of river flows, for urban water supply and irrigation, can reduce water availability. In some cases, the effects of these anthropogenic variables overlap with climate issues.

When assessing potential threats to the electrical system in a context of climate change, it is repercussions on the capacity of the National Interconnected Power System to ensure regular supplies of electric power that are of greatest concern. Only by adopting this focus is it possible to make an informed assessment of the vulnerabilities of the system and to determine possible adaptation actions.

Aspects relating to demand for energy brought on by climate change (e.g., increased use of air-conditioning in response to higher temperatures) should be considered when addressing issues of energy availability. On the other hand, greater energy efficiency brought on by technological developments should also influence energy consumption. There follows a list of such aspects as they relate to the electrical system:

[19] Consumptive uses of water refer to uses that abstract water from its natural courses, decreasing spatial and temporal availability. For example: watering livestock, irrigation, public water supply, industrial processing etc.

Impact of the introduction of new technologies, for example, electric vehicles and energy-efficiency policies;
Impact of future consumption patterns in residential and commercial buildings (dwellings and smart buildings);
Penetration of new technologies, such as intelligent networks and ultra-high-voltage transmission lines;
Greater penetration of distributed generation from different sources, for example, photovoltaic arrays on rooftops;
Self-production of electricity by large consumers, using renewable and fossil-fuel sources, such as cogeneration using natural gas.

Adaptation strategies for the electricity sector must also take into account issues relating to environmental legislation for protection and restoration of natural resources (fauna, flora and physical environment). Reducing environmental impacts, through adoption of Ecosystem-based Adaptation (EbA) strategies is an important step toward building resilience.

Such strategies include electricity generation by hydroeletric power plants of various sizes, wind farms, local and distributed solar-power generation, and thermal power plants that use sugarcane biomass as a feedstock. Such systems are subject both to changes in average climate parameters and to extreme events, the latter being the phenomena most likely to cause outages of transmission and distribution systems.

Assessment of the impact of changes in weather patterns entails evaluation of the vulnerabilities of the energy power system to such changes. In the case of hydroelectric power plants with large reservoirs, for example, the characteristics of such reservoirs may mitigate the effects of river-flow variations and, in turn, their electricity-generation capacity. Such characteristics affect not only operational capacity of the power plant, but also regularization of downstream flow levels.

On the other hand, run-of-river plants and plants with small reservoirs lack storage capacity and are thus more exposed to climate variability. This implies that a balance needs to be struck between ensuring continuity of electricity-generation services and the sensitivity of generating systems to climate-change impacts.

In order fully to appreciate the vulnerability to impacts of climate change of the infrastructure of the electrical system as a whole, a synergistic approach is needed. Some regions of Brazil are likely to suffer increases in rainfall, temperature, winds, and solar radiation, whereas others will probably experience declines.

The National Interconnected System enables offsetting of many such effects by shifting and matching available supply to areas of greatest demand. Such offsetting provides the electrical system with intrinsic adaptation capacity that, to some extent, compensates for certain vulnerabilities. Notwithstanding the flexibility that such offsetting provides, Brazil's national energy policy must continue to pursue its goals of ensuring energy security and lowering costs for consumers. Other examples of the adaptation capacity of the sector are:

- A robust transmission system with ramifications to all the regions of the country, interconnecting power plants and load centres in different river basins, with transmission of large blocks of energy over thousands of kilometres, with high reliability;

- A centralised management agency (ONS) that dispatches power throughout the nation;

- A diversified electricity mix with electric power derived from a variety of sources. Seasonal differences in the conditions for energy generation from different sources create complementarities, e.g., generation from wind farms and thermal biomass plants tends to be most productive in months when river flows are lowest. Figure 11 shows typical monthly variations in energy production from different sources over the year.

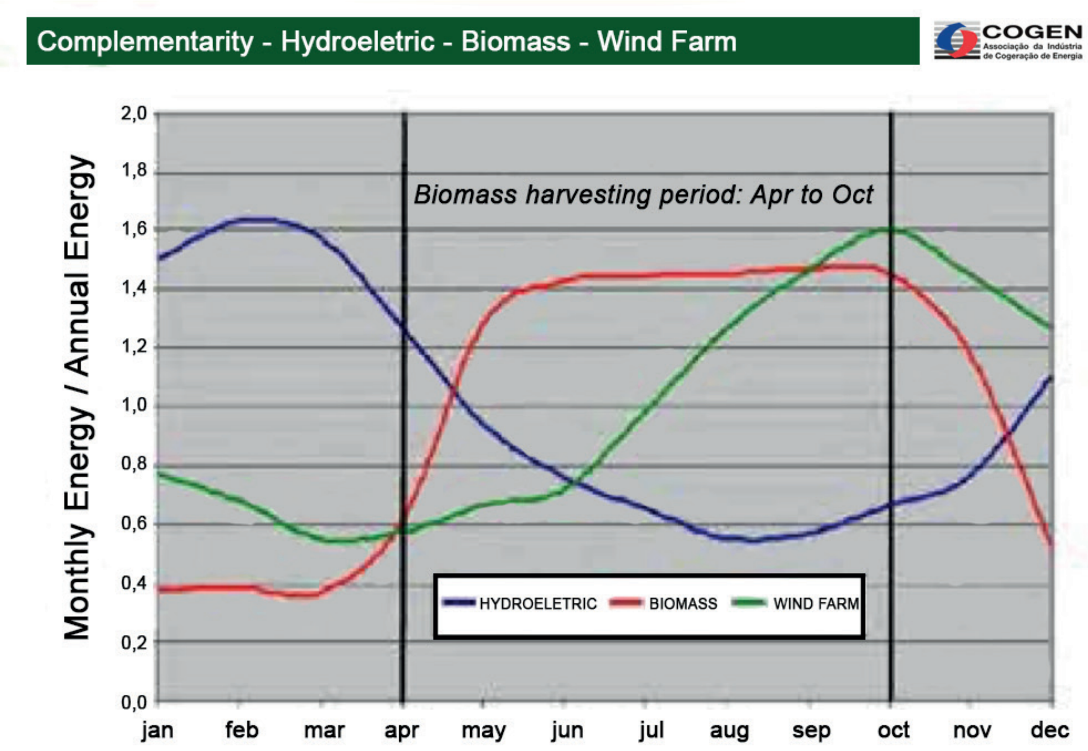


Figure 11- Typical Monthly Variation of energy generation from Hydro, Biomass and Wind sources
Source: Electric System National Operator – ONS

- Reserve generation capacity that can be brought on line to ensure stability of the system.

Certain impacts of climate change may, in effect, strengthen the resilience of the electricity generation system. This could be the case if:

- Climate change accentuates differences in seasonal rainfall patterns of river basins of the Central-South and those of the North region of Brazil. Should this occur, with adequate storage capacity, more intense rainfall in one region could, to some extent, offset lower rainfall in other regions;

- Likewise, offsetting of electricity produced from different sources could occur if climate change favours generation from a particular source in one region, this could offset generation shortfalls in another region.

In the light of these inherent characteristics of the electrical system, an accurate analysis of the real vulnerabilities that it is likely to face can be made, and adaptation measures to mitigate such vulnerabilities and increase resilience can be proposed.

Though in view of their complexity, any quantitative analyses of the vulnerabilities of the electricity sector must entail a great variety of studies, it is nonetheless possible to identify certain isolated climate-change impacts on specific systems, without dwelling upon their synergistic effects on the electrical system as a whole.

Projections from the wide range of climate models present great variability of results for different regions of Brazil, without conclusive quantitative convergence. This shows that caution should be exercised when examining projected impacts suggested by climate modelling, without underestimating them.

An approach to this theme using modelling scenarios for analysis of impacts on different sectors is therefore recommended. Among the array of potential future scenarios, some possible threats to the energy sector can be identified. The following notes, based on studies by the Brazilian Research Network on Global Climate Change (*Rede Clima/*MCTI) and the Secretariat of Strategic Affairs of the Presidency of the Republic (SAE, 2015) focus on qualitative aspects, i.e., impact trends presented in these studies:

- Based on the Water Balance (WB)[20] concept, i.e., the relationship between rainfall and evapotranspiration, which has repercussions on river-flow rates, the value for this indicator applied to river basins presents different behaviours in different parts of Brazil. A declining WB is observed in basins located more in the North (the Amazon Basin) Northeast and East Atlantic. For basins in the South and Southeast, which include the Paraná and Uruguay river basins, the WB will tend to rise during this century. Basins located within the transition regions between these extremes are likely to have a stable WB, i.e., close to zero;

[20] Positive WB: Trend of increasing water availability. Negative WB: Trend of reduced water availability. Zero WB: No influence on water availability.

- A trend toward higher wind velocities is predicted for certain specific areas of the Northeast and South, coinciding with good potential for wind-power generation. Regions where wind speeds are forecast to decrease include some areas of the Amazon and of the Central-West.

- Forecasts for solar radiation indicate that usable sunlight for electricity generation in the North region is likely to remain high. By contrast, in the South, increased cloud cover is likely to result in a decrease in solar radiation. In overall terms, the studies indicate that Brazil has a considerable number of areas suitable for solar-power generation, mostly located in its North, Northeast and Central-West regions.

- For generation from biomass, particularly sugar-cane bagasse, studies show that higher temperatures will reduce the risk of frost in the South, Southeast and south-western areas of the country. This is likely to have a beneficial effect for sugar-cane production and hence energy generation from biomass, as climate restrictions on tropical crops become more relaxed;

- Climatic model projections indicate an intensification of the occurrence of extreme events. Such events may affect infrastructure for electric-power generation, transmission and distribution.

- The vulnerabilities identified should be regarded as merely indicative, and specific actions targeted at minimising their effects on the electricity sector cannot be overly reliant upon them. Further studies with higher degrees of quantification are needed to clarify uncertainties in several areas.

6.4.3. Guidelines for Adaptation

In view of complexities revealed in vulnerability studies on the electricity sector, adaptation actions need to be meticulously assessed and to meet with a solid consensus among bodies that comprise the National Energy Policy Council.

Sectoral policies are formulated within a framework organised to ensure effective fulfilment of goals. Within this framework, the Ministry of Mines and Energy chairs the National Energy Policy Council (an inter-ministerial body that advises the President of the Republic on energy-related policies and guidelines). The Brazilian Electricity Regulatory Agency (ANEEL) and its state-level counterparts is responsible for supervision and regulation of the sector. Other participants in this framework are the Electric System National Operator (ONS), the Brazilian Electric Energy Trading Chamber (CCEE), the Energy Research Company (EPE), and the Electricity Sector Monitoring Committee (CMSE). The Electrical Energy Research Center (CEPEL) is one of the bodies that foster technical and scientific development of the sector. Finally, energy services are provided by various companies that comprise the Eletrobras System[21], state and municipal-level electricity-generation and distribution companies, and the transmission companies.

[21] Centrais Elétricas Brasileiras S.A.

To stimulate debate, and hence consolidation of adaptation concepts that are compatible with objectives of the energy sector, guidelines are needed to ensure attainment of adaptation goals on the part of both private and public stakeholders.

Moreover, the proposed guidelines should orient technology-transfer programmes and capacity-building initiatives for the electricity sector through direct exchanges with other countries, or multilaterally through the United Nations Framework Convention. There follows a list of proposed guidelines for the electricity sector:

1. Promote a greater engagement of electricity-sector institutions in themes relating to adaptation, with a view to adapting institutional policies to new climatic parameters, when appropriate;

2. Deepen impact studies on specific areas of interest to the electricity sector in relation to climate-change trends;

3. Conduct studies on climate-change risks assessment to energy-sector infrastructures, with a view to improving management of activities, focusing on contingency planning for extreme events;

4. Evaluate potential co-benefits and synergies between mitigation and adaptation, relating to various alternatives applicable to the energy sector;

5. Assess, when relevant, interactions between adaptive measures for water, energy, land use and biodiversity, as a means for understanding and managing such interactions;

6. Conduct studies to define and improve planning tools, with a view to adapting parameters in response to scientifically verified climate change impacts.

The guidelines proposed in this Chapter seek to foster electricity-sector planning in the light of climate-change projections and to provide energy-policy guidance in the quest for greater resilience, while abiding by principles of security of supplies, environmental sustainability and moderate tariffs.

Strategy for Vulnerable Populations

National Adaptation Plan to Climate Change

7 Strategy for Vulnerable Populations

7.1 Introduction

Intensification of extreme weather events associated with climate change is likely to affect many of the day-to-day activities of human populations. Such effects include fewer job opportunities in a number of economic sectors. They are also likely to increase migration[22] flows, as entire population groups flee the effects of climate change or seek to adapt to them. The distribution of such impacts, however, will occur unevenly throughout the country and the principle effects will be borne by more socially and economically underprivileged groups.

The poorest groups will tend to be more heavily affected, as they have fewer alternatives for ensuring livelihoods than wealthier segments of the population (COEP[23], 2011).

The latest IPCC report (AR5, 2014) states that poorer populations (especially those in tropical countries) will be the most affected by climate change. Poverty is associated with socioeconomic fragilities that prevent resilience to adverse weather events. Thus, climate change is likely to result in increased exposure to disease, higher food insecurity and malnutrition, material losses, housing deficits, and fewer livelihood and income opportunities. Other factors associated to such vulnerabilities include: inappropriate land use, precarious housing, lack of access to basic sanitation and other public services, such as education and healthcare (COEP, 2011 b).

In Brazil, a vast country of great environmental and physical diversity, characterised by huge social and regional disparities, poverty[24] is among the main factors underlying the population's sensibility to climate change. Indeed, according to the IPCC (2007) poverty must be considered an important aspect for the assessment of the vulnerability of the population.

Currently, roughly 80 million Brazilians can be considered poor (MDS, 2014)

[22] The International Organization for Migration (IOM) defines Migration as "the movement of a person or a group of persons, either across an international border, or within a State. It is a population movement, encompassing any kind of movement of people, whatever its length, composition and causes; it includes migration of refugees, displaced persons, economic migrants, and persons moving for other purposes, including family reunification" (IOM, 2011 apud IOM, 2014, p. 23)."

"Environmental migrants are persons or groups of persons who, for compelling reasons of sudden or progressive changes in the environment that adversely affect their lives or living conditions, are obliged to leave their homes or choose to do so, either temporarily or permanently, and who move either within their country or abroad" (IOM, 214, p. 6).

Adaptation (linked to migration): in human systems, the process of adjustment to actual or expected climate and its effects, which seeks to moderate harm or exploit beneficial opportunities. Migration and mobility are adaptation strategies in all regions of the world that experience climate variability" (IPCC, 2014 apud IOM, 2014, p. 23)

[23] National Social Mobilisation Network.: <www.coepbrasil.org.br>

[24] The poor are those lacking security of fulfilment of basic human needs such as food, shelter, clothing, schooling, health care, etc. (MONTEIRO, 1995).

a condition that substantially reduces their adaptive capacity. Thus, the environmental impacts, both of extreme weather events and of gradual climate change, are likely to undermine improvements in living standards achieved in recent years and may even contribute toward a reversion to the former less favourable *status quo*. (COEP, 2011a). Other contributing factors to such social vulnerabilities include: issues of race and gender (particularly relating to the status of women[25]); traditional populations; Specific Traditional Population Groups (STPGs - GPTEs) including blacks, all of which reflect deeply ingrained structural disparities (COEP,2011).

The persistence of such disparities justifies an effort to identify the social groups most vulnerable to climate change in Brazil, with a view to reducing negative impacts and promoting social-policy actions and strategies, in line with Brazilian regional sustainable-development and climate-change adaptation goals. Gaps in the data on the vulnerabilities and adaptation capacities of specific groups and their distribution in the various regions and biomes of Brazil, require further research, in support of furthering the country's social-agenda goals.

This chapter is a collaborative effort, prepared jointly by the Ministry of Environment (MMA), the National Indian Foundation (FUNAI) and the Ministry of Social Development (MDS) with the aim of supporting contextualization and identification of the population groups most vulnerable to climate change, and of promoting their adaptation to new climate conditions.

To this end, the following premises and approaches were established.

Vulnerability to climate change and adaptation to its effects by peoples and communities are examined from different standpoints. Firstly, from a territorial municipality-based approach; next, an analysis prepared especially for this Chapter, examines vulnerability from a biome approach; and lastly, the Chapter focuses on the vulnerabilities of Brazil's indigenous peoples.

The focal points, responsible for coordination, promotion and implementation of actions and guidelines proposed in this Chapter, are MMA, MDS, FUNAI, and the Brazilian Forum on Climate Change (FBMC).

7.2 Historical and institutional framework

In mid-2010, under the coordination of the Committee of Entities in the Fight against Hunger and for Life (COEP), the FBMC's Working Group on Climate Change, Poverty and Inequality proposed a set of principles, objectives and guidelines to be observed during preparation of the National Adaptation Plan to Climate Change. Drafting of this Plan entailed a participatory and innovative process to identify and address the main issues, drawing upon the experience and expertise of various public and private organisations, namely: ASA, CARE, the

[25] Women, owing to the nature of some of their tasks and double workload, are among the most disadvantaged.

National Food and Nutritional Security Council (CONSEA), FASE, FIOCRUZ, IBAMA, IBASE, the Brazilian Network for Integration of Peoples (REBRIP), OXFAM, Vitae Civilis, and WWF-Brasil)(COEP, 2011). Members of the Working Group concurred that a significant number of measures were being undertaken on the part of governments at the various levels to assist vulnerable populations, for example, the policies related with the Unified Registry for Social Programmes of the Brazilian Federal Government (CadÚnico[26]).

For coordination of such measures, the CadUnico assists the Federal Government in identification of Specific Traditional Population Groups (STPGs). In recent years, the government has become accessible to the demands of different social groups, through its policy of creating and strengthening councils and national conferences such as the National Food and Nutritional Security Council (CONSEA), the Secretariat for the Promotion of Racial Equality (SEPPIR), and the Secretariat of Human Rights. Another example of institutionalization, that represents an important achievement for the traditional people that is vulnerable to climate change, is the institution of the National Council for Sustainable Development of Traditional Peoples and Communities (CNPCT). The role of this Council is to guide public policies targeted at traditional populations, by contributing toward measures for mitigation of poverty and extreme poverty among these groups (DIREITO and LICIO, s/d). Decree 6040[27] of February 2007, established the National Policy for Sustainable Development of Traditional Peoples and Communities (PNPCT) (MDS, 2014) and provided definitions for the terms 'traditional peoples' and 'traditional communities' within the scope of the policy.

In another recent milestone, Decree 7747/2012, established the National Policy for Territorial and Environmental Management of Indigenous Lands (PNGATI) for the purpose of ensuring: protection, restoration, conservation and sustainable use of natural resources in indigenous lands and territories, while ensuring the integrity of indigenous heritage, improving quality of life and of conditions for physical and cultural reproduction of current and future generations of indigenous peoples, respecting their socio-cultural autonomy.

The National Plan for Strengthening Extractive and Riparian Communities (PLANAFE)[28] was launched in 2015 for the purpose of "adapting, coordinating, integrating and proposing actions to promote access to health, education and social infrastructure,

[26] The Single Registry for Social Programmes of the Brazilian Federal Government (*CadUnico*) identifies and classifies low-income families, thereby facilitating understanding of the socioeconomic realities of this population. It records information such as: characteristics of residence, personal identification, schooling, employment and income status, etc.

[27] Traditional Peoples and Communities: culturally differentiated groups recognised as such, that possess their own forms of social organisation, that occupy and use territories and natural resources as part of their cultural, social, religious, ancestral and economic heritage, comprising knowledge, innovations and practices generated and transmitted by tradition (Decree Nº. 6040, 7/2/2007).

[28] Established by Inter-ministerial Order 380, of 11 December 2015, signed by the Ministers of Environment (MMA), Agrarian Development (MDA) and Social Development and Combatting Hunger (MDS).

with a view to promoting sustainable production, generating income, and fostering environmental and territorial management of areas for traditional use and occupation, to ensure quality of life, access to and sustainable use of natural resources, environmental conservation and promotion of human rights for extractive and riparian communities."

7.3 Identification of the populations most vulnerable to climate change in Brazil

7.3.1. Proposal for selection of Brazilian population groups most vulnerable to climate change

The approach for identification of the more vulnerable populations was chosen on the basis of available data and public-policy instruments. This strategy aims to serve as a tool for establishment of measures for identification and monitoring of vulnerable populations.

7.3.2. Social vulnerability in Brazil

Social vulnerability in Brazil is equated with the "sensitivity" component of vulnerability to climate change, as defined by the IPCC. It is assessed by means of various governmental initiatives that take into account the population's social, ethnic and cultural diversity. Based upon self-identification of groups, it is possible to analyse socioeconomic profiles and to identify layers of exclusion, thus enabling structuring and enhancement of public policies for addressing the realities identified.

For the purpose of identifying some of the most socially sensitive groups in Brazil, and those that, owing to their socio-economic status are considered highly sensitive to climate change, the CadUnico[29] was used.

Though designed primarily as a tool to support planning and implementation of federal-government social programmes, CadUnico is also quite well adapted to serving purposes associated with adaptation to climate change impacts. Much of the policy and institutional structure of the registry is equally appropriate for attaining adaptation goals, given the crosscutting nature of climate-change issues and their relevance to different line ministries and to state and municipal-level bodies.

CadUnico classifies socially vulnerable population groups in Brazil by the following characteristics: ethnic origin, environmental relationship, agricultural aptitude, and circumstantial situation. Within the Specific Traditional Population Groups (STPGs), wich includes indigenous, *quilombolas*, gypsies, among other groups, the most vulnerable category are those with a per capita income of less than R$ 77.00. This category comprises: 114,791 indigenous and *Quilombola*

[29] The Single Registry for Social Programmes of the Brazilian Federal Government (*Cadastro Unico - CadUnico*) was established at the end of 2001 to identify the socioeconomic profile of poor families and provide inputs for design of public policies targeted at families in situations of social vulnerability (BRAZIL/MDS, 2014). It comprises a set of targeted strategies for registration of families, classified by specific life-style, cultural, belief and critical-vulnerability features. CadUnico has laid the foundations for differentiated registry (GM/MDS Order 376 of 16 October 2008). Since 2004 it has identified families belonging to 15 traditional population groups and living in specific situations (GPTES).

families registered in 2010; however, by June 2014, this number had risen to 1.27 million families belonging to 15 groups recognised by the MDS (Figure 12). The groups with highest percentages of extremely poor people among the STPGs can be broken down by specific ethnic categories (indigenous 77.4%; *quilombola* 74.2%; and gypsies 75.2%); environmental categories (extractivists 81.7%; fishermen 75%; and riparian 84.5%); homeless (87.6%); and family farmers (74.1%).

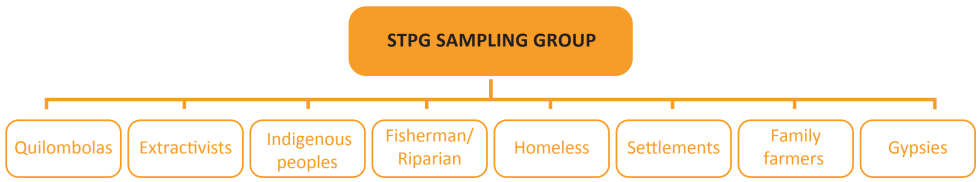


Figure 12. Some STPG categories. (MDS, 2015)

7.3.3. Population group categories most sensitive to climate change, according to CadUnico

For purposes of this Chapter, analysis of the sensitivity of certain Brazilian populations to climate change is based on STPG categories. This choice is justified, since such groups suffer high degrees of socio-economic exclusion. When compared to other poor and extremely-poor families, the data reveals that STPGs have higher sensitivities (lower income, lower schooling and less access to basic services) than other families. Apparently, families in this category suffer a process of double exclusion since, aside from discrimination generated by economic factors, social invisibility and institutional prejudices hamper their access to public policies. Additionally, unlike most other families registered in CadUnico that are predominantly urban (80%), STPG families tend to live in rural environments (69%).

7.4 Approaches for understanding vulnerability

This item examines approaches for identification and analysis of the vulnerability of populations and, though different approaches are used, they can be applied simultaneously.

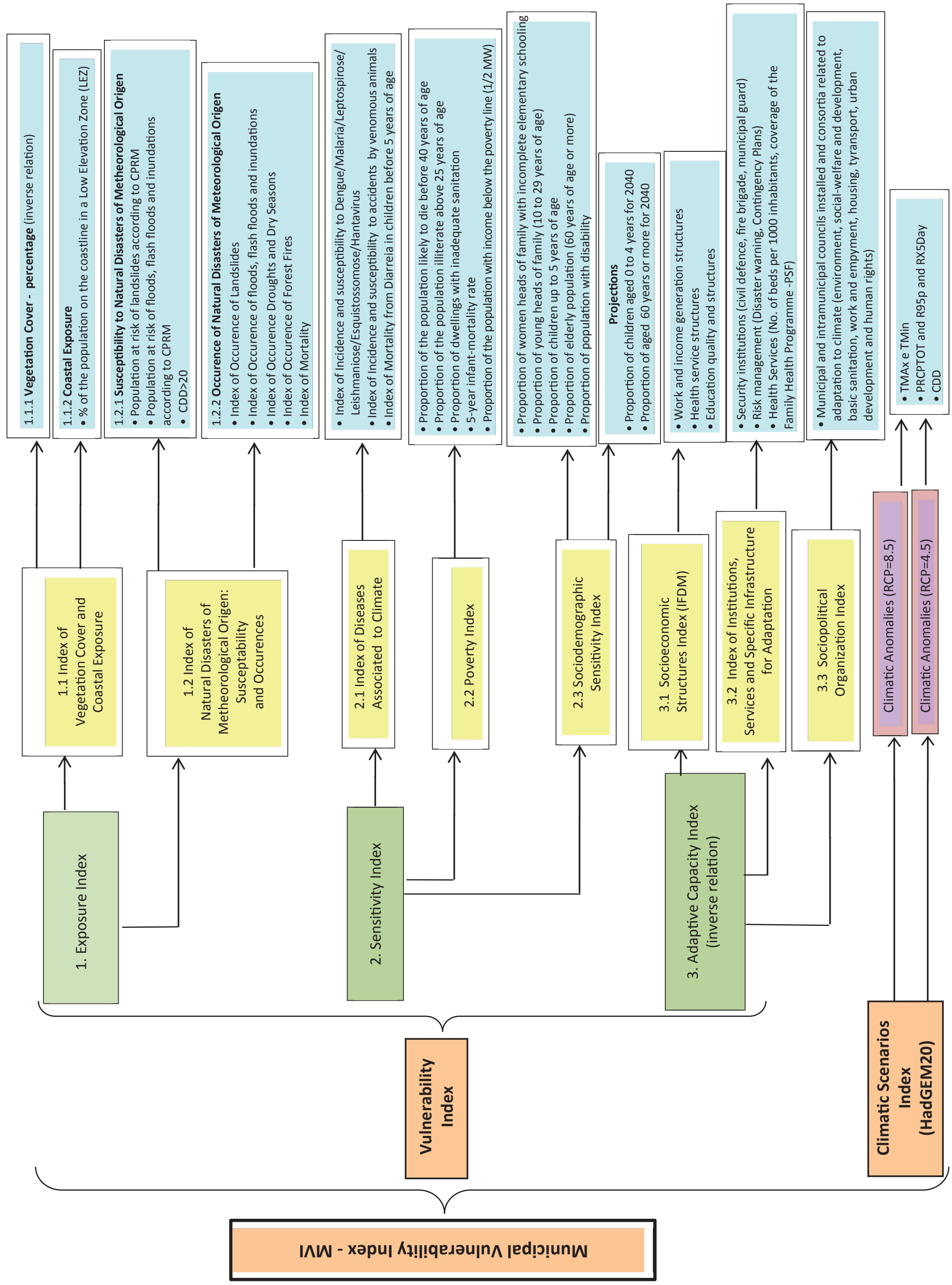
7.4.1. Territorial Municipal-based Approach

This methodology was developed within the scope of a project for “Construction of Population Vulnerability Indicators as an Input for Drafting of Climate-Change Adaptation Actions in Brazil”, carried out through a partnership between the Ministry of Environment (MMA) and Oswaldo Cruz Foundation (Fiocruz).

The project developed indices for Assessment of Social Vulnerability to Climate Change at the municipal level (Confalonieri *et al* 2014). Initially, this index is to be applied in six Brazilian states, and may later be adopted in other states and municipalities.

Components of municipal indices can be broken down into sub-indices, for exposure, sensitivity, and adaptation capacity that comprise the Vulnerability index. Table 12 presents the proposed index and a description of the indicators used to comprise its sub-indices.

Table 12. Climate Change Vulnerability Index of Municipal Populations (FIOCRUZ, 2015).



The MMA is providing states and municipalities with this tool as a means of supporting local strategies for addressing the vulnerabilities of different population groups. Further information on this tool is available on the MMA website.

7.4.2. Biome-based Approach

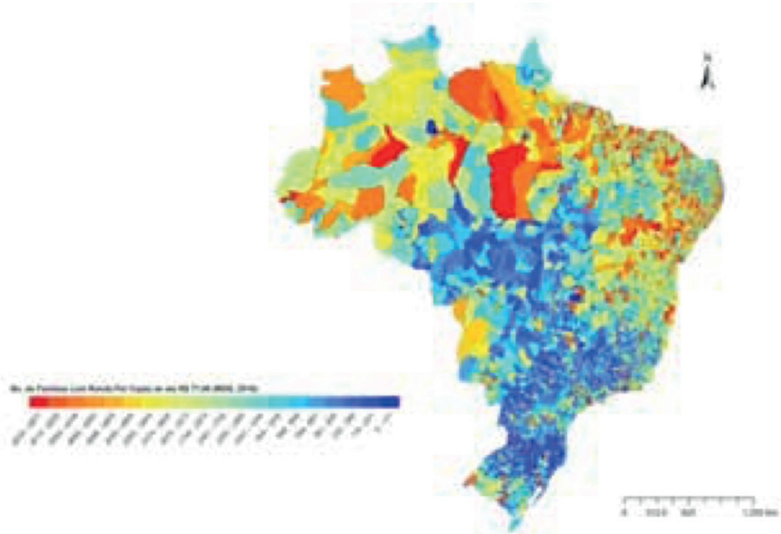
a. Current exposure of STPG in Brazilian Biomes

From a territorial standpoint, it can be perceived that STPGs are mainly concentrated in the Amazon (60.3%) and Caatinga Biomes (19.9%). The Amazon accounts for the largest contingents of groups dependent upon the environment for livelihoods, i.e., extractivists (68.7%), riparian populations (79.9%) and indigenous peoples (42.1%). A great wealth of information on climate change vulnerabilities in Brazil relates to indigenous peoples.

A study on disasters in Brazil between 1991 and 2010, by the Research Centre for Disasters of the Federal University of Santa Catarina (CEPED/UFSC, 2012) found that the most disaster-prone areas are located in the North, Northeast, Southeast (north and coastal areas), and South regions (Risk - Figure 13). When this map is contrasted with the number of families with per-capita incomes amounting to no more than R$77 (STPGs supposedly more sensitive - Figure 13b) it can be observed that most are located in regions of greater climatic exposure, mainly in the North and Northeast.

Although Brazil's South region (in the Pampa and partly in the Mata-Atlântica Biomes) is exposed to climatic threats, its socioeconomic vulnerability is lower in view of better income distribution and smaller presence of STPGs, as a consequence of regional historical factors.

(a)



(b)

Figure 13. Figure (a) shows the intensity of disasters in Brazil between 1991 and 2010 by municipality (darker colour indicates a greater number of disasters). Figure (b), shows the (more sensitive/exposed) groups of families with per-capita incomes of no more than R$77 (Blue indicates a smaller number of families and Red a higher number)

By contrast, the North (Amazon) and Northeast (Caatinga) regions suffer repercussions not only from climatic exposure (i.e., drought and flooding) but also from socio-economic aspects and the greater number of STPGs in places where, historically, such groups have settled. In the Caatinga, exposure to drought is a longstanding phenomenon and, owing to political, cultural and socioeconomic factors, solutions are hard to apply, thereby increasing the vulnerability of STPGs. Moreover, in addition to threats and exposure to current and future climate, other factors exacerbate disaster risks in these biomes.

The Cerrado and Pantanal, though less prone to disasters than other biomes, are nonetheless subject to extended dry periods and risks arising from seasonal floods and runoff. From the standpoint of socioeconomic vulnerability of STPGs, both these biomes are in a more comfortable situation in terms of numbers of sensitive households, except in the southern part of the Pantanal and in north and north-eastern Minas Gerais, where exposure levels pose greater threats and the numbers of economically vulnerable families are higher.

There follows an analysis of biomes from a future-climate standpoint, in the light of global and regionalised predictions for Brazil, in terms of rainfall and temperature anomalies, until 2040.

Table 13 describes projected temperature and rainfall changes of the HadGEM model for 2011-2040 in the IPCC's AR5 8.5

emissions scenario for Brazilian biomes, which would cause greater exposure of STPGs. It shows some of the sensitivities and exposures of these groups, by biome, and some gaps and bottlenecks that must be understood, measured and addressed, in order to gauge the vulnerabilities of STPGs to climate change.

The table does not show vulnerabilities for each STPG separately, nor their spatial distribution within each biome. This represents a knowledge gap which will require further studies in coming years.

There is a lack of updated and systematised information on the demographics and location of STPGs. This represents a bottleneck for formulation and implementation of public policies targeted at improving living conditions, addressing their invisibility, and reducing neglect of their vulnerability status. Such information gaps aggravate other structural limitations of policies targeted at STPGs and, to some extent, explain flaws in their basic rights (i.e., access to territories and to basic services).

Table 13. Contributing factors to future vulnerability of Specific Traditional Population Groups (STPGs) in Brazilian biomes, under the IPCC's AR58.5 Wm^2 scenario

Vulnerability components of Specific Traditional Population Groups in Brazilian biomes	
Amazon	**Groups:** Indigenous peoples, quilombolas, extractivists, artisanal fishermen, squatters, riparian populations and family farmers.
	Exposure: Risk of fire/prolonged drought/heavy rainfall; strong dependence on biodiversity and related ecosystem services; risk of flooding and of landslides; changes in phenology of domesticated and native species, dependence on soil quality.
	Sensitivities: High degree of dependence on natural resources; high incidence of diseases associated with hot and humid weather; low migration capacity; land-tenure insecurity; strong identification with the land; houses in remote areas of difficult access; poor access to public services and private markets; incomes; sudden changes in local weather cycles threaten traditional production practices; and interference in the traditional knowledge on planting and harvesting cycles.
	Some potential impacts: Reduced fish stocks; impaired livelihoods; impairment of material goods; increase in vectors of diseases caused by higher temperatures; increased incidence of lung diseases caused by smoke from fires and burning.
	Gaps: Lack of knowledge of the specific vulnerabilities of each STPG category, by biome.

Cerrado	**Groups:** Extractivists, quilombolas, indigenous peoples, gypsies, family farmers, land-reform settlers and homeless.
	Exposure: Extreme rainfall events; more intense urban landslides and flooding that may affect populations living in risk areas; more extended periods of drought; increase in the risk of fires and burnings; threats to remaining forests and endemic and/or endangered species.
	Sensitivities: High incidence of respiratory diseases associated with dry weather, livelihoods highly dependent upon natural resources; food insecurity; reliance on farming for income; dependence on biodiversity and ecosystem services.
	Possible impacts: Impairment of large-scale and family farming, hampering not only subsistence activities but also production of soybeans, sugar cane, cotton, and other commodities and foods. Dry air and burning may cause higher incidences of respiratory disease.
	Gaps: Lack of time-series information on vegetation cover in the biome; lack of smaller-scale climate modelling and research on the impacts on specific populations or groups; poor knowledge and mapping of biodiversity within the biome and its potential to support the population; and poor coverage of weather stations in these areas.
Caatinga	**Groups:** Quilombolas, family farmers, indigenous peoples, extractivists, artisanal fishermen, gatherers, homeless, gypsies.
	Exposure: In semi-arid portions of the Northeast, warmer and drier climate foreseen in models points and more intense droughts in this region. Low vegetation cover. Areas susceptible to extreme climatic effects of drought.
	Sensitivities: Low-income population groups; poorly managed energy mix based on biomass.
	Possible impacts: Climate change scenarios for the Caatinga point to replacement of current vegetation cover with more drought-resistant desert vegetation; water levels in local reservoirs are likely to decline, posing threats to water-supply and health of local populations. Subsistence agriculture, especially rain-dependant farming, will suffer; undermining livelihoods and posing a threat to food security. Warmer and drier weather may cause migration to big cities of the region and to other regions, in waves of environmental refugees. Poor availability of high-quality and timely data for monitoring signals and observing impacts of climate change; lack of adequate indicators and systems for monitoring the water balance, salinization and deforestation.

Mata-Atlantica	**Groups:** Indigenous peoples, extractivists, artisanal fishermen, gypsies, family farmers, homeless, quilombolas.
	Exposure: Risks of flooding, landslides and higher sea levels. High population density in the coastal region. This biome is characterised by rugged terrain that is susceptible to landslide and flooding events. Risk of increased periods of droughts and of longer dry seasons.
	Sensitivities: This biome has Brazil's highest population densities and encompasses one of the most economically dynamic parts of South America. Prevalence of insect-transmitted diseases, such as dengue and yellow fever, is high. Sanitation and wastewater treatment indices are low. A major portion of the population lives in high-risk areas.
	Possible impacts: Hurricanes may begin to reach Brazil's southern coast (as occurred in Santa Catarina). Longer dry seasons may affect the regional water balance, with consequences for human activities, such as abstraction of water for agriculture, energy generation and food production. There may be more frequent flooding, landslides and floods brought on by extreme rainfall events, causing economic damage and loss of lives. Waterfronts may be washed away; ports destroyed and populations displaced. Even though rainfall will tend to increase, the high air temperatures predicted by models may, at the same time, reduce availability of water for agriculture, human water supply, and electricity generation, owing to foreseen increases in evaporation or evapotranspiration.
	Gaps: Inadequate mapping of risk areas, taking into account climate-related disaster risks and real-time early-warning systems; participatory development of master plans; adequate urban planning.
Pantanal	**Groups:** Artisanal fishermen, riparian populations, indigenous peoples, land-reform settlers and family farmers.
	Exposure: Higher temperatures, lack of rain, flat and low terrain, susceptible to floods.
	Sensitivities: Economic activities highly dependent upon the seasonal ebb and flow of the water cycle. Any significant disruption of this cycle, resulting from climate change or deforestation, may affect the water-retention and control capacity of these wetlands; populations thinly distributed in remote areas.
	Gaps: Few studies on the impacts of climate change on this biome and their repercussions on specific population groups and; poor coverage of weather stations in these areas.

Pampa	
	Groups: Family farmers, land-reform settlers, homeless, indigenous peoples.
	Exposure: Some areas already undergoing desertification; land-use changes may increase vulnerability to drought. Higher frequency of extreme weather events, with intense and frequent waves of heat and cold. Dry hot summers. Intense and concentrated rainfall. Longer dry seasons. Increase in wind speeds and possibility of hurricanes.
	Sensitivities: Characteristics of buildings/homes; deforested areas and threats of further land clearing; few conservation units in the region.
	Possible impacts: Grain production and reforestation with exotic species may be undermined in the Pampa region. Higher temperatures and rapid temperature variations may lead to higher incidences of associated diseases. Intense rains may increase flooding and landslide risks, mostly affecting populations living on deforested hillsides and residents of poorer neighbourhoods that lack infrastructure; excessive heat and drier air may cause salinization of soils in areas affected by reforestation with pine and eucalyptus.
	Gaps: Few studies and little knowledge of biodiversity of this biome; further studies are needed on the impacts of climate change in the Pampas and their effects on specific population groups.

7.5 Indigenous peoples and climate change: vulnerability, adaptation and traditional knowledge

Any evaluation of the effects of climate change on Brazil's human populations must take into account the vast ethnic and cultural diversity of its more than 300 indigenous peoples[30]. The cosmologies, languages, traditional knowledge and identities of such population groups comprise totally distinct social, cultural, political, legal and economic systems, within a variety of territorial and social contexts. These peoples have long and multigenerational histories of interactions with surrounding Brazilian society, with the environment and, more especially, with the territories they traditionally occupy, which have little relationship with concepts of private land ownership or tightly bounded borders. From an indigenous standpoint, territory is ecological, social and symbolic space, which harks back to historical and mythological references, of fundamental importance to the physical and cultural reproduction of the group, its ways of life, and its autonomy projects.

The specialised scientific literature predicts that, in view of lifestyles based on sustainable management and use

[30] The Population Census (IBGE, 2010) estimates the Brazilian indigenous population at 817,963, of which 502,783 live in rural areas and 315,180 in towns in all the Brazilian states and the Federal District. There are 305 different peoples, speaking 274 indigenous languages, and an estimated 69 as yet un-contacted indigenous groups, according to FUNAI. Brazil, as a multi-ethnic and democratic State, has a number of legal and constitutional provisions that acknowledge, protect and establish rights to such diversity. Provisions of the 1988 Federal Constitution govern relations between the State and indigenous peoples, ensuring protection and guaranteeing their collective rights, and sweeping away assimilationists, tutelary and integrationist premises of earlier laws.

of natural resources and the biological diversity of territories in which they live, the impacts of climate change on the cultures and territories of indigenous peoples will be come early and with severe effect. Such exposure and sensitivity are, in part, linked to the fragility of the ecosystems in which many communities are located, their vulnerability to climatic extremes, and rapid spatial transformations caused by anthropogenic activities and unsustainable development models. Indigenous peoples possess detailed traditional knowledge on seasonal, annual and inter-annual cycles and of their interrelationships with other components of the ecosystems in which they live and which they use in the exercise of landscape-scale land-use and natural-resources management, and around which their social and ceremonial lives revolve. Moreover, they are keen observers of environmental dynamics and changes and of related impacts and trends that affect their lives. Since before the dawn of recorded history, they have developed varied creative and sustainable responses and strategies to address climate change, and assumed active roles in design of distinctive change and adaptation scenarios, based on their own culture-specific and astute climate perceptions.

When considering synergies between aspects of adaptation and mitigation, it should be acknowledged that traditional knowledge and cultural, patterns of territorial land use and the inherent systems for management and conservation of environmental assets pursued by indigenous peoples in their territories have, historically, promoted conservation of biodiversity and of hydrological cycles, retarded deforestation, maintained forest carbon stocks and provided numerous significant environmental services for maintenance of a stable climate.

The Traditional Knowledge Initiative (TKI) of the Institute for Advanced Studies of United Nations University (UNU) is endeavouring to promote greater appreciation of the traditional knowledge and practices of indigenous peoples. It has sought to promote acknowledgement that such knowledge can: 1) provide valuable local and regional-level information, serving as means for verification of regional and global scientific-data models and provide a basis for preparation of adaptation and mitigation strategies; 2) provide a solid basis for development of adaptation measures for communities and micro regions; 3) serve as a basis for development of strategies for adaptation and natural-resources management in response to environmental and other types of change; 4) assist in understanding of the potential of cost-effective, participatory and sustainable adaptation strategies[31]. It was recommended that representatives of indigenous peoples be invited to participate in debates,

[31] Contributions of Working Group II ("Impacts, Adaptation and Vulnerability") to the 4th and 5th IPCC evaluation reports, provide numerous case studies; documents of the 31st and 32nd Sessions of the IPCC; the compilation of summaries presented in the joint IPCC - UNU Workshop "*Pueblos Indigenas, poblaciones marginados y cambio climatico: vulnerabilidade, adaptacion y conocimientos indigenas*" (IPCC, UNU, 2011) and the report "Weathering Uncertainty – Traditional knowledge for climate change assessment and adaptation" (UNESCO, UNU, 2012).

evaluations and planning of policies to counter the adverse impacts of climate change, in recognition that a blend of scientific, traditional and local knowledge could foster adaptation capacity and reduce vulnerabilities.

Notwithstanding their accumulated traditional knowledge on functioning and interrelationships of natural cycles and ecosystems, the intensity and rapidity with which climate-change is affecting the different biomes may lead to situations in which the magnitude of future risks exceeds the adaptation capacity and resilience of these peoples, jeopardising maintenance of their cultural practices and livelihoods. Few studies and initiatives have sought to understand the perceptions of Brazil's indigenous peoples with respect to the indicators and signals of climate change, or their adaptive practices and strategies for dealing with such changes.

IMPACTS OBSERVED

Some recent experiences[32] indicate that, rather than normal weather variations or effects predicted in future scenarios, various communities of different socio-cultural and territorial backgrounds report changes in temperature and rainfall patterns and in humidity and seasonal river-flow levels. Alongside other exposure factors and variables, they report that climate change has variously affected important environmental, cultural and territorial dimensions, and that its impacts include, among others: increases in burnings and deforestation, extreme weather events, desertification; changes in plant and animals life cycles, agricultural cycles, water dynamics and fisheries, ritual and traditional-medicine practices, organisation of community life; sustainability of livelihood activities, food production and food security, and health. An important auxiliary planning tool for adaptation actions for indigenous territories and for the peoples of the Brazilian Amazon is the online digital System for Observation and Monitoring of the Indigenous Amazon (SOMAI platform)[33]. Developed by the Amazon Environmental Research Institute (IPAM) the platform provides scientific information on climate scenarios and vulnerabilities of Amazonian indigenous territories (including maps and rainfall and temperature change scenarios); and on their role in maintenance of regional and global climatic stability.

Climate change is thus but one among the multiple threats to Indigenous Lands. It cannot be analysed separately from other social, political, economic and environmental threats that such peoples currently face. Thus, strengthening the resilience and adaptive capacity of indigenous peoples must necessarily entail efforts targeted at overcoming

---

[32] Information was gathered from seminars and training sessions "Climate change from the standpoint of the indigenous peoples of Brazil", promoted by the Association of Indigenous Peoples of Brazil, FUNAI, IPAM and partners in the second half of 2014; provided by the Indigenous Council of Roraima's publication entitled "Amazad Pana'adinhan: perceptions of indigenous communities on climate change – Serra da Lua Region/RR", resulting from a long and careful process of collaborative research conducted by teachers and indigenous territorial and environmental agents (ATAIS) and partner researchers, as contributions for a plan for combating the effects of climate change in the region and reducing the consequences of climate change.

[33] <www.somai.org>

structural disparities, promoting climate justice[34] and safeguarding human rights.

A variety of adaptive measures and responses are used by indigenous peoples in Brazil, stemming from traditional knowledge and practices, including:

Cutting and maintenance of firebreaks and training of fire fighters;
Surveillance and monitoring of boundaries of indigenous lands;
Community debates on fire management, use of irrigation and soil conservation techniques;
Projects for recovery of springs and agroforestry systems;
Renewal and strengthening of traditional farming practices, with guidance and knowledge of elders;
Relocation and redistribution of villages and plantations within territories;
More flexible production activities, choice of more resilient strains that are less dependent upon seasonal factors, changes in hunting/gathering/planting/harvest intervals and diversification of crops;
Changes in time and location of ritual and ceremonial practices;
Use of new production technologies; establishment of seed banks and promotion of inter-community exchanges; medicinal herb gardens and projects for strengthening knowledge of traditional medicine; local and regional-level management and planning instruments e.g., ethno-mapping, ethno-zoning and territorial and environmental management plans for indigenous lands in compliance with the National Policy for Territorial and Environmental Management on Indigenous Lands (PNGATI);
Regional plans for facing up to climate change; educational activities and training on the theme of environmental and territorial management, targeted at strengthening capacities;
Diagnoses, case studies, collaborative research and intercultural dialogues on climate-change themes;
Participation in climate-change forums.

[34] Proponents of Climatic Justice argue that those who are least responsible for greenhouse gas emissions are the ones who will suffer most from impacts of climate change. To redress these problems, they propose deployment of initiatives and policies that address ethical and human-rights dimensions of climate change, with a view to reducing vulnerabilities of social groups disproportionately affected by climate change (EBI, 2009; ROBERTS & PARKS, 2009; SHEPARD & CORBIN-MARK, 2009; TYREE & GREENLEAF, 2009).

The basis for discussion of strategies for adaptation to climate change as it affects indigenous peoples must be based upon acknowledgement of provisions on integral protection and promotion of their rights enshrined in law. These encompass: an understanding of the multiple forms of sociocultural and environmental vulnerabilities to which they are subject; visibility of contributions of their traditional knowledge and practices; fostering of intercultural and cross-scientific dialogues; guarantee of adequate training, information, participation and consultation processes for indigenous peoples; and coordination, liaison and synergy among public policies for addressing climate change and support for territorial and environmental management of indigenous lands.

In support of the development of future programmes, the following guidelines for adaptation strategies of indigenous peoples are suggested:

Acknowledge, highlight and enhance the contribution of indigenous territories and peoples and of their knowledge, traditional technologies and livelihood practices, management and use of natural resources, toward conservation of biodiversity, the containment of deforestation, maintenance of the stability of weather conditions, and formulation and implementation of public policies for adaptation and mitigation of the effects of climate change;

Ensure budget resources and from international cooperation for implementation of the PNGATI, which has proven a useful tool for coordination of public policies for indigenous lands, enabling actions for adaptation and addressing the effects of climate change. With a view to supporting development of future programmes, the following guidelines and adaptation strategies for indigenous peoples are suggested;

Expand and strengthen protection, supervision and land-tenure status of lands traditionally occupied by indigenous peoples, in a coordinated, synergistic and integrated manner, with the promotion of territorial and environmental management of their territories;

Strengthen participatory and on-going processes for implementation of the National Policy for Territorial and Environmental Management of Indigenous Lands, promoting synergies with the guidelines, objectives and instruments of the National Climate Change Policy and prioritizing actions for protection, recovery, conservation and sustainable use of the natural resources of the indigenous lands and territories, with appropriate budgetary funding;

Promote appropriate training, information, participation and consultation on climate change themes, at grass-roots levels (including different generational and gender-based themes) and support creation of networks for exchanges of experiences and dialogues;

Ensure the participation of indigenous peoples in decision-making and discussions, drafting and implementation of related policies, such as the National Plan for Adaptation, the National REDD+ Strategy, the REDD+ Information System on Socio-environmental Safeguards, the National Policy for Territorial and Environmental Management in Indigenous Lands (PNGATI) and in other forums and instruments relating to climate change and payment for environmental services;
Promote research, mapping and diagnostic studies targeted at a deeper analysis of (current and potential) vulnerabilities to climate change of indigenous peoples, and of their knowledge, adaptive practices and strategies, with priority for participatory methodologies, intercultural dialogues, participation of indigenous researchers and networking for broader educational and training purposes.

7.6 Guidelines

7.6.1. General guidelines for implementation of the Biome-based Adaptation Strategy

In view of the scarcity of data for measuring vulnerabilities of more sensitive populations within a biome, most of the guidelines proposed in this section are targeted at improvement of knowledge management. The following measures are proposed: (1) develop institutional frameworks for cooperation strategies to join states and municipalities (2) develop methodologies for identification and measurement of social vulnerabilities, taking into account the diversity of groups and territories in different biomes; (3) promote multi-sectoral and crosscutting actions to promote more synergistic government policies, especially for primary health infrastructure and prevention against events and associated impacts, and climate change; (4) increase social inclusion of more vulnerable peoples, with emphasis on training to foster autonomy among populations highly dependent on government subsidies; and (5) identify poverty hotspots in territories and where they intersect with areas of greatest physical, environmental and climatic vulnerabilities; (6) promote territorial planning initiatives, ensuring access to territory and fostering actions for economic inclusion in association with the sustainable management of territorial resources and recovery of degraded areas, when appropriate.

7.6.2. Ecosystem-based Adaptation (EbA) Tools

Ecosystem-based Adaptation (EbA) is an important tool for identification of adaptation measures. The premises of EbA include enabling populations to raise their adaptive capacities, through use of ecosystem services and biodiversity as components of a more comprehensive adaptation strategy. This strategy aims to assist people and communities in adapting to negative effects of climate change on local, regional, national, and global levels. EbA is based upon use of biodiversity and ecosystem services (including actions for conservation, recovery and ecosystems management); it promotes adaptation measures for people and communities; it applies a climate perspective, preferably conducted within the scope of evaluation and vulnerability studies; and it involves participatory multi-stakeholder processes (ICLEI, 2015). Further information on this methodology is available on the Ministry of Environment website.

The following table reproduces the priority goals for vulnerable populations presented in Volume 1 of this NAP:

Sectoral Strategy and Themes: Vulnerable Populations

Objective 3. Identify and propose measures to promote adaptation to and reduction of climate risk

Goal 3.6	Initiatives	Responsible
Diagnosis of Vulnerability to Climate Change of target populations of the National Territorial and Environmental Management Policy for Indigenous Lands- (PNGATI).	Spatial analysis of climate risk of target populations of the National Territorial and Environmental Management Policy for Indigenous Lands (PNGATI).	FUNAI
	Analysis of the degree of vulnerability of each group using pre-set and agreed-upon indicators.	
	Establish a vulnerability scale for identification of priority groups.	
Indicator/Monitoring:	Progress of on-going activities.	
Impact:	Identification of priority groups for support under governmental programmes.	
Goal 3.7	**Initiatives**	**Responsible**
Diagnosis of Vulnerability to Climate Change of target populations of the National Food and Nutritional Security Plan (PLANSAN).	Spatial analysis of climate risk of target populations in Federal Government's Unified Register of Social Programmes (*CadUnico*), especially Traditional and Specific Population Groups (TSPGs) identified in the register.	MDS/ SESAN/ CAISAN
	Analysis of the degree of vulnerability of each group using pre-set and agreed-upon indicators.	
	Create a vulnerability scale for identification of priority groups.	
Indicator/Monitoring:	Percentage of CadUnico population groups classified by vulnerability indicators and the climate-risk scale.	
Impact:	Identification of priority groups for support under governmental programmes.	

<table>
<tr><th rowspan="8">Objective 3. Identify and propose measures to promote adaptation to and reduction of climate risk</th><th colspan="3">Sectoral Strategy and Themes: Vulnerable Populations</th></tr>
<tr><th>Goal 3.8</th><th>Initiatives</th><th>Responsible</th></tr>
<tr><td rowspan="3">Diagnosis of vulnerability to climate change for vulnerable populations and beneficiaries of public policies for agro-extractivism.</td><td>Analysis of the degree of vulnerability of peoples and traditional communities residing in the 10 priority territories.</td><td rowspan="3">MMA</td></tr>
<tr><td>Analysis of the degree of vulnerability, by means of establishment of a vulnerability scale for identification of priority groups.</td></tr>
<tr><td>Foster application of measures to foster resilience in populations classed as vulnerable.</td></tr>
<tr><td rowspan="2">Indicator/Monitoring:</td><td colspan="2">Progress of on-going activities.</td></tr>
<tr><td colspan="2">Progress of actions for reducing vulnerability applied to vulnerable populations in the territories listed.</td></tr>
<tr><td>Impact:</td><td colspan="2">Identification of vulnerable populations for support under public policies for agro-extractivism.</td></tr>
</table>

7.7 Final considerations

Identification and analysis of the vulnerabilities of populations to climate change need to advance in coming years.

Public policies targeted at promoting development among these groups must include assessments of climate risk, with a view to promoting resilience among these populations.

For this purpose, territorial vulnerability assessment tools are available, such as the indicator developed by the Ministry of the Environment and Fiocruz, as well as tools such as Ecosystem-Based Adaptation. These, among other tools and methodologies, are available for use by organizations and society.

Strategy for Water Resources

National Adaptation Plan to Climate Change

8 Strategy for Water Resources

8.1 Presentation

This Strategy was developed within the scope of the Water Network (Rede Água) which comprises a group of experts and researchers of various research institutions under leadership of the National Water Agency (ANA) and with the support of the Secretariat for Water Resources and Urban Environment (SRHU/MMA), the Secretariat for Climate Change and Environmental Quality (SMCQ/MMA), and the Centre for Management and Strategic Studies in Science (CGGE). Contributions were also received from a public consultation to which a previous draft of this document was submitted. ANA is the agency responsible for implementation of this strategy.

This Strategy examines the impacts of climate change on water resources and on the main categories of water users. It identifies adaptation measures for improving capacity to respond on the part of water-resources management bodies and for governance of the sector, in a context of greater climatic variability.

It presents the main foreseen impacts of global climate change on water resources on Brazil's macro-regions, provides guidelines for adaptation using water-resources management instruments, and identifies the main water-user sectors. It also names potential institutional players for drafting and implementation of action plans and specific activities.

Implementation of this National Adaptation Plan (NAP) should take into account guidelines provided by the National Water Resources Policy[35], the National Water Resources Plan (PNRH) and other related policy coordination instruments.

8.2 Introduction

Alterations in temperature and rainfall patterns brought on by climate change are likely to cause significant impacts on water availability (volumes and distribution) affecting the multiple uses of water and the general population as a whole. Extreme water-related climate events (flooding and drought) are likely to become more intense. In view of the indispensability of water, water-related issues are likely to be among the first impacts of global climate change felt by populations.

Increasingly, flooding and drought have caught the attention of the public, not merely as a consequence of their economic and social impacts, but also because of mass media coverage. It should, however, be remembered that impacts of extreme events attributed to climate change may also be exacerbated by other pressures on water resources, including inappropriate land-use and settlement in river basins, increasing demand for urban water supply, agriculture and power generation;

[35] Law No. 9433/1997. Available in <http://www.planalto.gov.br/ccivil_03/leis/L9433.htm>.

the intensification of processes that impair water quality, higher exposure of populations, and increased anthropogenic intervention.

Aside from Increased in the variability of hidrological extreme events, one of the potential effects of climate change is a shift in hydrological data series[36] patterns, nowadays considered stationary. Such a shift in stability would affect planning and operation of water-resources infrastructure for multiple uses, since such planning was based on the assumption that historical statistical series would be indicative of the future availability. The planning of water infrastructure and allocation must take into account that the historical hydrological series may not be a reliable guide to future water availability, and may vary in ways not yet completely understood, thereby raising uncertainties as to the design of adaptation measures to be adopted.

To address such uncertainties and reduce information gaps, further investment is needed for climate projections and for studies of potential impacts of climate change on water availability in Brazil.

The question this raises is: how to plan for future water-infrastructure needs, taking into account potential changes in hydrological variables patterns and the high degree of uncertainty of these projections? Such changes may make it necessary to embark upon large civil engineering projects for reservoirs, canals, pumping stations, etc. In seeking to address this situation, society must learn to live with natural climate variability, including its extremes, as a first step towards adaptation to climate change. At the same time, while accepting the possibility of an increase in the frequency of extreme weather events phenomena, water-resources managers must be prepared for potential effects of variability in long-term average flow.

Uncertainties with respect to measurement of the impacts of future climate on the water balance, scarcity of financial resources and implementation gaps in water-resources management indicate a need to adopt no-regrets[37] adaptation measures. Such measures are targeted at problems linked to current climate variability, and hence strengthening resilience to future climate change. i.e., addressing current problems in a more robust manner and thereby increasing the capacity of society, of ecosystems, and of the economy to cope with expected changes.

The main interfaces between water resources and climate change relate to adoption of adaptation measures, targeted at increasing capacity to respond and reducing the vulnerabilities of populations and ecosystems to expected

[36] A data series is considered stationary when it maintains a constant average over time, reflecting some form of stability. (Analysis of Temporal Series, MANOEL IVANILDO SILVESTRE BALOCH, 2006. Available in <http://www.ebah.com.br/content/ABAAAe8xcAD/apostila-analise-series-temporais>.

[37] No regrets adaptation measures are those targeted at problems linked to current climate variability and that, at the same time, seek to strengthen adaptive capacity to future climate change. The benefits of no regrets measures will be perceived regardless of the degree of climate change. - Mainstreaming Adaptation to Climate Change in Agriculture and Natural Resources Management Projects (World Bank, 2010. Available in <http://siteresources.worldbank.org/EXTTOOLKIT3/Resources/3646250-1250715327143/GN5.pdf>.).

adverse climate-change effects. This should be the main focus of an adaptation plan for the water resources sector to complement and reinforce significant Brazilian and international efforts to reduce greenhouse-gas emissions.

8.3 Impacts of Climate Change – Vulnerability

8.3.1. Climate changes Scenarios and its impact on Water Resources

River-basin level simulations carried out in Brazil (NÓBREGA *et al*., 2011; TOMASELLA *et al*., 2009; CAMPOS and NERIS, 2009; MEDEIROS, 2003) generally corroborate studies conducted on a global level (MILLY et al., 2005; UK MET OFFICE, 2005) and on a national level (SALATI et al., 2008) with respect to signs of climate change, i.e., temperature and rainfall variations, etc.

Based on studies of climate-change impacts on water resources at the global level, projections indicate that the various regions of Brazil will be affected differently by the climate change.

The main impacts of climate change on Brazilian water resources can be broken down into four major trends:

More critical water balances in river basins of the Northeast Region, but there is no consensus about rainfall dynamics.
Rapid decline in flow levels, in about 2100, in basins in the western part of the Northeast and Western-Atlantic hydrographic regions;
A decline in availability of surface water in almost all regions of Brazil (lower rainfall may impact river flows in basins that generate hydroelectricity);
Increased rainfall and, consequently, flows in Brazil's South region.

Compounding these effects on surface water, climate change is likely to affect groundwater replenishment rates. One study (Doll & Florke, 2005) estimates that groundwater replenishment capacity in the Northeast region will drop by roughly 70%, by 2050. Likewise, for the Guarani Aquifer System, almost 70% of the climatic scenarios predict variations in the water-table, dropping below those detected by monitoring between 2004 and 2011 (MELO, 2013).

However, knowledge about groundwater levels and its recharge is still incipient. Few studies exist on the impact of climate change on groundwater or on the relationship between surface waters and aquifers (KUNDZEWICZ et al., 2007).

8.3.2. Expected impacts of climate changes on major user sectors

Changes in the water cycle arising from altered rainfall patterns will significantly affect the availability and temporal distribution of river flows. Moreover, impacts on the hydrological regime and increases in demand from various user sectors are to be expected, both as a function of population growth, and of the demands of economic development.

8.3.2.1. Urban Water Supply

Human water supply relies directly upon the availability of quantities of water of appropriate quality, on demand. Regions where demand for human water supply is greatest will be the most heavily impacted by changes in the hydrological cycle. Aside from burgeoning demand arising from population growth and urbanisation and universalization of water-supply services, water stability is likely to be affected by increased consumption stemming from rises in average global temperatures.

Many years of low investment in public water-supply services exacerbate vulnerability to the effects of climate change.

The National Basic Sanitation Plan (PNSB) estimates the costs of repressed demand for investment in universalization of the four components of sanitation services (water-supply, wastewater, urban solid wastes and storm drains)[38] at roughly R$ 508 billion. ANA's 2011 Atlas Brazil on Urban Water Supply[39] presents the results of an evaluation of the status of water sources and water production systems for towns throughout Brazil. The study has enabled verification of the current vulnerabilities which, in a scenario of changing availability and higher frequency of extreme events, will tend to worsen.

Guidelines for urban water supply sector

Orient sectoral planning toward:

1. Consideration of additional vulnerabilities associated with water availability changes.
2. Integration of water resources planning with that of other sectors.
3. Reduce losses; stimulate rational use and quantitative and qualitative monitoring of water sources.
4. Increase investment in wastewater collection and treatment, especially in basins subject to water scarcity, so poor quality does not pose an additional obstacle to use of water resources.

8.3.2.2. Irrigation

It is likely that, in a critical water-availability scenario, conflicts will arise between irrigation and other water-user sectors, including urban water supply and power generation. In critical periods, effective measures will have to be deployed to ensure priorities established in law and to balance the interests of different user sectors.

The irrigation sector currently accounts for 54% of abstracted flows and 72% of effectively consumed flows, making irrigated farming Brazil's largest water-user sector (ANA, 2015). The area under irrigation in Brazil, in 2012, was estimated

[38] Available at <http://www.tratabrasil.org.br/saneamento-no-brasil, accessed on 25/3/2015.>.

[39] Available at <http://atlas.ana.gov.br/Atlas/forms/Home.aspx>.

at 5.8 million hectares, or 19.6% of a potential 29.6 million hectares, according to data from the 2006 Agriculture Census[40] and projections of the National Transport Logistics Plan 2002- 2023. Moreover, aside from the trend for expansion of irrigated farming, changes in rainfall patterns in different regions of Brazil, including some areas traditionally unaffected by drought, may lead to increased demand for complementary irrigation.

In regions with greater water scarcity and, consequently, with greatest limitation on abstractions, two trends may be observed: (1) reduced demand for irrigation water in certain areas as a consequence of introduction of newer technologies or crop substitution, motivated by water scarcity or implementation of water-use charges and other economic instruments; (2) an increase in water-use conflicts, leading to difficulties in enforcement of the decisions of basin committees and constraints of different types.

It should also be remembered that irrigated farming is a highly elastic form of water use. In view of the array of water-saving irrigation techniques now available and the possibility of switching to crops that are less demanding in terms of water, the irrigation sector could, with relative ease and in specific cases, reduce volumes abstracted to adjust to current availabilities.

Guidelines for the irrigation sector

Possible adaptation measures for the irrigation sector include:

1. Capacity building and mobilisation of users for formulation and implementation of contingency plans.

2. Improvement in short and medium-term predictions of water availability for irrigation.

3. Replacement of irrigation technologies by more efficient methods of water and energy use.

4. Adoption of efficient management of irrigated areas.

5. Infrastructure to guarantee integrated supply with other uses and with water resources planning.

6. Strategies for soil conservation with an impact on water production, such as no-tillage, maintenance and restoration of Permanent Preservation Areas (APPs), promotion of conservation, and increased infiltration in aquifer recharge areas.

[40] IBGE, 2010. Available at: <http://www.ibge.gov.br/home/estatistica/economica/agropecuaria/censoagro/default.shtm>.

8.3.2.3. Energy

Brazil is a leading producer of hydroelectric power, accounting for 10% of worldwide generation capacity. According to data from the Brazilian Electricity Regulatory Agency (ANEEL) hydroelectricity accounts for roughly 61% of Brazil's energy mix[41]. This system is highly dependent on medium and long-term availability of water for energy generation and to ensure stability of electricity supplies. Such dependence implies a high degree of vulnerability to changes in the water regime.

Various studies predict, somewhat inconclusively, a decline in rainfall and, hence, of water availability in the Northeast region where significant volumes of hydroelectricity are produced, and in the North where most future generation capacity is likely to be harnessed. For some key Brazilian hydroelectric generation areas, including the Southeast region and the Tocantins river basin, there is no consensus on the part of climatic models as to which future flow-level trends will prevail, and as to whether rainfall levels will rise or decline. For the South region, however, increased rainfall is likely to result in higher flows; however, their use will depend upon storage capacity and allocation decisions.

The option in recent years for run-of-river hydroelectric plants (i.e., without large reservoirs) with a lighter environmental footprint increases vulnerabilities in the event of scenarios with longer and more severe dry periods since, with little storage capacity, such plants rely exclusively on current river flow levels. This may impact operation of reservoirs of other plants that supply the National Interconnected System (SIN) since production levels may not necessarily correspond to the interests of stakeholders in basins in which they are located, thereby intensifying local water-use conflicts.

Hydroelectric plants coupled to large reservoirs offer greater possibilities for management and are less vulnerable to river flow-level variations. A study by CEBDS[42] shows that hydroelectric power plants are subject to different types of impacts, depending on their installed capacity and that, consequently, different strategies for reducing vulnerabilities must be pursued, including switching to other energy sources in the months of water deficit. Moreover, greater storage capacity and the ability to regularise flow levels in water bodies can reduce vulnerabilities for other water-use categories, especially human water supply.

---

[41] Available at: <http://www.aneel.gov.br/aplicacoes/capacidadebrasil/operacaocapacidadeBrasil.cfm, accessed on 12/3/2015>.

[42] Available at: <http://cebds.org/publicacoes/gerenciamento-of-riscos-hidricos/#.VddBD4tRGUk>

Guidelines for the electric-power sector

Possible adaptation measures for the electric-power sector include:

1. Increase inter-annual storage capacity of new hydropower investment Projects.

2. Better management of multiple uses of reservoirs.

3. Increased investment in local electricity generation solutions so as to complement the National Interconnected System.

4. Increased investment in conservation measures and recovery of APPs, with a view to reducing silting of reservoirs and extending their lifespans.

8.3.2.4. Industry

Industry accounts for 17% of total abstractions and for 7% of water consumed, according to a report on the status of water resources in Brazil (ANA, 2015). That the hydrographic regions with highest industrial demand for water are the Paraná, the South-Atlantic and the Southeast-Atlantic demonstrates that this category of use is highly concentrated.

Impacts vary by type of industry and geographic location. Changes in the water regime and the impacts of extreme hydrological events may affect industrial activity (e.g., situations of water scarcity and consequent total or partial lack of supply). The adaptation capacity of industries depends upon size and volumes of resources available for investment.

Guidelines for the industrial sector

Possible adaptation measures for industry must take into account the specific characteristics of each industrial activity:

1. Increase investments in water storage capacity.

2. Stimulate rational use and reuse of water.

3. Use alternative or new energy sources and relocate industrial plants.

4. Invest in technologies to increase water use efficiency for all types of industry.

5. Prepare contingency plans for extreme hydrological events; e.g., define procedures and mechanisms to be adopted in situations of prolonged drought.

8.3.2.5. Water quality and the environment

Climate change may significantly alter water quality and associated ecosystems. It is, however, not easy to quantify these changes, owing to uncertainties relating both to climate projections and to the complexity of interaction among the various factors that affect water quality (hydrology and chemical, physical and biological processes).

Higher water temperatures are expected to be among the most immediate manifestations of climate change. Such temperature rises may causes changes in chemical and biological processes, affecting the water quality. One of the principal impacts will be reduced concentrations of dissolved oxygen that will interfere with the self-purification of water bodies and their ability to sustain aquatic biodiversity.

Warming of surface waters of lakes and reservoirs also increases vertical stratification in these water bodies, thereby reducing the mixing of surface and deeper waters.

Lower flow levels also impact the quality of surface waters. Reduced river flows hamper the capacity to dilute pollution loads, resulting in increased downstream pollution levels.

Longer duration and higher intensity rains can increase non-point pollution caused by sediments, nutrients and pesticides. Higher nutrient levels cause proliferation of algae, which can significantly alter aquatic ecosystems, leading to mortality of fish and food-chain alterations. Cyanobacteria, which produce toxins, generally undergo a greater proliferation at higher temperatures (above 25ºC) when they exert a competitive advantage in relation to another species.

Deterioration of water quality implies higher treatment costs for domestic water supply and industrial uses. It reduces the feasibility of irrigation systems, damages aquatic biodiversity and fish stocks, raises incidences of waterborne diseases, and reduces the attractiveness of landscapes and their value for tourism.

Guidelines for water quality and environment

Possible adaptation measures include:

1. Implement systematic water-quality monitoring.
2. Implement water safety plans, water-quality control and surveillance procedures for human water supply.
3. Invest in technologies to reduce discharges of pollution loads into water bodies.
4. Increase investment in treatment of effluents.
5. Ensure effectiveness of instruments for classification of water bodies in accordance with main categories of use.
6. Invest in recovery of Permanent Protection Areas (APPs).

8.4 Water-resources management adapted to climate change

8.4.1. Guidelines for Water Resources Governance

Good governance of water resources, regardless of the impacts of climate change, depends upon the capacity of federal, state and municipal authorities to make appropriate and timely decisions to ensure compliance and coordinate with stakeholders in the system. In view of uncertainties as to future availability and demand for water and prospects of more frequent and severe extreme hydrological events, there is an increasing need for technical capabilities, appropriate planning instruments and inter-sectoral cooperation among federal, state and municipal bodies, and for new arrangements to strengthen the capacities to respond to situations that stretch the envelope of normality.

This can be a challenge in view of the complexities of Brazil's Water Resources Management System, with its multiplicity of levels and authorities, overlaps and gaps that cause high transaction costs that hamper adoption of more agile and flexible arrangements, undermining the feasibility of timely decision-making. At times, current legislation hinders adoption of more streamline and flexible decision-making arrangements (e.g., formation of dedicated temporary or standing management groups for specific locations and issues).

As important as the structure of the management system is the ability of the institutions to adapt to changing circumstances. This greatly influences the effectiveness of water-resources and of management for multiple use. Recent flooding and drought events have posed challenges to the capacity of the system and to its component institutions, thus revealing the magnitude of the problem of adaptation to critical situations.

Guidelines for governance of water resources systems

Potential adaptation measures are targeted at:

a. Increased capacity of institutions to respond to uncertainties and changing future scenarios:

1. Information and knowledge: generate and disseminate reliable and timely information and knowledge on natural and human systems, taking into account uncertainties (reliable updated water-user registries, climate forecasts, monitoring, appropriate hydrological series, etc.).

2. Conflict management: create or adapt mechanisms for settlement of potential conflicts, including specific suitably empowered bodies, contingency plans and allocation of water in situations of drought, etc.

3. Compliance with rules: setting of well-defined well-publicised rules for use of water resources, consistent with local realities, with mechanisms to ensure compliance and appropriate and enforceable sanctions for violations.

4. Adequate physical infrastructure: (reservoirs, canals, aqueducts, wells, etc.), technology (computer models, climatic-forecast models, weather radars, sensors, etc.) and an institutional framework (institutional diversity, user participation, legislation, etc.) capable of withstanding potential effects of climate change.

5. Learning and adaptation: institutions should be designed to foster transformations needed to address new problems and changing contexts, in a constant process of learning and adaptation. To this end, mapping and assessments should be conducted by the public sector and by sectors of the Brazilian economy.

b. Increase coherence and consistency among the public policies for water resources and other related sectors:

1. Strengthen governmental management; establish the necessary coordination to ensure that water-resources management is incorporated into on-going public-policy planning processes for related sectors, including environment policies.

2. Strengthen participation of municipalities in the SINGREH, in view of its key role in planning of land-use and settlement, management of urban solid wastes, local environmental licensing, and sanitation issues.

3. Clarify concepts and principles relating to water-resources legislation, notably for treatment of critical events, which may entail rationing, suspension of licences and/or reallocation of available flows.

c. Increase the effectiveness of river-basin governance:

1. Prioritise local approaches to problems, through compatible institutional arrangements.

2. Apply the principle of subsidiarity and strategic territorial approaches, for critical/priority regions.

3. Consider targeted management models for the Amazon, semi-arid areas and the South, Southeast and Central-West regions.

4. Expand initiatives for integration of water-resources management among the three levels of government and for increasing the capacities of state-level management systems (especially management agencies) by means of shared goals and incentives.

5. Seek alternatives so that different institutions can perform water resources management tasks, e.g., by means of agreements, management contracts or public-private partnerships.

6. Reduce the distance between collegiate deliberative structures and water-resources management agencies, thereby increasing administrative capacities.

7. Ensure transparency and accountability.

---

[43] Subsidiarity is the principle that any decision that can be made locally and does not affect third parties and/or broader issues shall not be submitted to higher hierarchical levels.

There follows a listing of goals relating to the specific objectives of this NAP:

Objective 3. Identify and propose measures to promote adaptation to and reduction of climate risk

Sectoral and Thematic Strategy: Water Resources		
Goal 3.9	**Initiatives**	**Responsible**
Incorporate measures for adaptation to climate change into actions carried out by the National Water Agency.	Identify/propose "no regrets" adaptation measures, targeted at enhancing capacity to respond of the National Water Resources Management System and at reducing vulnerabilities of the main water-user sectors, populations and ecosystems to foreseen adverse effects.	ANA
Indicator/Monitoring:	Progress in deployment of water resources management projects and instruments.	
Impact:	Enhanced the capacity of ANA and of other component bodies of the National Water Resources Management System (SINGREH) to respond to challenges posed by climate change.	

Sectoral and Thematic Strategy: Water Resources		
Goal 3.10	**Initiatives**	**Responsible**
Develop integrated climatic and hydrological models and assess their impact on water resources management.	Use of new modelling techniques with dynamic and statistical methods borrowed from other Global Climatic Model (GCM) families, thereby increasing the number of projections available for analysis of the impact of climate change on water resources.	ANA
	Develop studies using Economics of Climate Adaptation (ECA) methodology, based on the Piracicaba-Capivari-Jundiai River Basin project.	
	Support development scientific and technological researches, by means of a specific call for proposals to be drafted jointly with CNPq, targeted at the climate-change/ water-resources interface.	
Indicator/Monitoring:	Progress in the development of projects.	
Impact:	Enhanced capacity of component bodies of SINGREH to respond to challenges posed by climate change.	

8.4.2. Management Instruments foreseen in the National Water Resources Policy

The main objectives of the National Water Resources Policy (Law 9433/1997) are to ensure availability of water resources for integrated and rational use by current and future generations for purposes of sustainable development, and to promote prevention and defence against natural and anthropogenic critical hydrological events. The Law provides the following instruments for achievement of these objectives:

Water Resources Plans, developed for multiple spatial and temporal scales;
Classification of water bodies into classes, according to prevalent categories of use;
Grating of water right;
Water use charges; and
The National Water Resources Information System (SNIRH).

The main challenge, in the context of expected climate change, is to ensure effective deployment of management instruments that can be adapted to varying conditions, i.e., providing managers and decision-makers with adequate and flexible means of responding to a dynamic system, with a view to improving resilience of the water-resources management system and to addressing the long-term prospects of climate change.

8.4.2.1. Water Resources Plans

Water Resources Plans must seek to identify potential threats to future water availability caused by climate change and indentify their impacts on future demand for water, as like as set guidelines for operation of the water-resources management system under new conditions. To facilitate understanding of the problems involved and ensure uniformity and compatibility of information, an analysis of prospective scenarios should be conducted, encompassing expected climate-change impacts and drawing upon well-established methodologies and a robust database platform.

Contingency plans (especially for droughts and flooding) need to be drawn up and periodically reviewed within the scope of long-term planning to orient actions of the different players involved during extreme weather events, and guide preparations to mitigate the adverse effects of such events. In parallel, a plan for financing the necessary investments must be prepared. Furthermore, planning must encompass definition of structural and non-structural measures and strategic guidelines for allocation of water in basins where conditions are considered most critical.

During elaboration, implementation and review of national, state and basins-level water resources plans, the guidelines provided in this NAP must be considered.

8.4.2.2. Classification of water bodies

Many decision-makers and water-resources managers have not yet understood that classification essentially serves as a river-basin planning tool for setting of water-quality targets with acquiescence of local stakeholders. Climate change may have significant repercussions on water quality and flow levels, and on reducing the capacity of water bodies to dilute pollution loads, thereby exacerbating point and non-point sources of pollution.

Adoption of a single reference flow level as a basis for classification creates a constraint for management, since quality targets are usually set on the basis of extremely limited reference flows, making such targets hard to meet. Moreover, adoption of a single reference flow level for decision-making fails to allow for adjustments in changing scenarios, thereby increasing uncertainties stemming from such restrictions. One alternative entails adoption of a 'probability of occurrence' approach to water-quality parameters. Under this approach, a certain degree of risk of not meeting water-quality targets is accepted, taking into account the cost of depollution measures needed to ensure compliance with classification goals. This type of approach enables greater flexibility for management, since the risk of non-compliance is not tied exclusively to a progression of classification goals, but also takes into account changing climate scenarios.

Adoption of the following practices would help achieve effective deployment of water-body classification:

Integrate classification goals with municipal sanitation plans.
Expand funding mechanisms for deployment of depollution actions.
Expand and standardise water-quality monitoring to accompany effects of climate change and attainment of classification goals.
Take into account climate-change scenarios and uncertainties when setting water-quality targets and classification criteria.
Coordinate activities of different institutions to obtain environmental license and grant water-use rights according to classification criteria.

8.4.2.3. About Grating of water right

Climate-change projections indicate that the status of water resources in certain basins will become critical in both quantitative and qualitative terms. This situation demands strong institutional arrangements and more flexible water-use licensing criteria to enable management of the water balance, allocation among water users and different categories of use. Endowing licensing instruments with sufficient robustness and flexibility to respond to different possible scenarios implies adoption of less conservative service parameters, specific procedures for critical areas and transparent mechanisms and criteria for cancellation, curtailment or suspension of water rights.

A new set of procedures should encompass less conservative reference flows and allocations to different users, collective grants and temporary licenses, risk and economic-value assessments for decision-making, and reallocation of volumes. Such special situations require reliable information, more technical training, greater coordination and communication with the water users, and higher supervision capacity.

The following alternatives are suggested for adapting water-resources licensing instruments to address the impacts of climate change:

Examine the possibility of licenses that establish limitations in the event of critical flow levels in atypical water-availability situations; this implies proportional curtailment or interruption of permitted abstractions, duly explained in contingency plans or allocation agreements and with prior acquiescence of users, drawn up on the basis of technical studies that demonstrate the need for such actions.
Draw up negotiated water-allocation agreements for areas where critical levels have been reached or in cases of extreme hydrological events.
Consider risk assessments and stakeholder preferences when examining alternatives for addressing risks, taking into account the capacity of water users to absorb such risks.
Introduce more flexible service parameters: when adopting criteria for setting abstractions limits of licenses, possibly in association with reference-flow variations.
Verify institutional and legal security (criteria and sequencing of actions) for suspension of water-use rights in situations of extreme hydrological events.
Seek more effective compliance with licensing conditions.

8.4.2.4. Water use charges

Water use charges play an important role in acknowledgment of water as an economic good, for indicating its value to users, encouraging rational use, and securing funding for defrayal of water-resources management actions. In view of the expected impacts of climate change on availability and demand for water resources, incentives for rational use and investment in specific actions become more urgent.

When viewed as a revenue source for river basins, such charges serve as an important instrument for deployment of strategies for adaptation to climate change, within the context of water-resources plans and contingency plans and when setting investment priorities. Investment of such resources in programmes and activities that effectively result in a reduction of risks stemming from climate change may assuage the perception of users that such charges are just another tax.

Flexibility may be called for when investing proceeds of water-use charges and should include participation of private-sector stakeholders, with a view to attracting further investment and ensuring the effectiveness of interventions.

In view of projected scenarios that point toward increased hydrological risks, water use charges may be used to defray deployment of other management tools. Such tools might include insurance for users that suffer losses owing to unfulfilled demand and rewards for users that reduce their abstraction volumes, thus mitigating the risks of failure to meet local river-basin priorities.

On the other hand, the main purpose of water use charges is to make users aware of the monetary value of these resources, with the proviso that, in critical situations (i.e., scarcity) the rates should increase. To this end, it is important that the sums charged reflect the status of the local water balance, and that charges should rise in situations of scarcity and for more extravagant forms of use, with a view to stimulating greater efficiency and rational water use.

Alternatives for maximising the positive effects of water-use charges in a scenario of climate change include:

Prioritise actions under basin plans and contingency plans, defrayed by proceeds of water use charges.
Increase transparency and accountability with respect to investment of the proceeds of water use charges.
Conduct economic analysis in support of water use charge increases, when justified.
Allow flexibility of charges to reflect the status of the water balance (higher charges in times of scarcity) and the efficiency of water use.
Allocate part of the proceeds of water use charges to preparation of adaptation projects, enabling access to specified funding.

8.4.2.5. The National Water Resources Information System (SNIRH)

Adaptation of water resources management to uncertainties brought on by climate change requires the best possible information, provided in a timely and practical manner, to assist with decision-making. Therefore, the adaptation of the SNIRH must entail endowing it with the capacity to provide current and readily-accessible data to stakeholders, based upon a robust database platform.

To meet such demand, and to provide real-time availability (especially during flooding events) more automated data-gathering and processing capabilities will be needed, including standardised methodology and information formats, with the aim of applying the latest methods for setting up a good communication and dissemination strategy.

The national hydro-meteorological network is in need of some water-resources management enhancements to address changing behaviour of hydrological scenarios. The main challenges are:

Increase the availability of information from rainfall monitoring stations and flow-level measurement posts in urban areas.
Increase the number of flow-monitoring stations in small river basins.
Expand monitoring of evaporation and evapotranspiration, sediments and water quality.
Increase availability of flow-level data series for rivers subject to eddy and tidal or reflux effects.
Strengthen early-warning networks and deployment of situation rooms in regions with histories of extreme events.

Investments in science, technology and innovation are needed for modelling and monitoring water resources availabilities, as will be discussed in more detail in Section 8.6.

8.4.3. Complementary water-resources management instruments

In view of new foreseen water-resources management challenges and in addition to instruments already provided for in current legislation, new regulations and approaches could afford solutions or minimise potential losses caused by climate change, including as yet unforeseen consequences. Listed below are some examples of new tools that could be adopted:

Implement Decision-making Support Systems (DSS): the growing need to manage ever increasing amounts of water-resources management information requires the use of analytical tools capable of quantifying cause-and-effect relationships and orienting decision making. DSSs are ideal tools for such functions, since they offer flexibility and facilitate communication with users and decision makers.
Stimulate and regulate deployment of an insurance system for extreme hydrological events targeted at each user sector and category of use.
Define and reach agreement upon offset mechanisms among user sectors for each type of situation where restrictions apply to certain categories of use, in order to protect other categories.

Consider permanent or temporary adoption of other economic instruments, targeted at promoting sustainable use of water, such as subsidies, taxes and fees, including for effluent discharges.
Increase the range of fiscal incentives to expedite objectives of water-resources plans.
Support payment for environmental services, whereby beneficiaries earn financially rewards for initiatives that quantitatively and qualitatively enhance water availability.
Consider Payment for Environmental Services (PES) as an instrument for recovery and conservation of river basins

Other management measures that could be adopted include: water user organisations, rules for water rationing, compliance monitoring of water rationing, and establishment of funds for damage mitigation.

8.5 Conflict Management

Burgeoning demand from an array of water-user sectors and the prospect of increasing water scarcity may cause or aggravate water-use conflicts. To handle such potential conflicts, the management system must be capable of issuing clear guidelines and offer compensation mechanisms for sectors that are required to reduce their water consumption.

Adaptation measures proposed in water resources plans or in other instruments and programmes must be perceived as firm commitments to be fulfilled within foreseen timeframes. Thus, goals and targets need to be negotiated between the representative bodies appointed by SINGREH and those responsible for execution of said programmes and actions, with a view to ensuring their effective deployment and appropriate coordination.

To this end, it is essential that negotiation mechanisms clearly identify potential or actual points of conflict stemming from the effects of climate change. It is desirable that basin-level entities have experienced negotiators, capable of drafting agreements among the parties concerned. The role of water resources management bodies in such processes is essential, and they need to be prepared to manage conflicts over allocation of increasingly scarce water resources.

Conflict management groups, comprised of water-resources managers and stakeholder representatives, should participate in water-resources management discussions when and wherever necessary. Water resources plans and other management instruments should adopt procedures, criteria, and priorities for management of conflicts.

Risk management plays an important role in reducing conflicts and in preparations for addressing them. To this end, joint efforts should focus on reducing all factors that contribute toward increasing risk, by means of the planning and preparation of responses. In practice, it entails raising awareness about risks and deepening studies and simulations to define methodologies/ parameters for achieving an adequate risk-sharing balance among the various water-user sectors. Indeed, a good risk-transfer agreement can significantly minimise potential conflict situations

Finally, it is important that open communication channels be maintained among the various user sectors and water-resources managers, with a view to preventing or managing potential conflicts.

8.6 Science, Technology and Innovation

There are a number of evident weaknesses and knowledge gaps that hamper or undermine the feasibility of actions for addressing vulnerabilities and potential impacts on the water-resources sector of effects associated with climate change.

Such difficulties include: insufficient research on climate and water resources; though basic hydro-meteorological information is available, the degree of detail does not meet the needs of small basins; there is a lack of hydro-meteorological information and of climate-change projections broken down by biome; and consistent data is not always available within required timeframes. The following suggestions aim to overcome these weaknesses:

Award priority to the development of the following lines of research: climatic and hydrological processes, prognosis of hydro-climatic variables, impact assessment of hydro-climatic scenarios and respective strategies for adaptation and mitigation of impacts, correlation between land use and changes in flow patterns of water courses and of water quality.
Prepare an evaluation study to modernise the physical and hydrological database, with a view to improving the current hydro-meteorological network (new technologies, remote and hard-to-access areas, provision of information and data series, seasonal and short-term forecasting).
Ensure that outputs of monitoring and scientific research are suitable for application to water resources, especially in terms of (1) temporal and spatial resolution; (2) information update time; (3) standardisation of data and of network operations.
Promote technology transfers and capacity-building, in line with the UNFCC's Capacity Building principles.
Ensure the systematic monitoring of key hydrological variables to enable characterisation of risks and uncertainties involved in three types of networks: (1) systematic observation; (2) reference river basins; (3) early warning.

8.7 Communications

The expected impacts of climate change on water resources raise questions for decision-makers, water users and the general public, relating to factors such as: lack of consensus among the most prominent models; uncertainties of impact projections, especially on regional and local levels; and incompatibilities between the scales on which climate studies are conducted and the appropriate scale for water-resources planning and management. A good communications approach for the theme must provide a unified outlook for addressing the phenomena and risks involved, and express them clearly to all players, so as to provide the best information available and indicate approaches for coping with expected impacts.

Communication between scientists and decision-makers

There is a disconnection between providers and users of information. It is thus necessary to strengthen consensus on the need for active involvement and understanding and for actions and links between scientists and water resources policy makers. To this end, communication channels for disseminating scientific knowledge must be strengthened, using tools that enable sharing of results with society and decision-makers, expressed in clear language and applying of said knowledge to practical problem solving. Scientists should provide inputs for decision makers, based on the best technical possible information so that it can be evaluated alongside the policy components and the appropriate decision made.

Understanding and incorporation of risk

Notwithstanding their inherent uncertainties, climate-change projections contain valuable information, provided it is efficiently communicated to water users. Decision-makers are accustomed to dealing with uncertain and incomplete information, but they need a better understanding of the sources and degrees of uncertainty involved. A clear characterisation of possible climate risks and of the confidence levels of their projections can provide a better basis for planning and decisions as to the need for adaptation measures. There is thus a need to consider communication strategies for conveying the risks to water-user sectors, clearly communicating potential impacts associated with climate change on water availability and the possibility of supply failure, so that they can prepare to cope with such risks.

More transparent communication with the public

Appropriate and timely communication is essential, so that society can appropriately prepare to confront impacts associated with climate change, especially in relation to extreme hydrological events. To prepare the public, channels for constant dialogue must exist between government and the public, and especially the more vulnerable segments of the population. Such channels endow government actions with transparency and enable more efficient communication with the business sector, academics and civil-society organisations.

Another challenge entails standardisation of a common language, to be adopted so as to avoid divergent interpretations among user sectors. To this end, the climate change agenda will require an institutional structure of working forums, comprised of representatives of different user sectors and of government.

8.7.1. Institutions responsible and timeframe

The guidelines discussed in this chapter feature elements to enable identification of potential institutional players to participate in the drafting of relevant plans of action (Table 14). Some of these elements are crosscutting, entailing coordinated networking among two or more institutions and thus greater complexity in terms of execution. The table below indicates potential partner institutions to lead implementation of this plan over the coming years. ANA, as the body responsible for implementation of the National Water Resources Policy, will have varying degrees of responsibility over all these actions, and thus does not appear on the list. However, since no agreement has yet been reached as to the specific attributions of these institutions, the list should be regarded as merely indicative.

Table 14. Potential institutions for elaboration of plans of action

INSTITUTION RESPONSIBLE	
Item/Guideline	**Partner institution**
WATER-RESOURCES MANAGEMENT ADAPTED TO CLIMATE CHANGE	
Governance	SRHU, state-level institutions and authorities representing the SINGREH (committees and councils)
Adaptation of current instruments	SRHU and state-level institutions
Conflict management	SRHU, state-level institutions and authorities representing the SINGREH (committees and councils)
SCIENCE, TECHNOLOGY AND INNOVATION	
Develop priority lines of research	MCTI/MEC/SRHU
Studies for evaluation to modernisation of the physical and hydrological database, with a view to integrating the existing network	ONS/CPRM
Promote the suitability of outputs of monitoring and scientific research	MCTI/MEC/SRHU
Ensure systemic monitoring of key hydrological variables and development of key indicators.	MCTI/MME/SRHU
COMMUNICATION	
Communication between scientists and decision-makers	MCTI/MEC/SRHU
Communication with society should be more transparent	MCTI/MEC/SRHU/MI

Strategy for Health

National Adaptation Plan
to Climate Change

9 Strategy for Health

9.8 Introduction

Assessment of the effects of climate change on human health is a complex process requiring an interdisciplinary approach to examine relationships between social, economic, biological, ecological and physical systems (Barcellos *et al*., 2009). Evidence indicates that climate change, associated with socioeconomic and environmental factors, will influence the impacts of disease on health, affecting demand for healthcare, surveillance, and health promotion services provided by the Unified Health System (*Sistema Unico de Saude* - SUS)[44].

This strategy presents the vulnerabilities, impacts and risks of climate change on human health, and provides guidelines and strategies for the SUS, in line with the National Policy on Climate Change (PNMC).

It is hoped that it will promote, within the Ministry of Health (MS) and other SUS management levels, public and private institutions and organised civil society involved with the sector, deeper consideration of information on the impacts of climate change on health, and lead to upgrading and adaptation of policies and measures for appropriate action.

[44] The *Sistema Unico de Saude* (SUS) was created by Law 8080, of 19th September 1990. More information is available at: <http://portalsaude.saude.gov.br/index.php/cidadao/entenda-o-sus and http://bvsms.saude.gov.br/bvs/sus/legislacao.php>.

The expected outcome is adoption of adaptation measures to increase resilience of healthcare services and mitigation of the effects of climate change on the health of the population, thereby promoting a climate-change adaptation agenda for the health sector.

The Ministry of Health's Secretariat for Health Surveillance (SVS/MS) is the focal point for coordination of this agenda within the SUS and coordinated preparation of this Strategy, in cooperation with other secretariats of the Ministry of Health, the Oswaldo Cruz Foundation (FIOCRUZ), the National Health Foundation (FUNASA), the National Health Surveillance Agency (ANVISA), the Evandro Chagas Institute (IEC) and other partner institutions, with support of the Secretariat for Climate Change and Environmental Quality (SMCQ) of the Ministry of Environment (MMA).

9.9 Institutional ownership of the theme "Adaptation of Health to Climate Change"

Discussion and formulation of public policies targeted toward issues relating to climate change, including mitigation and adaptation actions, gained prominence on the Brazilian Government's agenda and of health authorities in 2007, when the Ministry of Health first participated in processes relating to the National Policy on Climate Change. At the sectoral level, studies and research were pursued as inputs for the Management Commission and Executive Committee for Climate and Health (GM/MS Order 3244/2011)[45] under coordination of the Executive Secretariat and the Secretariat for Health Surveillance and for preparation of the Sectoral Health Plan for Mitigation and Adaptation to Climate Change (PSMC).

SVS/MS, through its Department for Environmental Health Surveillance and Worker's Health (DSAST), is responsible for surveillance of determining factors and environmental conditions that affect human health and for coordination of application of the National Policy on Climate Change in the Health Sector.

In 2011, a task force (*Força Nacional do Sistema Único de Saúde* - FN-SUS)[46] was set up to address disasters, service failure, and epidemiological emergencies under the Public Health Emergency Response Plan, and Contingency Plans were drawn up for coping with public-health aspects of such events (flooding, drought, injuries and diseases)[47] .

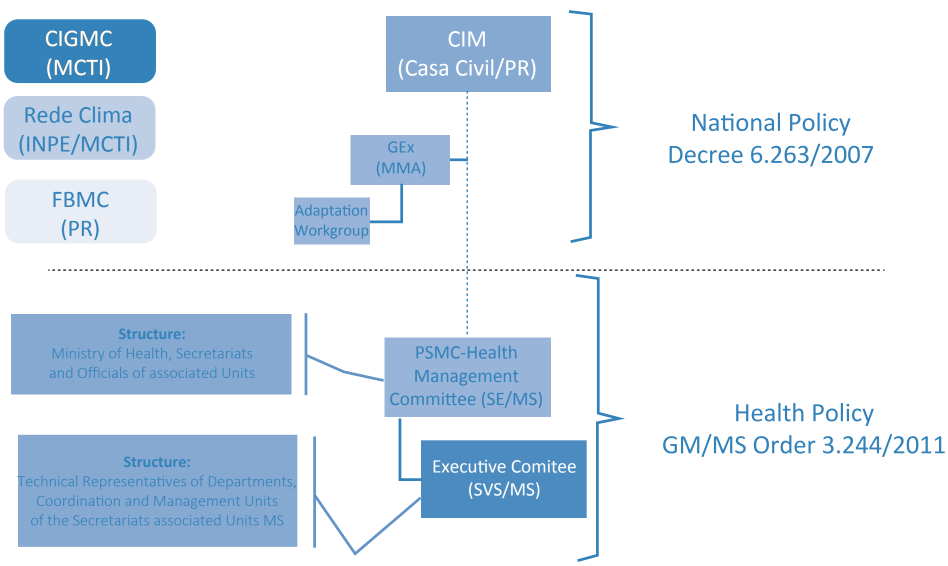


Figure 14. Ministry of Health Institutional Structure for Climate Change
Source: CGVAM/ DSAST/SVS/MS, 2011

45 <http://bvsms.saude.gov.br/bvs/saudelegis/gm/2011/prt3244_30_12_2011.html>.

46 *Força Nacional do SUS* was created by Decree 7616, of 17th November 2011 and regulated by GM/MS Order 2952, of 14th December 2011. For further information, access: <http://portalsaude.saude.gov.br/index.php/o-ministerio/principal/secretarias/sas/dahu/forcanacional-do-sus>.

47 Plans for Response to Public Health Emergencies., see: <http://portalsaude.saude.gov.br/index.php/o-ministerio/principal/leia-maiso-ministerio/197-secretaria-svs/12109-planos-vigilanciaambiental>

Through partnerships with FIOCRUZ and the National Institute for Space Research (INPE), the National Observatory for Climate and Health[48], and the Environmental Information System Integrated to Environmental Health (SISAM)[49] were established. Support was provided for founding of the Studies and Research Centre on Emergencies and Disasters (CEPEDES)[50] and for training and specialisation courses in environmental health at various institutions, including the Institute of Collective Health Studies of the Federal University of Rio de Janeiro (IESC/UFRJ)[51]. With a view to strengthening the disaster-relief activities of the SUS, a number of activities were carried out in close coordination with the National Center for Monitoring and Early Warning of Natural Disasters (CEMADEN) and the Brazilian National Risk and Disaster Management Centre (CENAD) of the National Secretariat for Protection and Civil Defence (SEDEC).

9.10 Climate Change and Health: impacts, vulnerabilities and risks

Sensitivity of human health to the adverse effects of climate change is associated to individual and collective vulnerabilities and to specific territorial aspects. The determinants for individuals are variables such as age, health profile and physiological resilience; whereas collective resilience is determined by socio-environmental factors such as population growth, poverty, environmental degradation, economic models, sanitation, and degree of urbanization (BARCELLOS *et al*., 2009).

Precisely how each of these factors is affected by climate change determines the degree of health vulnerability as a whole. Extreme climate events with alternating waves of cold and heat, and disasters such as flooding and prolonged drought directly affect human health. Indirect effects tend to be induced by gradual and long-term changes in rainfall, temperature and humidity patterns, which alter ecosystems and biogeochemical cycles. Such changes increase exposure of individuals and populations to atmospheric pollutants, expand areas susceptible to transmission of infectious diseases (PAHO/MS, 2009) and to emergence of new diseases and re-emergence of known ones, to water shortages and deterioration of the quality of drinking water, to crop failure and economic losses, cause upheavals in social-welfare systems, weakening the work force and the functioning of healthcare systems (IPCC, 2014).

---

48 National Observatory for Climate and Health, see <http://www.climasaude.icict.fiocruz.br/>.

49 See: <http://sisam.cptec. inpe.br/msaude/informacoes.html#>.

50 CEPEDES, see <http:// andromeda.ensp.fiocruz.br/desastres/>

51 IESC/ UFRJ courses related to environmental health, see: <http://www.labead.iesc.ufrj.br/eadportal/index.php/cursos>

Identification and monitoring of such challenges to the Health sector is of fundamental importance for definition of crosscutting sectoral adaptation actions for addressing vulnerabilities. Responses must entail strengthening of the SUS's risk-mitigation, emergency-management and recovery capabilities.

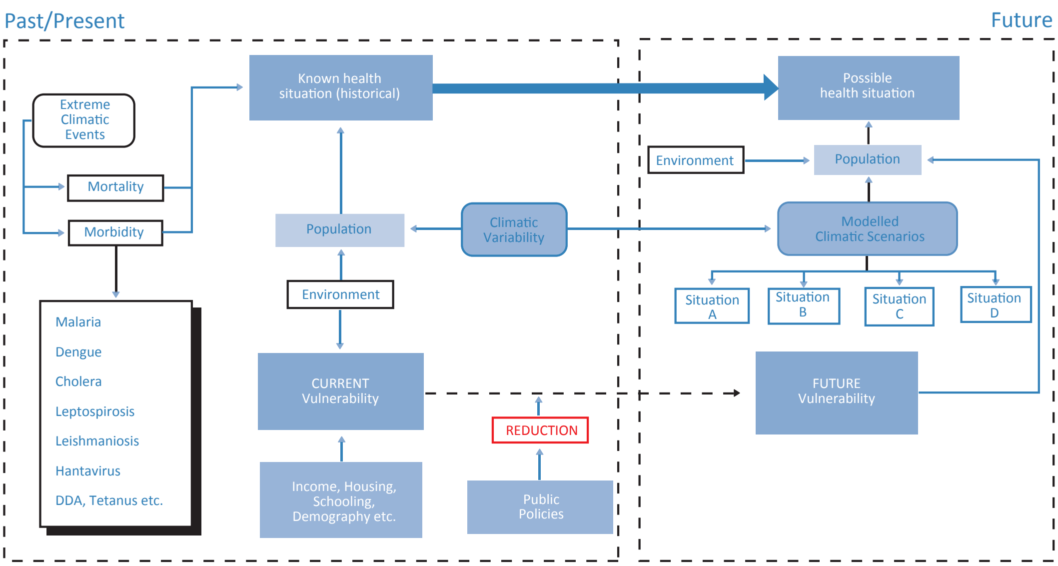


Figure 15. Climate Change Risks, vulnerabilities and impacts on human health (Source: Adapted from Barcellos *et al*., 2009)

In view of potential social, economic and environmental vulnerabilities associated with disasters, air pollution, infectious diseases and water scarcity that are likely to be exacerbated by climate change, the SUS faces the challenge of strengthening its prevention, readiness and rapid-response capabilities. Vulnerabilities and effects of climate change on human health and on the SUS are shown in the following table.

Table 15: Assessment of vulnerabilities and impacts of climate change, and their effects on human health

Exposure	Vulnerabilities		Effects	
	Environmental Conditioning Agent	Socioeconomic Conditioning Agent	Population	SUS
Disasters: Flooding and Drought	Terrain, hydrography, silting of rivers, deforestation of hillsides, irregular settlement, river-flow levels (water-use quotas), vegetation cover, land use altitude.	Housing conditions, water supply systems, solid-wastes collection, inadequate wastewater treatment and drainage, settlements in high-risk areas, population density, most vulnerable populations (elderly, children, pregnant women), residents of high-risk areas (favelas and hillsides).	**Short term:** Deaths and hospitalisations related to external causes (drowning, landslides, fractures, trauma etc.); Homeless, evicted, displaced. **Medium term:** Increase in infectious diseases, Epidemics. **Long term:** Mental and cardiovascular problems; Malnutrition and food insecurity.	Overloading of health facilities; Disruption of service networks; Impacts on infrastructure (buildings, inputs, equipment and personnel); Discontinuity of routine healthcare services.
Air pollution	Terrain, hydrography, vegetation, deforestation, seasonality, wildland fire.	Age composition of the population (children and elderly); Combustion of fuels; Industrial activity, Forest fires; Population density, housing and schooling levels.	Increase in infant, and under-5 and elderly over 60 mortality from respiratory diseases, and of adults over 40 from cardiovascular disease (arrhythmias and heart failure); Neoplasms (lung cancers), dermatological diseases, etc.	Overloading of health facilities; Increase in numbers of deaths, hospitalisations and outpatients care.

Table 15 (Continued): Assessment of the impacts of climate change, vulnerability and its effects on human health

Exposure	Vulnerabilities		Effects	
	Environmental Conditioning Agent	Socioeconomic Conditioning Agent	Population	SUS
Reduced capacity and quality of water resources	Rising sea levels, reduction in bulk-water supply for treatment and human water supply, and extreme weather events (drought or flooding)	Poor or no sanitation; Reduced treated water supply for human consumption; Poor treated water supply distribution network; Poor availability of alternative sources; Intermittent water supply; Total or partial interruption of water-supply services.	Water-borne and food-related diseases (diarrhea, hepatitis A and E, typhoid, leptospirosis, dengue, yellow fever, cholera, dehydration, schistosomiasis, trachoma, among others)	Overloading of health facilities due to increased demand, hospitalisations and deaths. Collapse of routine operation of the health units
Climate-sensitive infectious diseases	Rise or fall of temperature, humidity and rainfall, greater frequency of extreme weather events (too much or not enough rain), changes in the quality of drinking water, land use and vegetation cover, deforestation, fires.	Territorial planning, housing model and changes in land use; Population movements and migrations; Proximity of households to hazardous locations and mobility of populations of high-risk areas; Immunisation coverage; Occupational exposure (extractive, rural workers) or leisure (rural-tourism, ecotourism); Existence and quality of basic sanitation; Quality of drinking water; Availability of household hygiene measures; Such social indicators as: schooling and income levels.	Increased numbers of cases such health hazards as: illnesses associated with thermal discomfort, dengue fever, malaria, yellow fever, leishmaniosis, schistosomiasis, trachoma, leptospirosis, viral hepatitis, acute diarrhoeal diseases, cholera, Chagas disease, severe acute respiratory syndrome (SARS), influenza syndrome (influenza and other agents).	Overloading of health facilities owing to increased demand, hospitalisations and deaths. Re-emergence of controlled diseases.

Source: Adapted from Observatory of Climate and Health[52]

[52] Observatory of Climate: <http://www.climasaude.icict.fiocruz.br/>

9.10.1. Disasters and impacts on Health

Recent data point to flooding and drought as accounting for more than 90% of the disasters occurring in Brazil. Such events affect populations unevenly, directly and indirectly and in a variety of different long and short-term ways, depending on characteristics of the event and local socio-environmental vulnerabilities (ALDERMAN *et al.*, 2012). Owing to precarious living conditions, poor social-welfare services and environmental degradation, certain population groups, especially the poorest, are especially vulnerable to disasters occurring as a consequence of extreme climate events.

Disaster-induced health effects may afflict such populations not only in the direct aftermath but also for months or even years after such extreme climate events. Such afflictions may range from deaths, injuries and infectious diseases, to exacerbation of chronic psychosocial disorders, malnutrition and accidents with venomous animals. (PAHO/MS, 2014).

Reducing the impacts of disaster damage on human health is one of the functions of the public health system. With a view to promoting adaptation strategies and increasing resilience, the SUS has considered a risk management model for service delivery at the federal, state and municipal levels. Among the measures already in place for addressing these issues are the System for Surveillance of Environmental Health Risks associated with Disasters (VIGIDESASTRES)[53], the *Força Nacional*/SUS, and state and municipal Disaster-Health Committees.

All components of the National Protection and Civil Defence System (SINPDEC) need to adopt coordinated and synergistic measures to assist in the adoption of adaptation measures for strengthening the performance of the SUS. Mapping of vulnerable areas, monitoring of climate events, early-warning and management of risk-reporting systems are essential elements for timely actions on the part of the SUS.

9.10.2. Air pollution and impacts on health

Air pollution has been identified a major environmental risk to human health, which increases the incidence of respiratory, cardiovascular, dermatological diseases, neoplasms, etc. (WHO, 2015; Cançado *et al.*, 2006).

Vulnerabilities to diseases associated with air pollution are affected by environmental factors that influence dispersion of pollutants; by socioeconomic factors that lead to emission of pollutants; and finally, by factors relating to individual immunological-response mechanisms.

Climate change is taking place against a background of economic development based on establishment, maintenance and growth of industrial clusters and constant urban expansion, changes in land-use and settlement patterns and increased deforestation and burning, all of which affect deterioration of air quality and impact the health of populations in

[53] VIGIDESASTRES <http://portalsaude.saude.gov.br/index.php/vigilancia-de-a-a-z>

various regions of Brazil.

It is against this background that the Ministry of Health has implemented an Instrument for Identification of High-Risk Municipalities (IIMR)[54] for mapping of priority healthcare actions and to address problems associated with exposure to air pollution. The objective is to identify major pollution-emissions sources that compromise air quality, such as mining and manufacturing operations, vehicle fleets, and heat sources caused by burning and deforestation, etc., in the highest-risk municipalities. A significant group of these municipalities is located in parts of the Amazon region known as the "Arc of Fire", where dry-season burning, deforestation and mining and logging activities cause high levels of air pollution. Another significant group comprises municipalities located in metropolitan regions of the South and Southeast, where Brazil's largest vehicle fleets and industrial facilities are located.

Another health surveillance mechanism adopted by the Ministry of Health for the purpose of identifying health risks is the Sentinel Units for monitoring of Populations Exposed to Air Pollution (VIGIAR)[55]. This system monitors incidences of respiratory diseases attributable to atmospheric pollutants in children under the age of 5 years and the elderly over the age of 60, the age-groups most vulnerable to air pollution.

[54] Instrument for Identification of the Risk Municipalities (IIMR) <http://177.153.6.85/iimr/>

[55] VIGIAR <http://portalsaude.saude.gov.br/index.PHP/vigilancia-de-a-a-z>

Notwithstanding adoption of these instruments, the SUS needs to expand its capacity for detecting changes in healthcare profiles, with a view to adopting timely measures for addressing diseases caused by exposure to pollutants. Among the essential tools available for this purpose are Health Status Analyses, based on inter-sectoral data and information. Currently, poor access to environmental data poses one of the main limitations to this approach.

Thus, definition of a strategy for reducing health risks must entail combined multi-sectoral efforts to reduce exposure of the population and strengthen and enhance the readiness and prompt-response capacity of the health services.

9.10.3. Reduced availability and quality of water resources

Change in rainfall patterns and increased frequency of extreme climate events, associated with factors such as poor sanitation, lead to reduced availability of drinking water and, in consequence, populations are exposed to water shortages and to water, food and vector-borne diseases, all of which overload and compromise healthcare services.

Disasters, such as flooding and drought may also cause changes in drinking-water quality, and thereby increase the incidence of diseases. In such situations, water supply is often intermittent. Many households suffer acute shortages, and thus seek alternative forms of access to water that may not be adequate for human consumption. This can lead to additional health risks through spread of contamination and transmission of diseases. Drought and extended dry seasons may lead to proliferation of cyanobacteria in water sources, seriously compromising the quality of drinking-water supplies.

Among the infectious diseases associated with the low drinking-water quality and inadequate sanitation, the most serious concerns in Brazil are dengue fever, zika, chikungunya, schistosomiasis, leptospirosis, viral hepatitis, acute diarrhoeal diseases (ADD), cholera, typhus, trachoma and acute dehydration.

Besides these diseases, other ailments that require monitoring are: the risk of poisoning, which may occur as a consequence of exposure to water contaminated by chemical substances of anthropogenic origin, such as pesticides, medical drugs, hormones, and industrial or domestic chemicals. Poisoning may also result from exposure to substances present in the natural environment, such as cyanobacteria and cyanotoxins.

From a climate-change perspective, all these risk factors, and especially those relating to compromised sources of drinking water, influence the adaptation and resilience capacity of populations.

In a country as large and diverse as Brazil, guaranteeing access to appropriate quantities of high-quality drinking water requires sectoral public policies that take into account the importance of the role of basic sanitation services in: disease prevention and control, by breaching contamination chains and hindering proliferation of vectors; reducing environmental impacts; and in fostering preservation of surface-water sources and groundwater tables. This relationship further illustrates the importance of maintaining ecosystem services for the various sectors involved in this NAP, including public health.

With the aim of reducing risks to public health, the SUS issues specific regulations for drinking water standards (MS Order 2914, of 12th December 2011)[56]; conducts surveillance of drinking-water quality (VIGIAGUA)[57]; provides support for quality control for all forms of water supply, in urban, rural and indigenous areas[58]; and carries out sanitation actions in rural areas[59] (MS, 2005; MS,2013).

In the light of current vulnerabilities and the potential impacts of climate change, strengthening of institutional coordination and integration among sectoral public policies (including water resources, environment, health, sanitation, and Civil Defence) are essential for overcoming challenges and ensuring access of the population to appropriate quantities of high-quality drinking water.

---

[56] MS Order. 2914/2011 <http://bvsms.saude.gov.br/bvs/saudelegis/gm/2011/prt2914_12_12_2011.html>

[57] VIGILANCIA (*Surveillance*) <http://portalsaude.saude.gov.br/index.php/vigilancia-de-a-a-z>

[58] Sanitation and quality of water for human consumption in indigenous people areas <http://portalsaude.saude.gov.br/index.php/o-ministerio/principal/secretarias/secretaria-sesai/mais-sobre-sesai/9482-destaques>

[59] Sanitation and support for control of water quality for human consumption <http://www.funasa.gov.br/site/>

9.11 Infectious diseases sensitive to climate

The areas and dynamics of the spread of infectious diseases are influenced by multiple factors. These include climate, environment, socio-economic and demographic, biological (life-cycles of vectors) and socio-medical factors (immunological status of the population, effectiveness of local healthcare services, specific disease-control programmes, etc.) and the epidemiological history of each location (BARCELLOS *et al*., 2009).

In Brazil, (as mentioned earlier) the main infectious and endemic diseases relating to climatic variability that afflict the population are: dengue fever, malaria, yellow fever, Chagas disease, cuteneous and visceral leishmaniasis, schistosomiasis, trachoma, leptospirosis, viral hepatitis, acute diarrhoeal diseases, cholera, acute respiratory infection, influenza syndromes (influenza and other agents) and severe acute respiratory syndrome (SARS) among others.

The socioeconomic vulnerability factors that influence infectious disease scenarios are: encroachment of human settlements on natural areas, unplanned land use; globalised trade; voluntary and forced migration; tourism; rising population, development and unplanned urban densification; distortions of the economic model; social and structural problems; and lack or ineffectiveness of sanitation systems.

Of the world's ten most neglected diseases, according to the World Health Organisation (WHO) nine are prevalent in Brazil (LINDOSO *et al*., 2009). Some 40 million Brazilians have one or more of these illnesses, thus compiling the highest burden of neglected diseases in the Latin America and Caribbean region. These include practically all the cases of trachoma and of leprosy and most of the cases of ascariasis, dengue fever, hookworm, schistosomiasis and visceral leishmaniosis (HOTEZ, 2008).

Surveillance and healthcare approaches, such as vaccination, fumigation, campaigns for promoting food hygiene, etc., aim initially to address causes of disease by interrupting transmission chains and, secondly, to avoid spread of the disease and apply treatment.

Implementation, within the SUS and other sectors of adaptation measures that influence environmental and socioeconomic factors that affect health and directly or indirectly interrupt climate-sensitive transmission chains of infectious diseases, can play an important role in reducing the incidences of such diseases.

9.12 Health Status Analysis and Indicators

Health status analysis enables description, measurement and explanation of the health/disease profiles of populations, including health impairments or problems and their determinants, thereby facilitating identification of healthcare needs and priorities, choice of interventions and appropriate programmes, and impact evaluations (MS, 2015). To draft such profiles, indicators that reflect the different variables involved must be established.

Indicators are tools that facilitate understanding and monitoring of determinants and variables affecting human health and that assist in decision-making processes of the SUS. Some indicators, including those for epidemiology and environmental health used by the Ministry of Health, are agreed upon within the framework of the Interagency Health Information Network (RIPSA) which organises and maintains a database on the health status of the population (RIPSA, 2015).

With a view to studying and assessing the influence of climate change on human health, the Ministry of Health and FIOCRUZ have created the Brazilian Climate & Health Observatory[60] in partnership with the National Institute for Space Research (INPE). This observatory brings together environmental, climatic, epidemiological, social, economic and health data and information from different institutions, needed for analysis of relationships between climate and human health and of long-term trends. This partnership also created the Environmental Information System Integrated to Environmental Health (SISAM)[61] to facilitate access and handling of interactive and geo-referenced environmental data and indicators from various areas.

[60] Brazilian Climate & Health Observatory is available at: <http://www.climasaude.icict.fiocruz.br/>

[61] SISAM is available on the website: <http://sisam.cptec.inpe.br/msaude/informacoes.html#>

These projects are useful for public managers, researchers and organised civil society, assist in decision-making and complement other sources during monitoring of the health status. They may also assist in the selection or review of indicators for measuring impacts and outcomes of implementation of this NAP, and for setting new indicators, as required.

Health status analysis and reducing scientific and decision-making uncertainties with respect to climate and its impacts on human health remain outstanding challenges for government. They require information of various types (environmental, climatic, geographic, economic, health, etc.), data-sharing and collaboration among institutions, and integration and interoperability of information systems.

9.13 Strengthening of Crosscutting Public Policies

At Rio+20, it was acknowledged that “health is a precondition for and an outcome and indicator of all three dimensions of sustainable development ... (environment, economic and social) ”, and that “action on the social and environmental determinants of health, both for the poor and the vulnerable and for the entire population, is important to create inclusive, equitable, economically productive and healthy societies” (UN, 2012).

This illustrates the crosscutting nature of health issues and underscores the importance of strengthening environmental resilience of the SUS and of other government sectors, private institutions and organised civil society by adopting policies for adaptation to climate change.

Setting adaptive measures for health requires a multidisciplinary approach that takes into account vulnerabilities stemming from different economic sectors and from such characteristics as climate, geography, vegetation, economy, culture, social models and epidemiological profiles of each of Brazil's regions that may pose health risks to humans.

Figure 16 illustrates the relationship between sectoral actions and reduction of socio-environmental vulnerabilities, and demonstrates the need for crosscutting approaches for improvement of public policies.

Driving forces, Pressures and Situations that generate socio-environmental vulnerabilities	**Actions for Reduction of Socio-environmental Vulnerabilities**							
	Cities Statute	National Policy on Protection and Civil Defence	National Solid Waste Policy	National Basic Sanitation Policy	National Water Resources Policy	National Health Protection Policy	National Environment Policy	National Social Welfare Policy
Extreme poverty			●			●		●
Population density	●	●						
Housing deficit								
Inadequate urban infrastructure		●	●	●	●		●	
Environmental degradation of fragile areas		●	●	●	●		●	

Figure 16. Government actions for reducing socio-environmental vulnerabilities caused by driving forces and development pressures applied to territory (adapted from PAHO/ Ministry of Health, 2014)

Thus, to promote resilience of the population to climate change, it is essential that all sectors and spheres of government be committed, and that crosscutting approaches to management be adopted. This is necessary both for formulation and implementation of public policies and to reduce vulnerabilities of the population.

9.14 SUS Guidelines and Strategies

In view of the impacts of climate change and their effects on human health, SUS guidelines and strategies were drawn up to orient formulation of public policies, in compliance with the National Policy for Climate Change (Law 12187/2009) and adaptation measures targeted at strengthening activities of the SUS were adopted, with a view to reducing the impacts of such effects.

For purposes of this NAP, guidelines encompass accomplishment of goals that extend far beyond the lifespan of the Plan and that should be used during selection of strategies and priorities, in accordance with the epidemiological and organisational features of services.

Studies and research on the impacts of climate change on human health and action strategies drafted within the scope of the World Health Organisation (WHO), the Pan American Health Organisation (PAHO) and MERCOSUR also took into consideration 4 dimensions, namely: evidence and information management; awareness and education; alliances; and adaptation. (PAHO, 2014; PAHO, 2011).

With respect to the SUS management model, the guidelines and strategies presented in this NAP will serve, from a climate change perspective, as inputs for the definition of objectives, goals and actions of agencies and units of the Ministry of Health. Proposals for assimilation of these guidelines and strategies at the state and municipal levels of SUS, taking into consideration the particularities of each, will also be submitted the Health Councils.

The main federal-level planning instrument for mitigation measures and adaptation to climate change of the SUS is the Sectoral Health Plan for Mitigation and Adaptation to Climate Change (PSMC-Saúde) 2016-2019.

Table 16: Guidelines for incorporation of Adaptation to Climate Change into policies of the SUS

AXIS	GUIDELINES	STRATEGIES
"Information Management" Deals with expansion of scientific and technical knowledge; production and availability of official data and information for research on the relationship between health and climate; the burden of disease attributable to climate change; the economic costs and benefits of adapting to climate change; and mitigation measures to reduce the impact of climate risks on health in Brazil	**GUIDELINE 1.** Improvement of the quality of information and processes for risk reporting to assist with SUS activities in public-health emergencies associated with climate change.	Cross-reference reports of injuries and disease with hospital-admissions records relating to disasters, localities with high concentrations of air pollution and poor access to drinking water;
		Improve reporting of deaths classified as stemming from disaster events, air pollution, cold and heat waves;
		Set up, within the SUS, a system for reporting and warning of disasters, integrated with Civil Defence;
		Develop and deploy Risk Notification Management, involving all sectors and management levels of the SUS;
		Expand and encourage use of geographic and modelling information systems for understanding the dynamics and prevention of diseases;
		Establish indicators and monitoring systems to enable monitoring of impacts of climate change on health and the expected outcomes of this Plan.
	GUIDELINE 2. Promotion of studies and research on the effects of climate change on human health, considering traditional knowledge, regional characteristics and ecosystems when constructing knowledge.	Perform studies that establish costs/benefits of adaptation and mitigation actions for the health sector;
		Encourage and identify national climate and health research leaders;
		Encourage creation of climate and health research centres within research institutions and universities;
		Promote research on the burden of climate-sensitive diseases in Brazil to assess the influence of climate and of social, economic and environmental vulnerabilities in their occurrence;
		Promote studies and research to identify human health risk areas and vulnerable populations, in the context of the impacts of climate change in Brazil;
		Create stable funding sources for public investment and incentives for health-related science, technology and innovation (CT- Saúde).

Table 16 (CONTINUATION): Guidelines for incorporation of Adaptation to Climate Change into policies of the SUS

AXIS	GUIDELINES	STRATEGIES
"Awareness and Education" Entails promoting awareness of the risks of climate change to human health, by means of campaigns, events, courses, capacity-building, training, publications, policy guidance, etc. on the theme, to encourage changes of behaviour and enlist support of the public and authorities for development of strategies to reduce vulnerabilities and protect health, making the population more resilient to climate change.	**GUIDELINE 3.** Promotion of capacity-building and actions to raise awareness of the population and of SUS professionals on the effects of climate change on human health and the importance of sustainable development, and encouragement of community participation in definition of mitigation and adaptation policies.	Include climate-change and human health themes in specialisation courses, capacity-building and training programmes targeted at SUS professionals, within the context of the programme.
		Develop a capacity-building programme for SUS professionals on the impacts of climate change and its effects on health, within a sustainable-development approach;
		Provide inputs for actions within the framework of the Healthy Cities programme;
		Promote education and awareness on climate-change and its effects on human health within measures and actions targeted at SUS professionals and organised civil-society partner institutions to promote changes in risk perception;
		Develop specific training programmes to guide actions of SUS professionals in disaster situations;
		Strengthen community involvement in the definition of priority public-health policies, in compliance with Law 8142/90.
"Alliances" Entails strengthening of inter-sectoral and inter-institutional coordination and partnerships to stimulate knowledge and promote resilience of the population, through provision of data and information, technology transfers and actions to promote adaptation and mitigation.	**GUIDELINE 4.** Strengthening of the inter-sectoral and inter-institutional coordination, targeted at definition of crosscutting actions, including provision of data and information for knowledge production, technology transfers and actions to promote adaptation and mitigation in the health sector.	Establish mutually-agreed instruments to promote access to environmental and socioeconomic data and information;
		Establish methodologies and techniques for health-status analysis of the population in relation to risks associated with current climate factors and prepare future projections and scenarios;
		Promote technology transfers and exchanges of practices within the health sector to enable adoption of effective adaptation and mitigation measures in the health sector;
		Strengthen inter-institutional, and intra and inter-sectoral coordination spaces for continuous improvement of technical and management instruments and the effectiveness of crosscutting actions relating to the impacts of climate change and their effects on health.

Table 16 (CONTINUATION): Guidelines for incorporation of Adaptation to Climate Change into policies of the SUS

AXIS	GUIDELINES	STRATEGIES
"Adaptation" Covers adaptation measures required to strengthen prevention, preparation and response capacity of the health sector, to minimise vulnerabilities of the population in face of impacts of climate change, thereby contributing toward resilience of the health system and of the population.	**GUIDELINE 5.** Fostering of sustainable, resilient and secure infrastructure for public healthcare and Supplementary Health facilities, to ensure continuity of health services in disasters relating to water and energy-insecurity scenarios; promote sustainable development among the many segments of the health sector; and contribute to reducing GHG emissions.	Implement and expand clean renewable energy generation and increase energy efficiency within SUS and Supplementary Health facilities;
		Reduce water consumption and ensure continuity of drinking water supply in health facilities;
		Replace hazardous chemical substances used in health facilities for less polluting and safer alternatives;
		Reduce, treat and ensure secure disposal of waste from health services;
		Reduce use of oil-based substances and other pollutants in the manufacture of cosmetics, health products, household cleaning and medical-drugs;
		Reduce inadequate disposal of pharmaceutical products and consequent pollution;
		Adopt principles of the Programme for Sustainable Public Hiring during procurement of products, materials, furniture goods, and real estate and promote sustainable innovations within the SUS and Supplementary Health framework;
		Improve strategies for transport of patients and staff to reduce GHG emissions;
		Purchase and supply healthy and sustainably cultivated foods for the healthcare network;
		Build a GHG inventory for the health area (motor vehicles, industrial complex, disposal and treatment of health-services waste);
		Issue a technical regulation to address the planning, programming, preparation and evaluation of physical projects for healthcare facilities, covering: 1) recommendations and concepts of the Pan American Health Organisation for construction of hospitals and disaster-proof health units, with a view to ensuring their operation during and in the aftermath of public health emergencies, and 2) use renewable energy sources and reduce water consumption.

Table 16 (CONTINUATION): Guidelines for incorporation of Adaptation to Climate Change into policies of the SUS

AXIS	GUIDELINES	STRATEGIES
"Adaptation" Covers the adaptation measures required to strengthen prevention, preparation and response capacity of the health sector, to minimise vulnerabilities of the population to the impacts of climate change, and contribute toward resilience of the health system and of the population.	**GUIDELINE 6.** Formulation of specific policies to increase resilience of social groups with greater vulnerability to climate change in rural areas, wetlands, and among forest populations, indigenous peoples and the homeless.	Establish information mechanisms targeted at vulnerable populations, to encourage adoption of low environmental-impact practices and their benefits for human health, in partnership with environmental, agricultural and agrarian-development bodies, among others;
		Establish a methodology for production of information by communities that are vulnerable to the impacts of climate change on human health;
		Adopt sustainable technologies to enable deployment of health services in indigenous, quilombola and remote areas, e.g., renewable modern solar energy sources and alternative technologies for treatment of health-services wastes;
		Perform health surveillance actions to build knowledge on epidemiological profiles of rural, wetland and forest, indigenous, quilombola and homeless populations for adoption of measures for adaptation to climate change.
	GUIDELINE 7. Strengthen implementation of the national policy for sanitation and health, with the aim of universalization of access to drinking water and sanitation services.	Expand and strengthen the Network of Laboratories for the monitoring, follow-up and dissemination of information on the quality of soil and of water for human consumption;
		Improve diagnoses, evaluation and risk-management instruments for assessment of availability, access to and quality of drinking water, considering urban and rural vulnerability scenarios and the specific vulnerabilities of states and regions, within a climate-change context;
		Stimulate adoption of new water-treatment technologies to serve demand related to public-health emergencies, arising from effects of climate change.
	GUIDELINE 8. Strengthen health surveillance for identification of human-health risks associated with climate change, with a view to supporting adoption of adaptation measures within the SUS context.	Include climate-change and human-health themes on the agenda of inter-disciplinary and inter-sectoral regional Standing Committees for Health Surveillance, with public participation (Decree 7508/2011) in support of prevention, preparation and response actions of healthcare networks;
		Encourage preparation and implementation of Public Health Emergency Plans within state and municipal-level SUS facilities, with participation of all SUS sectors and of partner institutions;
		Expand the Network of Reference Laboratories for monitoring and follow up of vectors and of clinical analyses of infectious and non-communicable diseases;
		Establish mechanisms and tools for identification of populations dependent upon health facilities in-disaster risk areas, in partnership with Civil Defence and other agencies that produce data;
		Identify etiological causes in health-emergency associated cases;
		Deploy climate and environmental-risk analysis in health surveillance activities.

9.15 Specific Objectives, Goals and General Recommendations

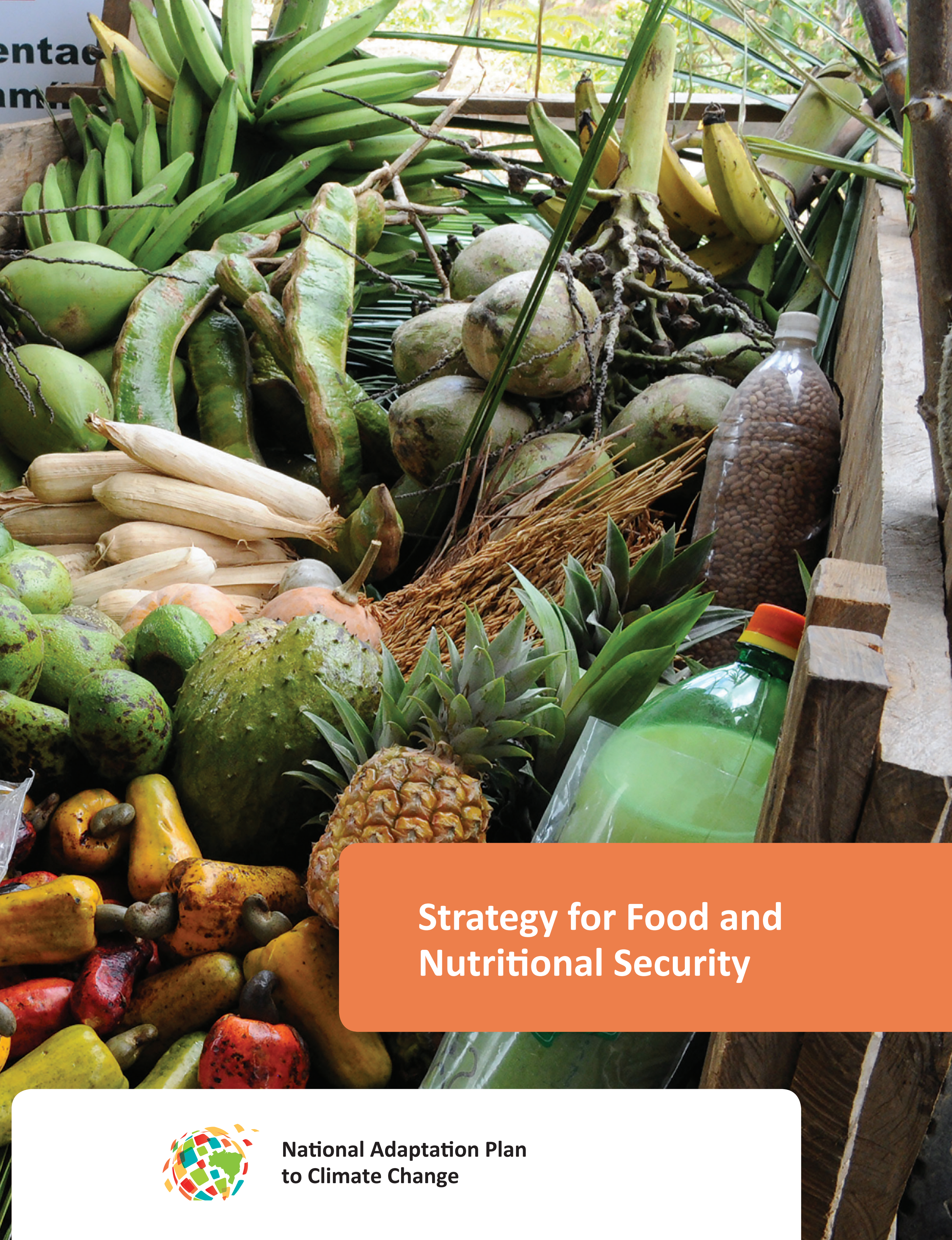
Volume 1 of this NAP identified priority goals agreed upon among the various sectors involved in this Plan. Attainment of these goals could have extensive repercussions, depending upon the planning and institutional capacity of each sector. For the health strategy, two priority actions were selected to be implemented during the initial phase of this Plan:

Objective 3. Identify and propose measures to promote adaptation and reduction of climate risk	Sectoral and Thematic Strategy: Health		
	Goal 3.11	**Initiatives**	**Responsible**
	Expand the scope of the National Drinking Water Quality Surveillance Program (VIGIAGUA) to reach 85% of Brazilian municipalities, by 2019.	Enhance the National Drinking Water Quality Surveillance Information System (SISAGUA) incorporating new features and health-risk management reports.	MS(SVS)
		Expand and establish the network of laboratories for monitoring, follow-up and dissemination of information on the quality of drinking water.	
		Record on SISAGUA information on registration, control and surveillance of drinking-water quality.	
		Draw up risk maps on the supply of drinking water, based on the information generated by SISAGUA.	
	Indicator/Monitoring:	Percentage of municipalities with information on registration, control and surveillance of drinking-water quality recorded on SISAGUA.	
	Impacts:	Strengthened surveillance of drinking-water quality.	
		Enhanced information on water supply for human consumption.	
		Reduction of risks to human health related to drink-water supply.	
		Support for attainment of sustainable-development goals relating to access to water of quality compatible with current standards.	

Objective 3. Identify and propose measures to promote adaptation and reduction of climate risk	Sectoral and Thematic Strategy: Health		
	Goal 3.12	**Initiatives**	**Responsible**
	Establish a study, research, monitoring and communication network on climate and health, with a view to expanding technical-scientific knowledge and inputs for health-status analysis and for consolidated decision-making of the Unified Health System (SUS).	Integrate climatic, environmental and socioeconomic risk analysis into SUS procedures for monitoring of public-health emergencies.	MS (SVS/ FIOCRUZ)
		Establish centres for studies and research on climate and health within the SUS.	
		Establish a panel for strategic information on climate and health to support the strategic management in the SUS.	
		Establish a Centre for Integration of Health, Environment and Sustainability Technologies (CITSAS) within the National Climate and Health Observatory and the Knowledge Centre on Public Health and Disasters (CEPEDES).	
	Indicator/Monitoring:	Network established and consolidated.	
		Cooperation agreement drafted and implemented.	
		Network project drafted.	
		CITISAS project drafted.	
		Protocol for monitoring public-health emergencies integrated with analysis of climatic, environmental and socioeconomic risk drafted.	
		Panel for strategic information on climate and health established.	
		Integration Centre for Health, Environment and Sustainability Technologies established	
	Impact:	Enhanced quality of information, management capacity, and disclosure of information on climate risk to human health.	
		Stimulus for production of scientific and technical knowledge on the relationship between climate and health and climate-sensitive diseases, in support of decision-making and definition of adaptive measures, within the SUS.	

NOTE: (*) Implementation of Goal 2 is linked to provision of environmental data required for analysis of health status, considering environmental, climate and socioeconomic variables.

Coordination: Management Committee and the Executive Committee of the PSMC-Health	***Jose Agenor Alvares da Silva*** Executive Secretary (MS) ***Antonio Carlos Nardi*** Secretary for Surveillance in Health (MS) ***Gilberto Alfredo Pucca Junior*** Director of the Secretariat for Surveillance in Environmental and Worker's Health (MS) ***Daniela Buosi Rohlfs*** Coordinator General for Surveillance of Environmental Health (MS)
Coordination: Ministry of Environment	***Karen Silverwood*** Director of the Bureau for Licensing and Environmental Assessment of the Secretariat for Climate Change and Environmental Quality (SMCQ) ***Pedro Christ*** Deputy-Director of the Bureau for Licensing and Environmental Assessment of the Secretariat for Climate Change and Environmental Quality (SMCQ)
Authors:	Liliam Angelica Peixoto Colombo (MS) Eliane Lima e Silva (MS) Ana Carolina Camara Ferreira (GIZ/MMA) Mariana Egler (MMA)
Collaborators:	Alana Coelho Maciel (SVS/MS) Alexandra Lima da Costa (DESAM/FUNASA) Aline Fonseca Rosa (SESAI/MS) Ana Cristina Barreto Peixoto Sampaio (SVS/MS) Andre Oliveira Rezende de Souza (ANVISA) Angela M. Imagosso Takayanagui (USP) Camila Vicente Bonfim (SVS/MS) Carla Ribeiro (SVS/MS) Carlos Machado de Freitas (ENSP/FIOCRUZ) Cassiana Perinazsso da Veiga (SVS/MS) Christovam Barcellos Netto (FIOCRUZ) Cristiane Reis Soares Medeiros (SAS/MS) Daniela Fortunato Rego (SVS/MS) Diego Ricardo Xavier Silva (FIOCRUZ) Fabio David Reis (SVS/MS) Fabio Gaiger Silveira (SVS/MS) Felipe Nunes Bonifacio (SCTIE/MS) Fernanda Barbosa de Queiroz (SVS/MS) Gabriela Freire Martins (SESAI/MS) Gisele Balbino Araujo Rodrigues de Sa (SVS/MS) Guilherme Franco Netto (FIOCRUZ) Helen Gurgel (UNB) Heloisa Helena C. Bastos (SVS/MS) Irania Maria da Silva Ferreira Marques (SE/MS) Jaqueline Francischetti Zago (SVS/MS) Jamyle Calencio Grigoletto (SVS/MS) Jose Braz Damas Padilha (SVS/MS) Jose Gustavo Ferez (IPEA) Julia de Albuquerque Pacheco (SAS/MS) Juliana Wotzasek Rulli Villardi (FIOCRUZ) Maria Emilia Aracema (SESAI/MS) Olavo de Moura Fontoura (SAS/MS) Osvaldo Telmo Melgares Lobo (DESAM/FUNASA) Pollyanna Teresa Cirilo Gomes (SCTIE/MS) Priscila Campos Bueno (SVS/MS) Raquel de Almeida Castanheira (SAS/MS) Rejane Maria de Souza Alves (SVS/MS) Simone G. El Khouri Miraglia (UNIFESP) Tatsuo Shubo (FIOCRUZ) Tiago de Brito Magalhaes (SVS/MS) Thiago Borges Lied (SGEP/MS) Vital de Oliveira Ribeiro Filho (SES/SP) Vinicius Pereira Moura (SGEP/MS) Zaira Farias Bosco (SGTES/MS) Walter Ramalho (UNB)



Strategy for Food and Nutritional Security

National Adaptation Plan
to Climate Change

10 Strategy for Food and Nutritional Security

10.1 Introduction

The aim of this strategy is to assess vulnerabilities, impacts and risks posed by climate change to Brazilian food supply and nutritional security and to propose guidelines and practices that contribute toward reducing such vulnerabilities.

To this end, a deeper examination of the six groups of actions presented in the National Food and Nutritional Security Policy will be presented, with a view to establishing guidelines to increase the adaptive capacity of this sector.

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5) was emphatic in concluding that the world faces unprecedented global warming, and that greenhouse gas emissions (GGEs) are its main cause. Chapter 2.1 (Volume I) of this National Plan for Adaptation (NAP) reports that, by the end of the 21st century, average global surface temperatures my rise by more than 1.5°C in relation to the 1850-1900 period, and that warming is likely to continue beyond 2100 under all the scenarios, except RCP 2.6. In such a context, the consequences for the Planet could be enormous, with grave impacts upon food supply and nutritional security in Brazil. Agriculture is one of Brazil's most vibrant economic sectors and one of its most sensitive to climate change, since it depends directly upon weather conditions. If adaptive measures are not taken, food production could be jeopardised and so could innumerable jobs and farm-sector incomes, with dire consequences for food and nutritional security. In Brazil, 17% of the population is employed in agricultural activities, but in the Northeast and North regions, this proportion rises to 29.6% and 20.2%, respectively (NEAD/MDA, 2011).

To block climate change, greenhouse gas emissions must be reduced at the global level. The impacts of climate change, however, can already be felt throughout the world and in all parts of Brazil and require adaptation measures to reduce risks and ensure national food and nutritional security.

The Inter-ministerial Chamber for Food and Nutritional Security (CAISAN) for purposes of preparation of this NAP, has undertaken coordination of this sectorial strategy and will be responsible for its implementation. To this end, a Technical Committee for Food and Nutritional Security and Climate Change was established in partnership with the Ministry of Social Development and Combating Hunger (MDS); the Ministry of Environment (MMA); the Ministry of Agrarian Development (MDA); the National Indian Foundation (FUNAI); the Secretariat-General of the Presidency of the Republic; the National Council for Food and Nutritional Security (CONSEA); and the National Supply Company (CONAB). This Chapter of the NAP is thus a collective and collaborative effort on the part of these institutions.

Participation of CONSEA ensures a channel for dialogue with civil society and debate on issues relating to food and nutritional security within the context of climate change, both during the initial preparatory phase and during subsequent implementation of this strategy, with a view to integrating adaptation measures and actions into public policies for fostering Brazil's development.

In summary, the mechanism and institutional framework created for drafting of this chapter placed value on public participation, inter-sectoral approach, institutional, inter and intra-government coordination with society, in line with the guiding principles of Brazilian food and nutritional security policy.

10.2 The National Food and Nutritional Security System and Policy and adaptation to climate change

Preparation of this sectoral strategy for Food and Nutritional Security (FNS) has sought to establish: 1) a priority focus on discussion of policy for promotion of food and nutritional security within the context of climate change and on the impacts on food production and subsequent repercussions on food supply; 2) a social and territorial approach that requires special attention, in view of the expected negative effects of climate change on food and nutritional security, on family farmers and, above all, on the semi-arid region.

These choices were based upon a diagnostic study on the impacts and risks of climate change for food production, and on the current National Food and Nutrition Security Policy (PNSAN). A review of this policy examined the extent to which current approaches collaborate toward building adaptive capacity and more resilient farming systems, capable of ensuring maintenance of measures for ensuring food and nutritional security of families. It was concluded that such measures should be reinforced and the scope of their activities expanded.

It should be stressed that, in this analysis of food and nutritional security, aside from production, a number of other factors were considered, given the inter-sectoral and holistic characteristics of this approach. These include, for instance, the interface of nutrition and health; logistics of access to and availability of food in cities; and other specific features relating to the food and nutritional security of families living in urban environments. For purposes of this NAP, the focus has been to prioritize discussion on the impacts of global climate change on food production, on family agriculture and on rural environments, especially in the semi-arid region. In the course of future periodic reviews of this NAP, other FNS dimensions will gradually be taken up to reflect the status of the on-going debate on the impacts of climate change and adaptation measures needed to face up to it.

The institutional framework of FNS policies is well aligned to the National Food and Nutritional Security System (SISAN) established by the Organic Law for Food and Nutritional Security (LOSAN - Law 11346, of 15th September 2006) for the purpose of promoting and protecting the Human Right to Appropriate Food (HRAF). It therefore fosters effective participation of various players by imbuing claims to this right with legitimacy and transparency.

One of the most innovative aspects of LOSAN is the way it establishes how the Brazilian State shall organise to ensure the HRAF. Two strategies are promoted under this institutional framework: inter-sectoral approaches; and participation of society.

Inter-sectoral aspects, though challenging, must be assessed, given that fulfilment of the HRAF involves not merely “having something to eat” but also, regular and permanent access to high-quality food in sufficient quantities, without compromising fulfilment of other needs, based upon food practices that promote health, respect cultural diversity, and are socially, economically and environmentally sustainable.

To ensure coordination and integration among the various actions of different sectors, the coordination of SISAN is conducted by two national-level bodies: CONSEA (Decree 6272/2007) that ensures participation of civil society; and the Inter-ministerial Chamber for Food and Nutritional Security (CAISAN) (Decree 6273/2007) presided by the Ministry of Social Development (MDS) with representatives of 20 ministries. CAISAN is responsible for networking, monitoring and coordinating the PNSAN and for coordination with state and municipal-level SISAN authorities.

In 2010, the right to food was enshrined as a social right in Article 6 of the Federal Constitution. At the same time, Decree 7272 instituted the National Food and Nutritional Policy and provided for its monitoring.

In 2011, the National Food and Nutritional Security Plan (PLANSAN-2012/2015) was launched. This Plan integrates dozens of actions and programmes that encompass the various dimensions of FNS, including access to food, food production and availability, and nutritional aspects.

Guidelines of the National Food and Nutritional Security Policy are listed below:

1. Promote universal access to appropriate and healthy food;
2. Promote sustainable and structured food supply systems, based upon agro-ecological production, extraction, processing and distribution;
3. Institute permanent food and nutritional education processes, research and training in the fields of food and nutritional security;
4. Promote, universalise and coordinate food and nutritional security actions targeted at quilombola and other peoples and communities;
5. Strengthen food and nutritional actions at healthcare facilities at all levels, in coordination with other food and nutritional security measures;
6. Promote universal access to sufficient quantities of high-quality drinking water;
7. Support initiatives to foster food sovereignty, food and nutritional security and the human right to adequate food at the international level.
8. Monitor fulfilment of the human right to adequate food.

10.3 Impacts of global climate change on food and nutritional security in Brazil

The risk of setbacks in recent FNS achievements in Brazil as a consequence of the negative effects of climate change is unacceptable. Such change poses a threat to the food and nutritional security of the population, by triggering extreme events, desertification and other impacts that may jeopardise the human right to appropriate food. This right implies regular and permanent access to food, in sufficient quantity and quality. Promotion of FNS policies becomes of even greater importance within the context of climate change, as they serve to promote adaptation capacity and resilience.

That climate change may further aggravate existing poverty is a major concern. Social vulnerability and vulnerability to climate change feedback on each other, since more vulnerable populations generally have lower capacity to adapt to adverse effects of climate change while, at the same time, such effects can exacerbate social vulnerabilities of Specific Traditional Population Groups, (e.g., extractivists, indigenous peoples, *quilombolas*, artisanal fishermen, riparian populations, family farmers and agrarian-reform settlers[62]) whose economic survival, customs, culture and lifestyles are strongly influenced by weather conditions.

[62] Notwithstanding their great diversity, such groups share some common features expressed in the legal concept adopted for "traditional peoples and communities" in Art. 3, item I of Decree 7040/2007 which establishes the National Policy for Traditional Peoples and Communities (PNPCT) quote: "culturally differentiated groups and that are recognized as such, that possess their own forms of social organization, that occupy and use territories and natural resources as a condition for their cultural, social, religious, ancestral and economic reproduction, using knowledge, innovations and practices generated and transmitted by tradition".

In Brazil, owing to deeply and spatially dispersed social disparities, global climate change may have diverse impacts on traditional population groups. Furthermore, in view of the vast size of the country, various different weather patterns may prevail, which may have either beneficial or adverse impacts upon such groups, depending upon location and distribution throughout Brazilian territory.

As discussed in Volume I of this NAP, exposure to such climate variations as temperature, rainfall, humidity, wind speed, rising sea levels, etc., stemming from global climate change, does not, in itself, determine the impacts on ecosystems, production systems and local communities. Social vulnerability and adaptive capacity account for the magnitude of the effect, whether it will be negative or beneficial. For example, building of cisterns for catchment of rainwater, better soil conservation, and protection of water sources are effective measures for facing up to temperature, rainfall and evapotranspiration variations, and for conservation of water resources.

Analysis of the risks of climate change for promotion of Brazilian food and nutritional security must take into account three dimensions that explain the vulnerability: sensitivity; exposure; and adaptive capacity. For exposure, given the vast size of Brazil and considering the diversity of current climate scenarios, it is strategically desirable that analyses be based on geo-referenced findings at the lowest possible level of geographical disaggregation. For sensitivity and adaptation capacity, findings should, whenever possible, stem from disaggregation of social factors entailing investigation of disparate socioeconomic conditions, capacity to respond and resilience, to guide the targeting of public policies for FNS.

10.4 Water availability

Promotion of universal access to sufficient quantities of high-quality water is a component of the National Food and Nutritional Security Policy. This policy is based on the human right to appropriate nutrition, which includes ensuring the right of access to drinking water. Water, in turn, is also an essential input for food and livestock production.

Water availability in Brazil is closely linked to climate and especially to rainfall during summer months. Late onset of rainy seasons can affect farming and electricity generation. Large scale flooding and droughts have had strong impacts on the Brazilian economy and on national food and nutritional security. Studies suggest that future changes in rainfall patterns and regimes may strongly affect flow levels of Brazilian rivers.

Conservation of agro-biodiversity, soil recovery in degraded areas, restoration of water sources and promotion of integrated crop-livestock-forestry systems are all factors that could contribute to greater stability of the water balance and availability of water for agricultural use. Such practices should thus be encouraged, as they contribute indirectly to the maintenance of food and nutritional security, given that water is an essential input for food production.

10.5 Food production of family farming and food sovereignty

Studies have indicated that, as a consequence of climate change, Brazil may face: 1) a reduction of up to 10.6 million hectares of agricultural land by 2030; 2) reduction of forests and woodland areas on farms, with increases of pastureland; 3) reduction of low climate-risk areas for planting the main staple and export crops (rice, beans, corn, soybeans and cassava); 4) regional redistribution of certain crops in search of more suitable climatic conditions; 5) more accentuated focus on livestock in rural regions of the Northeast, in detriment to crops; and 6) increased frequency and intensity of extreme climate events, with a tendency to generate adverse impacts on agricultural production and yields (MONZONI, 2013; PBMC, 2014; MARGULIS *et al.*, 2011; FERES *et al.*, 2011; EMBRAPA, 2008). In the short term, climatic extremes may cause crop failure, leading to shortages of staple foods and price volatility. These are, in short, the main effects that may impact the Brazilian food supply system, food prices, the basic family "food basket", and family expenditures on food.

The impacts of climate change can be expected to affect crop yields, but this will tend to vary by category: family farming; and agribusiness. This is because geographical location and soil characteristics of farms, and their agricultural potential and adaptive capacity, determine the degree of impact and potential food-production losses.

A pioneering study carried out by the MMA in partnership with OXFAM, and with collaboration of CAISAN, estimated potential losses stemming from global climate change for cassava, rice, beans, corn and coffee produced by family farmers.

These crops were selected in view of their importance for the food and nutritional security of families, for the Brazilian food supply, and for the proportion of national production from family farms. According to the latest Agricultural Census (IBGE, 2006) 84% of Brazilian farms are family owned and account for 74% of all rural labour. There are 4.3 million family farms that, as a group, account for 38% of farm Gross Production Value (GPV) and produce 70% of all food consumed in Brazil (UNSCN, 2014; IBGE, 2006). Family farmers account for 83% of the cassava, 70% of the beans, 46% of the corn (maize), 38% of the coffee and 33% of the rice produced in Brazil (KEPPLE, 2014).

The MMA/Oxfam research was based on agricultural production data for family farming from the 2006 Agricultural Census. It also relied upon future weather projections produced by the National Institute for Space Research (INPE) considering temperature and rainfall parameters for Brazil. It estimated expected yield losses for selected crops, stemming from temperature and rainfall variations. Factors such as soil characteristics and the agricultural aptitude of farm properties (fertility, erosion, topography, etc.) explain differences in productivity among farmers and were, therefore, used as control variables for the impact model.

Crop yields of family farms were calculated for the selected crops and, subsequently, future agricultural productivity was assessed, within projected climate-change scenarios. The difference between the first value observed and the projected value corresponds to the expected variation in agricultural productivity as a consequence of global climate change. The findings of this research are grouped by biome, based on projected impacts for municipalities and are summarized below.

Coffee yields may be affected either by water shortages or by excessive heat in traditional production regions. Thus, with higher temperatures, coffee grown in the Mata-Atlântica biome (Minas Gerais, Espírito Santo and São Paulo) is likely to migrate from areas of Mata-Atlântica in the Southeast to those in the South, in search of more favourable production conditions and profitability. In municipalities such as Lajedo do Tabocal (BA), São José do Mantimento (MG) and Santa Cruz do Rio Pardo (SP) productivity losses for coffee are expected to reach 100% by 2100, thus making local coffee production unfeasible.

There may be productivity gains for cassava, especially in the Pampa biome, with fewer areas subject to colder weather and frost. In the Amazon, cassava production may also benefit from less rainfall. The greatest productivity losses and declines in area under cultivation are expected to occur in the Caatinga biome (semi-arid and arid areas of the Northeast) where cassava is of great importance for the food and nutritional security of families. For more than half of the municipalities in the Caatinga, projections indicate severe losses in cassava yields, with dire consequences for subsistence farmers and incomes of labourers engaged in cassava production. In the Northeast, according to data from National Household Sample Surveys (PNAD) in 2012, cassava production accounted for 6.1% of farm jobs, a proportion second only to corn (maize) that employed 8.9% of the agricultural labour force.

Rice yields are likely to suffer smaller losses in irrigated production areas with abundant rainfall in the State of Goiás, the northern part of Mato Grosso and in Pará. According to data from MAPA, irrigated paddies in the South of Brazil account for roughly 54% of national rice production, and Rio Grande do Sul is the largest Brazilian rice-producing state.

Corn is already under threat and, with climate change and predicted higher temperatures and water shortages, the risk is expected to rise significantly. This is because projected future temperature rises throughout Brazil may affect the water balance and evapotranspiration in corn. Production restrictions cover almost all of Brazilian territory, with the exception of the Pampa, where productivity improvements are expected to result from fewer frosts. In the Northeast, where nearly 9% of the agricultural labour is employed in corn cultivation, the most affected municipalities are likely to be Porto Fraco, São João do Caru, Centro Novo do Maranhão, Feira Nova do Maranhão and Brejo, all in the State of Maranhão.

Yields of beans are expected to drop in several localities, owing to higher temperatures and water stress. In search of better production and profitability conditions, bean cultivation will tend to locate in the Pampa biome and in the southern part of Minas Gerais. In the Northeast, where beans account for 3.4% of agricultural jobs, the most affected municipalities are likely to be Pedra Lavrada (PB), Ceará-Mirim (RN/), Trindade (PE) in the Caatinga; and Humberto de Campos (Maranhão) in the Cerrado biome[63].

These expected climate-change induced productivity losses will have two types of impacts on food security: firstly, through reduced food supplies, including for subsistence consumption of family farmers; and through reduced capacity to generate income on the part of such farmers. Family farmers are generally both sellers and buyers, i.e., they specialize in the production of certain crops and, with income from their sale, purchase other foods, goods and services. Projected losses of agricultural productivity thus affect farm incomes which, in turn, influence the quality and diversification of the diets of families and their access to the basic goods and services needed for maintenance of their quality of life and food security.

An adaptive strategy for strengthening food security in Brazil is expansion of warehousing capacity, which entails a greater role for governmental regulatory stocks. Silos and warehouses are important for stockpiling harvests during periods in which climate conditions are favourable and enable longer planting and harvesting periods. Furthermore, in some situations, markets signal a need for intervention, e.g., in cases of crop failure caused by an extreme climatic event that my lead to higher price volatility in commodity markets.

To foster building of public and private stockpiles, warehousing capacity will have to be expanded. Data from the 2006 Agriculture Census revealed that only 1.6% of the Brazilian farms have silos or warehouses for grain and forage. Moreover, most of Brazil's silos and warehouses are located in the Central-West region where production of most of the grain for export is concentrated (Figure 17). Nonetheless, according to data from the National Supply Company (CONAB), Brazil's static storage capacity amounts to 152 million tonnes, whereas grain production in the 2014/2015 growing season was estimated at 200 million tonnes. The map in Figure 18 shows micro-regions where there is a gap between storage capacity and grain production.

Also according to CONAB, private companies own most (75%, equivalent

[63] An expanded discussion of these results can be found in a study produced by Speranza et al., 2015 for MMA/Oxfam available at: <http://www.mma.gov.br/clima/adaptacao/projetos>.

to 152 million tonnes) of Brazil's static storage capacity. Cooperatives own 21% and, finally, governmental bodies account for the remaining 4%. There are some 5.600 storage companies in Brazil, but 50% of this storage capacity is concentrated in the hands of 156 companies. From a regional perspective, 42%, of Brazil's static storage capacity is concentrated in the South, followed by 35% in the Central-West, and 15% in the Southeast. The North and Northeast regions, together, account for only 8% of storage capacity.

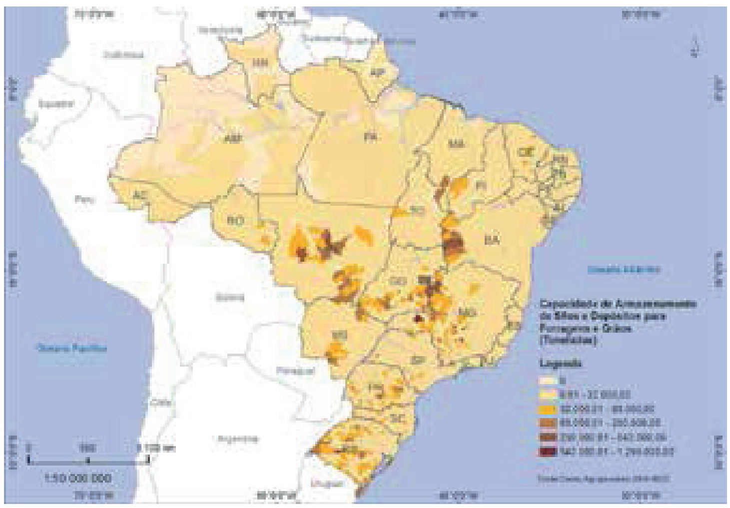


Figure 17- Distribution of silos and warehouses in Brazil

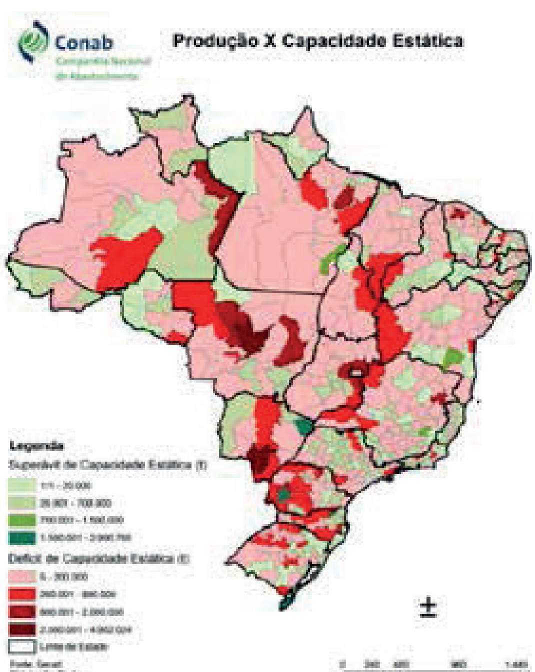


Figure 18- Comparison of grain production vs. static storage capacity in Brazil

In short, climate change will require a higher degree of planning and greater precision on the part of Brazilian farmers. More silos and warehouses would contribute to this, by enabling exploitation of the most favourable climate conditions and extending planting and harvesting periods. Without storage capacity, good harvests may be lost, thereby wasting the potential that stockpiles allow for regulating food supply, stabilising market prices and promoting FNS.

10.6 Living conditions in the semi-arid area

From a territorial and social perspective, the semi-arid region epitomises exposure, sensitivity and (low) adaptive capacity, making it the geographical priority area for implementation of measures for addressing negative effects of climate change.

Efforts have focused, for example, on ensuring access to water for human consumption and production systems. In recent years, the Brazilian Federal Government has brought about a paradigm change for public policies targeted at this region, by acknowledging the viability of survival under sustainable living conditions in this land as a right of the local (*Sertanejo*) population. Moreover, through an extensive network and partnerships with civil society, it has also promoted access to water by means of a programme for construction of rain-water catchment cisterns.

On the other hand, since 2012, Brazil's Northeast region has suffered the worst cycle of drought in 50 years, with more than 1,400 municipalities affected. The Ministry of National Integration estimates agricultural losses of the order of US$ 6 billion (MCTI, 2014). It is in this the region that the semi-arid area is located; where 1,340,172.60 km^2 are susceptible to desertification, an area equivalent to almost 16% of Brazilian territory, with a population of 34.8 million (17% of Brazil's total) distributed in 1,488 municipalities (PAUPITZ, 2013). These numbers provide a notion of scale of this area, the most highly populated dry region in the world.

The Harvest Guarantee Programme[64], an agriculture insurance scheme for family farmers of the semi-arid area, has had to expand the number of beneficiaries and the number of instalments granted, as a consequence of worsening drought in this region in recent years (2011/2012 and 2013/2014 growing seasons). Climate projections point to even more extreme weather for the Brazilian semi-arid region. Adaptation guidelines for this region will be discussed in greater detail in the section on strategies. The

[64] Harvest Guarantee (*Garantia-Safra* – GS) is an action under the National Programme for Strengthening Family Farming (PRONAF), under responsibility of the Ministry of Agrarian Development, initially directed toward farmers and their families located in the Northeast region, in the north of the State of Minas Gerais, Vale do Mucuri, Vale do Jequitinhonha and northern Espírito Santo. This is the area covered by the Superintendency for Development of the Northeast (SUDENE) and is mostly semi-arid, and suffers crop failures owing to drought or excessive rainfall. Farmers who sign up to Garantia Safra in the municipalities that suffered losses of no less than 50% of production of beans, corn, rice, cassava, cotton, or of other crops, as defined by the management of the Garantia Safra Fund, owing to drought or excessive rain, receive financial compensation directly from the Federal Government, in five monthly instalments, by means of smart cards provided by *Caixa Economica Federal*. Owing to intensification of the drought in the latest harvest seasons, the government has extended the number of instalments to eight.

challenge is to strengthen adaptation measures so that climate change does not jeopardise advances promoted by the Federal Government for improving living conditions of families in the semi-arid.

10.7 Conclusions and guidelines

10.7.1. The importance of a resilient agrarian system

Building of a more resilient food system requires adjustments to ecosystems, to social-welfare systems and to economic systems. Such changes will be difficult to effect in most regions and will fall most heavily upon more vulnerable populations in practically all regions. Climate change models suggest that the direst effects, such as more intense drought, are likely to be felt in tropical areas, including Brazil's semi-arid Northeast region.

Poor food-production sustainability poses a threat to resilience and must be addressed through changes in food production models and better governance of national and global food systems. Food production and distribution practices that are more efficient in allocation and use of natural and biophysical resources must be identified and supported, with a view to reducing negative environmental externalities, such as GGEs. In Brazil, between 2005 and 2012, agricultural-sector emissions jumped from 415,724 to 446,445 Gg CO_2eq, which corresponds to a relative change from 20% to 37% of total Brazilian emissions (MCTI, 2015). Currently, alongside those of the Energy sector (37%) agricultural emissions are the largest component of Brazil's total GGE footprint. Thus, a resilient food system, based on agro-ecological practices is a solution and counterpoint to the predominant food production system in Brazil which is responsible for most of national GGEs and has collaborated toward loss of productive diversity and depreciation of the value of agro-biodiversity products, thereby jeopardising national food sovereignty.

Brazil must take up the challenge of implementing mutually self-reinforcing mitigation and adaptation actions to reduce agricultural GGEs, through creation of more resilient agrarian systems that are better adapted to withstanding negative effects of climate change. The National Food and Nutritional Security Policy (PNSAN) encompasses implementation of sustainable food production and distribution systems, with a focus on promotion of agro-ecology systems, preservation and valorisation of agro-biodiversity, implementation of native seed banks, diversification of production, recovery and preservation of soil and of water sources, and lower pesticide and chemical-fertiliser use[65].

According to Olivier de Schutter (2012:23-24) an agro-ecological production approach provides a variety of advantages for the building of a sustainable food

[65] Between 1992 and 2010, ratio of fertilizer sold to area under cultivation more than doubled in Brazil (IBGE 2012). Brazil is world leader in consumption of pesticides. Nitrogen fertilizers accounted for 6.5% of GEEs produced by Brazilian agriculture in 2012 (MCTI, 2015). This could be reduced by avoiding waste when applying fertilizer and by cultivating nitrogen-fixing plants. Researchers from the universities of Harvard and Minnesota have estimated that 50% of the nitrogen applied for production of cereals in the world is unnecessary.

system, including better prospects for adaptation to climate change. As a former Special United Nations Rapporteur for the Right to Food (2008-2014) Schutter affirms that agro-ecology has contributed to fulfilment of the right to food by: 1) increasing yields at the field level; 2) reducing rural poverty[66]; 3) fostering better nutrition; 4) stimulating collaboration toward dissemination of best practices among farmers; and 5) (as already mentioned) improving resilience of agrarian systems to climate change.

The use of agro-ecological techniques can significantly attenuate negative impacts of climate change, and especially of extreme events, as resilience is strengthened by use and promotion of agricultural biodiversity within ecosystems. Agro-ecology production systems are much better equipped to withstand drought and flooding. Moreover, the diversity of species and agricultural activities that the agro-ecological methods stimulate serve to mitigate risks of the impacts of extreme meteorological phenomena, and to ward off invasive new pests, weeds and diseases. Agro-ecological practices consisting of growing consortia of cultivars rely on genetic diversity in fields to improve disease resistance in crops.

[66] The cost of creating jobs in agriculture is significantly lower than in other sectors. In Brazil, INCRA data reveals that each job generated in a settlement costs the Government US$ 3,640, while the cost would be 128% higher in industry, 190% higher in trade and 240% higher in the services sector. Comparisons among countries demonstrate that GDP growth stemming from agriculture is at least twice as effective in reducing poverty as non-agricultural GDP growth. Some types of investments are more effective than others in achieving this goal. The multiplier effects are significantly greater when growth is triggered by higher income of smallholders, stimulating demand for goods and services from local tradespeople and service providers. When large landholders increase revenues, most is invested in inputs and imported machinery and only a much smaller portion goes to local commerce (SCHUTTER (2012), based on WORLD BANK (2008) and MIGUEL CARTER (2010)).

Agro-ecology also places agriculture on the path to sustainability by liberating food production from dependence on fossil energy (oil, gas and chemical fertilizers). It contributes to mitigation of climate change, both by increasing carbon sinks through build-up of organic matter in the soil and by increasing quantities of biomass in surface soils. Moreover, it curtails emissions of carbon dioxide and of other greenhouse gases on farms, by directly and indirectly reducing energy use.

Another significant advantage of agro-ecology is that, by valuing traditional knowledge of family farmers and traditional communities (indigenous peoples, quilombolas, riparian communities, etc.) through constant networking between farmers and rural-extension and training networks, it fosters resilience. Agro-ecology is thus an alternative in counterpoint to new models that propose solutions to challenges posed by the negative effects of climate change under such labels as “intelligent agriculture”, “new double green revolution”, etc. These models are normally highly dependent upon agricultural inputs, machinery and equipment, and are generally based upon commercialisation of nature and entrepreneurial agricultural practices.

10.7.2. Guidelines for promoting adaptation

The need to strengthen food and nutritional security within a context of global climate change makes it imperative that current Brazilian public policies in this field be maintained. Institutional arrangements entailing coordination and integration among different agencies, ministries and representatives of civil society and the system for monitoring the FNS status of families account for much of the progress achieved.

Brazil's FNS system is based upon an inter-sectoral and holistic approach. These characteristics will facilitate attainment of the subsequent steps to be taken following publication of this National Adaptation Plan; i.e., establishing adaptation to climate change as a crosscutting theme permeating all aspects of governance at the federal, state and municipal levels. CAISAN and CONSEA are the appropriate loci for deliberations and debate on progress in this direction.

For creation of resilient agrarian systems, adaptation strategies need to be based on strengthening both communities and ecosystems. Such strategies include actions targeted at: 1) improving water-resources management through construction of water-abstraction and storage systems for human water supply and for food production (First and Second water[67]); 2) cultivation of short-cycle varieties; 3) establishment of community-based seed and cereal banks; 4) adaptation of farm practices to conserve soil humidity, organic material and nutrients; and 5) conservation and restoration of agro-biodiversity.

[67] First water: water for drinking and cooking. Second water: water destined for agricultural production.

There follows a list of current guidelines of the National Food and Nutritional Security Policy that are of relevance for fostering of a more resilient environment in the context of this NAP:

Guideline 1: Strengthening of programmes for access to drinking-water and water for food production in the semiarid region

One of the most commonly used techniques for withstanding long dry periods and sporadic rainfall in the Brazilian semiarid region is rainfall-catchment and storage in cisterns. The Ministry of Social Development and Combating Hunger (MDS) has a Cisterns Programme that aims to ensure supplies of drinking water (First water) and water for crops and livestock (Second water) for homes and public schools in rural areas.

The right to water is encompassed within the human right to adequate food, and it is the responsibility of the State to ensure this right to all citizens, especially those in situations of socio-environmental vulnerability. Effective guarantee of this right requires coordination among a variety of inter-sectoral actions, in view of its interfaces with water-resources, basic-sanitation and,recently, with FNS policies. Lack of regular access, or precarious access to drinking water sources are part of day-to-day reality for hundreds of families, especially those in situations of extreme poverty, living in rural areas of Brazil. Climatic variations that curtail water availability, pollution of water sources, and poor access to water resources mar the quality of life of families. The very survival of many families is jeopardised because they cannot afford access to safe drinking water or to water for food production.

To face up to this situation, new socially and economically feasible approaches for promoting universal access to water supply have been gaining strength, based on extensive social mobilization and participation.

Issues relating to water supply for underprivileged segments of the population were the focus of the National Programme for Universalization of Access to and Use of Water (Water for All - Decree 7535, of 26th July 2011) under which the Federal Government assumed a commitment to universalise access to water for rural populations, especially those in situations of extreme poverty. For indigenous families and schools in the semiarid region, universalization of access to water is foreseen within the next four years (2016-2019).

The persistent problem of water vulnerability of rural families in the semiarid region has prompted mobilization of numerous civil-society organisations in Brazil's Northeast region, dedicated to defence of the rights of this population, including the right to water as an essential element for survival and for nutritional security. Prospects of more severe climatic conditions make the strengthening of such initiatives all the more important, with a view to increasing the resilience of populations in the semi-arid region and their capacity to withstand drought, by capturing sporadic rainfall in cisterns and better managing scarce water resources.

With respect to water for food production, EMBRAPA has been engaged in development of strategies for promoting drought resistance. In view of onsets of desertification, much of the semiarid region is likely to become unsuitable for cultivation of many of habitual crops, particularly cassava and corn. To contain the advance of desertification and, at the same time, provide dietary alternatives for the population and forrage for livestock, several researchers have advocated solutions based on endemic species. They propose to use knowledge of drought-resistant plants and to encourage their extensive cultivation. Several characteristic species of the semiarid region are much more efficient at maintaining a water balance, including certain native drought-resistant forage grasses that have greater resilience than exotic grasses.

Guideline 2: Reduction of poverty and vulnerability of rural social groups, by strengthening inclusive rural production policies

There are three public-policy focuses for attainment of this guideline: establishment of seed banks in the semiarid region; the Development Programme (*Programa Formento*), and the Green Stipend Programme (*Programa Bolsa Verde*).

To stimulate productive inclusion of family farmers of the semiarid region, the MDS has sponsored the building of 640 community seed banks. This initiative, carried out in partnership with the Ministry of Agrarian Development (MDA) and the Brazilian Development Bank (BNDES) will benefit at least 12,800 rural families listed on the Single Registry for Social Programmes of the Brazilian federal government (*Cadastro Único*).

The aim is to increase food production and ensure food and nutritional security for families that already have access to drinking water and water for food production under the Water for All (*Água para Todos*) Programme. These seed banks store landrace (unmodified) seeds that are well adapted to the region and regular components of local diets.

Furthermore, access to such seeds will empower family farmers and grant them greater autonomy with respect to decisions on when and what to plant. Seed banks are also expected to induce farmers and their families to pass on knowledge and share seeds, with a view to preserving regional genetic heritage of food varieties and stimulating other families to participate in the project.

A major attraction of the initiative is that it is based upon the experience of local farmers with native landrace seeds and provides an opportunity to foster and enhance knowledge on the genetic heritage of the Semiarid region.

Landrace seeds play an important role in renewing diversity of food-crop varieties and broadening the adaptive capacity of production systems. Thus, seed banks constitute an adaptive strategy that should be strengthened in the context of climate change.

The Development Programme (*Programa Formento*) is a part of the strategy for productive inclusion of family farmers, traditional peoples and communities, and indigenous peoples living in situations of extreme poverty. Under joint coordination of the MDS and MDA, the programme consists of two actions: provision of technical assistance and of rural extension services contracted by public tender[68]; and direct income-transfer stipends distributed to families under the *Bolsa Familia* programme. Both these actions aim to foster the productive capacities of poor rural families, preferably through agro-ecological approaches that reinforce and diversify their ability to produce food for their subsistence and/or for generating income.

The Environmental Conservation Support Programme (Green Stipend - *Bolsa Verde*) launched in September 2011, grants quarterly benefits of R$300 to families in situations of extreme poverty living in priority areas for environmental conservation. This benefit is granted for two years and may be renewed. Since 47% of the 16.2 million people in situations of extreme poverty live in rural areas, this programme serves the twin goals of raising incomes of this population segment, and stimulating conservation of ecosystems and sustainable use of natural resources.

---

[68] The initial goal in the 2012/2015 PPA was to attend to an estimated 9,000 indigenous families. This goal was exceeded and, by the end of 2015, is expected to extend to roughly 17,500 indigenous families.

Bolsa Verde is targeted at populations that conduct activities involving sustainable use of natural resources in Extractivist Reserves, National Forests, Federal Sustainable Development Reserves, and Environmentally Differentiated Agrarian Reform Settlements.

Traditional populations, including riparian, extractivist, indigenous, quilombolas and other rural communities are also eligible for benefits under the Programme, which seeks to acknowledge and compensate such communities and family farmers for environmental services provided. The *Bolsa Verde* Programme, by strengthening conservation of agro-biodiversity and contributing toward construction of a resilient agrarian system, is closely aligned to the Ecosystem-based Adaptation approach advocated in this National Adaptation Plan.

Guideline 3: Enhancement of Family-farming into agro-ecological, organic and socio-biodiversity based production systems

Launching of the National Agro-ecology and Organic Production Policy (PLANAPO) marks a commitment toward expanded implementation of guidance for sustainable rural-development approaches, in the light of rising awareness on the part of grass-roots rural and forest-dwelling organizations, and of the general public of the need for healthier food production and conservation of natural resources.

Among the advantages promoted by Brazilian organic agro-ecological farming are the biological diversity of production systems, diversification of farming activities and development of niche markets that attend to socioeconomic, environmental and cultural needs, and their ability to ensure large-scale food and nutritional security for the population. The knowledge of conservation and of sustainable-use practices of indigenous peoples and traditional populations is an important contribution to agro-biodiversity approaches.

The Inter-ministerial Chamber of Agroecology and Organic Production (CIAPO) in compliance with item I of Art. 9 of the National Policy for Agroecology and Organic Production (PLANAPO) and with ample public participation through the National Agro-ecology and Organic Production Committee (CNAPO) launched the National Agro-ecology and Organic Production Policy (PLANAPO 2013-2015) targeted at implementation of programmes and actions for fostering transition to a new form of agriculture based on organic and agro-ecological production methods. This policy aims to improve the quality of life of the population, both by ensuring supplies of healthy foods and fostering sustainable use of natural resources.

The aim of the National Plan for Promotion of Sociobiodiversity Products (PNBSB) is to promote and strengthen production chains for the products of socio-biodiversity, by adding value and consolidating sustainable markets[69]. This initiative is part of the federal government's strategy for promoting sustainable development while, at the same time, fostering income-generation activities and social justice, through conservation, management, and sustainable use of the products of socio-biodiversity and strengthening the social and productive capacities of indigenous peoples, *quilombolas,* traditional communities and family farmers.

Guideline 4: Strengthening of the implementation of the National Policy for Territorial and Environmental Management of Indigenous Lands

Decree 7747 of 5th June 2012, established the National Policy for Territorial and Environmental Management of Indigenous Lands (PNGATI). The purpose of this policy is to guarantee and promote the protection, recovery, conservation and sustainable-use of the natural resources of indigenous lands and territories, while ensuring the integrity of indigenous heritage, improving the quality of life and fully ensuring conditions for the physical and cultural reproduction of indigenous peoples, and respect for their sociocultural autonomy. A great number of strategic lines of actions for strengthening the food and nutritional security of indigenous people is provided for in the seven specific goals/axes[70] of the PNGATI, among them: 1) strengthening and promotion of indigenous productive initiatives, with support for use and development of new sustainable technologies; 2) continuous high-quality technical assistance, adapted to the particular needs of indigenous peoples; 3) certification of indigenous products and their marketing; 4) fostering of actions for environmental recovery and restoration of indigenous lands; and 5) recovery and conservation of agro-biodiversity and of other natural resources essential for the food and nutritional security of indigenous peoples, with a view to restoring and enhancing the value of traditional seeds and cultivars.

Indigenous peoples are among the groups potentially vulnerable to such impacts of climate change as droughts, prolonged dry seasons, flooding and forest fires that threaten their territories. Strengthening of environmental conservation measures and sustainable management of indigenous territories, as proposed in the PNGATI, will increase the capacity of indigenous peoples to face up to the adverse effects of climate change.

Guideline 5: Mainstreaming of the climate change theme in the National System for Food and Nutritional Security - SISAN

[69] Placing socio-biodiversity products on institutional markets (e.g.: PAA, PNAE, PGPM-Bio) is an important FNS promotion mechanism. It ensures fair prices for products, enabling shorter marketing cycles and stimulates revival of traditional foods at indigenous schools, thereby strengthening cultural identity.

[70] Namely: axis I: territorial protection and of natural resources; axis II: indigenous governance and participation; axis III: protected areas, conservation units and Indigenous lands; axis IV: prevention and recovery of environmental damage; axis V: sustainable use of natural resources and indigenous productive initiatives; axis VI: genetic property and intellectual heritage; axis VII: qualification, training, exchanges and environmental education.

Implementation of SISAN at the state and municipal levels is voluntary. State and municipal authorities assume responsibility for instituting CAISANs and CONSEAs and a commitment to drawing up FNS Plans. All of the states have subscribed to the SISAN and, so far, 12 have published their FNS Plans. Some such plans contain provisions for actions and programmes for addressing adaptation to climate change; however, the mainstreaming of a climate perspective needs to be strengthened at the sub-national levels, and risk management assimilated into periodic-review procedures.

Guideline 6: Expansion public food stockpiles and warehousing capacity

The number of grain silos and warehouses for food and forage needs to be increased, in order to expand Brazil's storage capacity. Expansion of such facilities is the focus of the National Plan for Storage 2013/2014 over the next five years. CONAB is to receive an allocation of R$500 million to build 10 new warehouses, thereby increasing its static storage capacity by 756,000 tonnes. Each year, R$ 5 billion is to be allocated for investments in storage, amounting to a total of R$ 25 billion by the end of the Plan. These measures are designed to increase Brazil's static storage capacity by 65 million tonnes over the next six years. Silos and warehouses enable more efficient use of favourable climatic conditions, by shortening planting and harvesting periods and providing storage for good harvests. The National Food and Nutritional Security Plan (PLANSAN) that came into effect in 2016, contains guidelines for monitoring with specific markers relating to adaptation to climate change.

10.7.3. Information gaps and research recommendations

Building of adaptive capacity in Brazil requires production of scientific knowledge on the vulnerabilities, risks and resilience of key sectors, including food and nutritional security.

For an assessment of FNS risks and vulnerabilities posed by climate change, this strategy used as a basis a study carried out in partnership by the MMA and Oxfam. Though merely a preliminary contribution, this study nonetheless provided a profile of potential impacts of climate change on the rural environment and, more specifically, on family farmers. For a broader and more integrated analysis of the impacts of global climate change and assessment of the progress of food and nutritional security measures, a series of scientific knowledge gaps need to be overcome. There follows a listing of such knowledge gaps, accompanied by research recommendations:

- Expand the number of studies and research that include the analyses of vulnerabilities, risks and impacts of climate change on FNS in Brazil. Most of the current studies focus only on climate change effects on agriculture, which are not the same as its effects on promotion of FNS.

- Expand the number of studies and research that include analyses of vulnerabilities, risks and impacts of climate change on the FNS of specific population segments, especially: extractivists, indigenous peoples, *quilombolas*, riparian communities and family farmers, taking territorial aspects into account.

- Expand knowledge on observed and future impacts of climate change on the survival strategies of Brazilian artisanal fishermen, riparian and costal populations. The MDS has already provided food assistance to a group of fishermen in Lagoa dos Patos (RS) in response to declining fish and shrimp yields, attributed to climatic effects. Fishing is of vital importance for the diet of various vulnerable populations, traditional communities and indigenous peoples.

- Promote and publicise debate and exchanges of information relating to adaptation initiatives focused on the semiarid region recommended by EMBRAPA and other institutions.

- Promote studies on the impacts of climate change on food supply in Brazil, with a focus on short-cycle systems, production close to consumption centres, and urban agriculture.

- Promote studies on the technological feasibility and expansion and/or refocusing of the Water For All (*Água para Todos*) programme, in the light of future climate scenarios produced by INPE.

- Promote studies on the farming systems of indigenous peoples and traditional communities and on their knowledge and practices, with a view to recovery, conservation and sustainable use of agro-biodiversity and stimulating intercultural and inter-science dialogue.

Filling of such knowledge gaps and promotion of actions for fostering adaptive capacity and resilience of the Brazilian food system will not only contribute toward enabling Brazil to cope with the adverse effects of climate change without compromising the FNS of families, but also foster: (1) reduction of agricultural GGEs; (2) expansion and strengthening of productive diversification and rural incomes of families; (3) recovery and conservation of agro-biodiversity; (4) reduced wastage of food; and (5) and, more generally, promote social well-being.

Strategy for Coastal Zones

National Adaptation Plan
to Climate Change

11 Strategy for Coastal Zones

11.1 Introduction

This strategy was drafted through a participative process by members of the NAP Coastal Zone Task Force[71], under coordination of the Ministry of Environment (MMA). The task force was integrated by a group of specialists, sought to secure a more complete understanding of the aspects of climate change (CC) that affect the Brazilian Coastal Zone (CZ), its vulnerabilities, and adaptation capacities.

The main objectives of this Chapter are to identify current exposure of the Brazilian coastal zone to climate change, including its main impacts and related vulnerabilities, and to propose guidelines and actions for fostering climate resilience.

It is structured around three main topics: 1) characterization of the Brazilian coastal zone and description of phenomena and impacts that affect it; 2) assessment of the vulnerabilities of the coastal zone in the various regions of Brazil, based on studies using current climate data and projected for the future, as well as monitoring systems and gaps in the historical data set; and 3) presentation of an adaptation strategy for the coastal zone, including guidelines for actions, an institutional framework for implementation, and synergies with other sectors.

Within the institutional framework of the National Coastal Zone Management Plan (PNGC) described in item 5.2 of this Chapter, the focal point for the coastal zone adaptation strategy is the Ministry of Environment.

11.2 Climate Change and the Brazilian Coastal Zone

11.2.1. Brazilian Coastal Zone

The Brazilian coastal zone is located in the inter-tropical and subtropical zones, extending from 4°30' north to 33°44' south, covering approximately 8,500 km and facing the Atlantic Ocean. It comprises a transition zone between the continent and the sea, where constant air-sea-land interaction takes place in a highly dynamic environment. On the land portion, municipal boundaries influence phenomena occurring in the coastal zone (Decree 5300/2004[72]) whereas the marine

[71] The Coastal Zone Task Force (p. 262) comprised of coastal experts and managers, was established in July 2012 within the context of the interministerial working group on adaptation for the purpose of producing technical inputs for drafting of the Coastal Zone profile for the NAP.

[72] Decree 5300/2004 Art. 4 - Municipalities encompassed by land stretches of the coastal zone: I – facing the sea, as defined in a list by the Brazilian Institute for Geography and Statistics - IBGE; II- not facing the sea, located in coastal metropolitan regions; III – not facing the sea, adjacent to capitals and major coastal cities that form conurbations; IV – not facing the sea, up to 50 kilometers from the coastline, the territories of which encompass activities or infrastructure of great environmental impact on the coastal zone or coastal ecosystems of high relevance; V - estuarine-lagoon, even if not directly facing the sea; VI – not facing the sea, but that have all municipal boundaries with municipalities referred to in items I to V; VII - separate from those already included in the coastal zone.

portion is bounded only by the limits of territorial waters (i.e., 12nm[73] or 22.2 km counted from the coastline[74]). The land area of the Brazilian coastal zone varies in width and currently encompasses 395 municipalities[75] distributed in the 17 coastal states, which account for 19% of Brazil's population (or roughly 45 million people) and sixteen coastal metropolitan regions (IBAMA, 2013), thus comprising a complex and dynamic territory in constant movement.

The coastal zone may suffer significant climate change impacts in view of concentrated settlement patterns, consolidated urbanisation, and other natural dynamics of the region. Foremost among the driving forces of change that affect coastal and marine ecosystems, are those associated with disasters and global warming and from atmospheric CO2 emissions (all of which increased during the 20th century). It is these characteristics that make it important that the coastal zone be assigned a specific profile in the context of this NAP.

11.2.2. Main phenomena, exposure and impacts

Knowledge of impacts of climate change on the coastal zone in Brazil is patchy and thin spread. The main conclusion of the Brazilian Panel on Climate Change (PBMC, 2014) with respect to impacts on the coastal zone was that there is a lack of information as to the effects of climate change on coastal ecosystems and relating to the vulnerability of such ecosystems. This lack of systematic knowledge on coastline dynamics and inaccuracies of information relating to altimetry[76] and bathymetry[77] currently pose the major difficulties for determining the natural vulnerabilities of this region and how they may be exacerbated by climate change (see item 11.3).

With the aim of fostering a better understanding of these processes and of contributing toward the goals of this NAP, and in view of the lack of data, the following table presents phenomena and exposure factors and their respective impacts that were identified as possible causes of vulnerability to climate change in Brazil (Table 17)[78] for consideration during definition of adaptation strategies.

---

[73] 1 nautical mile (nm) = 1.8 km

[74] Defined by Decree 8400, of 4th February 2015, which sets the geographic coordinates for its outline along the Brazilian coast. It consists of demarcation of the coastline, in accordance with the definitions of the United Nations Convention on the Law of the Sea, exclusively for setting limits of territorial waters, the contiguous zone, the exclusive economic zone and the continental shelf, in accordance with provisions of Law 8617, of 4th January 1993.

[75] Coastal municipalities may be more numerous, in view of the need to improve identification of municipalities 50 km from the coastline, taking into account criteria, activities or high-impact environmental infrastructures in coastal areas or coastal ecosystems of high relevance

[76] Altimetry: measurement of the relative height of terrain, expressed by contour lines and points on a map with heights expressed in metres, taking sea level as the baseline (level zero).

[77] Bathymetry: measurement of depths of oceans, lakes and rivers, expressed cartographically by bathymetric lines that connect points of equal depth with vertical equidistance (isobathymetric curves) similar to topographic contours.

[78] Adapted from a report of the Centre for Sustainability Studies from a consolidation of collaborative efforts of a workshop within the framework of the Coastal Zones network on the theme "coastal zones and adaptation" (Brazil, 2014) – available at <http://mma.gov.br/clima/grupoexecutivo-sobre-mudanca-do-clima/grupo-executivo-sobremudan%C3%A7as-clim%C3%A1ticas/item/9649>

Table 17. Phenomena/exposure and impacts of Climate Change on the Brazilian Coastal Zone

Phenomena/Exposure	Impacts
Sea-level rise and extreme events	Increased coastal erosion and flooding
	Landward intrusion of seawater in estuaries and aquifers
	Damage to Natural Resources and Biodiversity
Higher CO_2 concentrations	Ocean acidification

11.2.3. Sea -level rise and extreme events

A rise in sea level of a few millimetres per year is significant, because loss of land in low-lying areas can rapidly destroy coastal ecosystems, such as ponds, lagoons and mangroves. From a socioeconomic and environmental standpoint, besides flooding of environmentally relevant and sensitive areas, higher sea levels may cause changes of the energy balance in coastal environments, bringing about major variations in processes of sedimentation and, consequently, causing erosion along large swathes of coastline (CASTRO *et al.*, 2010).

The Brazilian Coastal Zone, and especially its more densely urbanised areas, is subject to extreme events such as heavy rainfall, increased risk of extra-tropical cyclones, alterations in wave behaviour, and changes in rainfall patterns that result in flooding.

The following section describes the main impacts of higher sea levels and extreme events.

11.2.3.1. Coastal erosion and flooding

It is currently hard to determine whether cases of erosion and progradation[79] of the Brazilian coastline result from anthropogenic activities or are symptoms of long-term trends associated with rising sea levels. This difficulty is primarily caused by lack of, or difficulty in accessing, long-term environmental monitoring data, for example, on behaviour of average sea levels, weather data on interactions of the ocean and coastal zone, direct information on wave heights, changes in coastal and proximal continental shelf morphology up to a depth of 50 meters (NEVES & MUEHE, 2008).

Generally speaking, erosion is a natural process that may be accelerated or attenuated by construction of man-made coastline artefacts associated with urbanisation. Erosion is considered an impact when it affects man-made structures on the coastline. Settlement in intertidal zones represents a failure to respect the dynamics of natural systems, leading to loss of beaches, infrastructures

[79] Progradation: a natural process of expansion of beaches, caused by deposits of sediment into the sea.

and constructed spaces (DIETER, 2006 and IPCC, 2012).

Planning of coastal settlements, owing to persistent information gaps, often fails to abide by existing guidelines relating to areas susceptible to erosion, as can be seen in *Projeto Orla*[80]. Failure to observe such guidelines can lead to a dense settlement of coastal areas, many of which are extremely fragile. Rarely is an evaluation carried out of the impacts of erosion on shoreline engineering works or of effects triggered by them. In certain cases, emergency works are performed without prior studies to assess their effectiveness, effects or possible consequences. Moreover, planning often fails to take into account, the links between hydrographic and coastal dynamics and allows alterations in authorised land use and water resources use within a water basin, without considering the consequences for sediment balances in this zone.

A large and vulnerable contingent of the population lives in areas susceptible to flooding in the coastal zone and, from a social-sensitivity standpoint, it is evident that this population is unprepared for emergencies associated with extreme events. Already, some impacts of such events have been identified as consequences of rising sea levels. Impairment of infrastructures and damage to seaside property (including, among others, ports, vessels, terminals, pipelines, and sanitation works) is sure to affect coastal populations, by spoiling the quality of sanitation and water-supply networks, damaging tourism, disrupting urban-mobility systems, and compromising their health and well-being. Flooding of coastal areas may also jeopardise cultural heritage by damaging archaeological and historical sites and monuments.

From an environmental standpoint, erosion of beaches, mangroves, sandbanks and dunes increases exposure of the natural coastal environment by removing its natural protection. Changes in flow levels and of sediment loads in estuarine regions may intensify silting or erosion, depending on the balance between such factors. More exposed coastal coral reefs and rocky cliffs tend to be eroded by the action of large waves and their destruction may compromise local environments by causing changes in flows of materials between the continent and the sea, damaging biodiversity.

11.2.3.2. Landward intrusion of seawater in estuaries and aquifers

In view of the interconnected characteristics of natural systems, a rise in sea level may alter the hydrodynamics of coastal estuarine and lagoon systems, causing seawater intrusion, characterized by greater levels of salt in local aquifers. Seawater intrusion, which tends to be aggravated by prolonged drought, may cause salinization of aquifers, lagoons and estuaries, leading to changes in these environments and, consequently, affecting plant and animal habitats.

[80] <http://www.mma.gov.br/estruturas/orla/_arquivos/11_04122008110506.pdf>

Changes in such ecosystems pose potential risks for human activities. The penetration of a salt wedge may affect the quality of water abstracted for domestic water supply, industrial production or agricultural irrigation, causing huge potential losses (CASTRO *et al*., 2010). Thus, water supply in coastal cities may be compromised, either by deterioration of water quality or by damage to physical sanitation structures. Moreover, increasing demand for drinking water may lead to groundwater overdraft which, in coastal areas, may lead to saltwater intrusion into the water table (for further information on climate change impacts on cities, see the Strategy for Cities).

Other impacts arising from seawater intrusion include changes in productivity and exploitation of resources associated with coastal ecosystems, such as gathering and cultivation of crustaceans and molluscs, and the possibility of new invasive species.

11.2.3.3. Compromising of natural resources and biodiversity

The Overview for Conservation of Coastal and Marine Ecosystems in Brazil (MMA, 2012) states that planning for conservation of coastal-zone and marine biodiversity has so far failed to ensure connectivity or to protect the diversity of Brazilian coastal and marine landscapes.

The conservation status of marine ecosystems is critical; only 1.57% of the 3.5 million square kilometres of sea under Brazilian jurisdiction is under protection of Conservation Units (CUs). The study recommends that, for coastal ecosystems, priority be given to ensuring effective management of protected areas. This would require deployment of management instruments on the coastal zone and in river basins so as to minimize negative impacts on the Marine Zone.

The effects of climate change on biodiversity in the coastal region are occurring against a background of lack of studies and inventories on biota and coastal habitats; fishing statistics, considering the reality of fish stocks[81] that are overexploited or at the limit of exploitation[82]. Dynamic interconnections among the components of the natural environment intensify the effects of synergistic impacts, weakening and reducing the resilience of ecological systems. Thus, the accumulated effects of on-going processes, such as intense urban settlement in the coastal area, increased frequency of tidal flooding, salinization, and habitat loss caused by erosion intensify sensitivities and compromise coastal ecosystems. The lack of programmes for monitoring the functional and structural components of natural systems aggravates this scenario.

Intense settlement in coastal areas may interfere with the natural processes of adaptation of mangrove and marsh ecosystems, which will tend to migrate toward the continent when threatened by changes in natural conditions. If such

---

[81] Overexploitation is excessive unsustainable exploitation, causing negative consequences which, earlier or later, will be detrimental to operators or third parties.

[82] Exploitation - Act or effect of economic exploitation of certain resources, usually natural resources.

migration zones are occupied by urban and industrial facilities, losses of such ecosystems will occur, compromising natural communities which depend upon them. Moreover, changes in the structure and functioning of coastal interconnected ecosystems may result in proliferation of invasive species, causing further alterations to coastal fauna and flora.

All these impacts on biodiversity cause progressive losses of productive capacity, with changes in productivity and availability of live resources for exploitation, causing social and economic consequences in certain regions, by compromising the incomes of families whose livelihoods depend upon fishing (see the Chapter on the Strategy for Biodiversity and Ecosystems in this NAP).

11.2.4. Higher CO_2 Concentrations

a. Ocean acidification

Increased concentrations of carbon dioxide (CO_2) in the atmosphere lead to greater absorption of this gas by the oceans, causing acidification. Acidification reduces the calcification capacity of certain species that are essential for the resilience of certain environments, such as coral reefs and rhodolith beds[83], causing instability of such ecosystems.

[83] The rhodolith beds (calciferous algae) form oasis of high biological diversity in sandy marine environments. Rhodoliths are bioconstructing species, which provide cover and substrate for many and abundant benthic communities. In Brazil, these environments are common and represent large carbonate ''factories'' that play an essential role in the South-Atlantic biogeochemical carbon cycle. These organisms and environments are threatened by climate change (mainly acidification of oceans and global warming) and by local stressors, such as impacts of fishing and coastal effluent discharges.

Most studies on the effects of climate change and of acidification of oceans on calcareous algae report negative effects, not only on growth and calcification, but also on photosynthesis, cell-wall thickness, reproduction and survival of algae. Such findings underscore the need to establish a consistent research network, including an extensive and long-term monitoring programme, equipped with the necessary infrastructure for experimental evaluation of local and regional climate change impacts (HORTA *et al*., 2015).

Among the sectors most affected by acidification of oceans are: fisheries, aquaculture, shellfish cultivation and gathering, biodiversity and tourism. Communities whose livelihoods depend upon gathering or exploitation of calciferous organisms (i.e. some varieties of shellfish, seaweed, corals, plankton and molluscs) are especially sensitive. Local sensitivity increases when combined with extreme weather events and anthropogenic factors such as: oil and gas exploitation, mining, coastal pollution, urbanisation, etc.

11.3 Vulnerability of the Brazilian Coastal Zone to Climate Change

In view of the impacts discussed, it is evident that the adaptation capacity of the Brazilian coastal zone is low; and that this is, primarily, a consequence of poor basic infrastructure associated with unplanned settlement. Among the factors that aggravate this scenario is lack of knowledge on current vulnerabilities of the coastal zone, owing to huge data gaps and a dearth of studies, monitoring and research, on both biotic and abiotic aspects, and on socioeconomic factors. In recent years, new policies and plans have been announced with the aim of improving efficiency and instituting integrated territorial management. Foremost among these is the National Coastal Management Plan (PNGC), to be presented in item 16.5.2.

Table 18[84] shows the degree of vulnerability to effects of climate change in different coastal areas of Brazil, based on forecasts of global climatic models and regional studies.

Table 18. Degree of Vulnerability of Coastal Zones to the effects of Climate Change in different regions of Brazil

Region	Degree of Vulnerability
North	The North region presents low vulnerability, except for areas adjacent to the three major cities: Macapá (AP), Belém (PA) and São Luis (MA) where vulnerability was classified as high or very high. Such degrees of vulnerability are due to physical (coastal dynamics and geomorphology), socioeconomic (average incomes, lack of basic services) and technological (type of industry, typology of pollution and representativeness in terms of number of employees) factors.
Northeast	The Northeast region, unlike the North region where only metropolitan regions present high degrees of vulnerability, displays alternation between the five levels of vulnerability that do not necessarily relate directly to population dynamics. Sea-level rise may create risk areas or unfit for maintenance of urban infrastructure in this region.
Southeast	For the Southeast region, higher degrees of risk are relate to potential flooding of low-lying coastal areas, with a higher population density than average for the region. Localities ranging from medium to very-high vulnerability are: Rio Doce, Grande Vitória region and inland drainage areas of the Paraiba do Sul basin. The Rio de Janeiro Metropolitan region presents a high degree of vulnerability as it possesses one of Brazil's largest petrochemical hubs, with an intricate network of refineries, natural-gas production units, pipelines, offshore exploitation fields and ports. Rio de Janeiro has the highest ratio of population exposed to climate change-risk to total population (78%), which amounts to 11,194,150 people of which, approximately 5 million live in the capital (MDZCM, 2008).
South	The South region, between the south of Santa Catarina and the border with Uruguay, displays a high degree of vulnerability, owing to a high incidence of extreme events, as was the case of the hurricane that hit Santa Catarina in 2004 and devastated the border region between Brazil's two southernmost states.

[84] Based on NICOLODI & PETERMANN, 2010.

These differing degrees of vulnerability make evident the need for a better understanding of climatic phenomena and for adaptation strategies that include territorial planning and policies. To guide such policies and optimize use of public resources, both monitoring and integrated management of the coastal region must be strengthened.

Under the worst-case scenario, of rising sea levels and frequent occurrence of extreme weather events, estimates of the value of assets at risk along the Brazilian coastline range from R$136 billion to R$207.5 billion (MARGULIS & SCHMIDT, 2010). Nonetheless, assessment of the liabilities and of the cost of responses to climate change in the coastal zones of Brazil remains uncertain, because so little is known about highly significant factors, such as wave generation, meteorological tides, and the terrain and morphology of the proximal continental shelf.

11.4 Data gaps and the promotion of adaptive capacity

The sensitivity of Brazil's coastal zones, its degree of exposure and its adaptive capacity may be determined by a variety of factors, ranging from structural-physical issues and lack of specific research data, to institutional hurdles for planning and management of coastal territories.

With respect to structural issues, it should be remembered that adaptation measures for climate change in Brazil's coastal zone are still incipient, in view of information gaps that frustrate efforts to quantify or estimate the scale of the vulnerabilities of coastal areas. Moreover, as mentioned earlier, many planning initiatives for development and settlement of waterfront areas remain flawed and fail to comply with current guidelines.

On the subject of the lack of specific data and research findings, various experts cite lack of updated (nautical, topographic and planimetric) cartographic resources, with standard geodetic references and unified vertical and horizontal datum[85] for the entire length of the Brazilian coastal zone, as being a major obstacle. Responsibility for bathymetric surveys of Brazil's coastal zone lies with the Brazilian Navy's Directorate for Hydrography and Navigation (DHN). Altimetric surveys are the responsibility of the Brazilian Institute of Geography and Statistics (IBGE) and of the Brazilian Army's 5th Division for Surveys (V-DL). However, such surveys do not share common (horizontal and vertical) geodesic references, i.e., level zero on one database does not correspond to the same baseline on the other databases. Such incompatibility among databases hampers analysis of sea level variations for identification of vulnerable areas of the coastal zone.

Still lacking is a standardised methodology for continuous and systematic oceanographic monitoring that would enable observation of pre and post-storm features of extreme rainfall events. There are no detailed

[85] Datum, in cartography, refers to the theoretical mathematical model representation of the Earth's surface at sea level used by cartographers on a certain chart or map.

surveys on an appropriate scale of areas subject to erosion or retrogradation[86], nor are there inventories of coastal settlement providing information on problems encountered and solutions applied. Although it is acknowledged that hydrological and geomorphological characteristics influence processes of erosion in the Brazilian coastal zone, lack of knowledge on coastal dynamics (winds, waves, tides and river systems) and the imprecision of available altimetric and bathymetric surveys make it impossible to distinguish between short, medium and long-term events.

It is, nonetheless, worth acknowledging the relevance of certain currently operating data-collection programmes and systems. Table 19 lists systems that could be strengthened and integrated to form a systemic network, with addition of new enhanced features, especially with respect to dissemination of information collected, and which could help address data-availability shortcomings and provide the necessary inputs for identification of the vulnerabilities of Brazil's coastal zones.

Table 19. Major data-collection systems on Brazil's coastal zone and oceans

GOOS: Global Ocean Observing System for collection, quality control, operational distribution of oceanographic data and oceanographic and climatological monitoring in the South Atlantic and Tropical zones.
GOOS-Brazil: This project is aimed at establishing a permanent strategic system for the provision of information on sea level and monitoring of global changes. This project is coordinated by the Hydrographic Centre of the Navy (CHM) in partnership with universities, port companies and IBGE. Data from oceanographic stations is available at: http://www.goosbrasil.org/gloss/dados2.php.
National Buoys Programme (PNBOIA): This programme is part of GOOS-Brazil and has a network of satellite-tracked drifting and moored buoys in the coastal region to provide real-time meteorological and oceanographic data to the scientific community and the Brazilian Marine Meteorological Service.
PIRATA - BRAZIL: Prediction and Research Moored Array in the Tropical Atlantic (PIRATA) is an in-situ observation network comprised of anchored buoys for monitoring a series of variables of ocean-atmosphere interaction processes in the Tropical Atlantic Ocean. The goal is to study ocean and atmosphere interactions that are relevant for understanding climate variations in the region. The coordinators of the PIRATA-BRAZIL programme are INPE and the Navy's Directorate for Hydrography and Navigation (DHN).

[86] Retrogradation – retreating of the coastline.

ReBentos: The Monitoring Network of Coastal Benthic Habitats aims to implement an integrated studies network of coastal benthic habitats off the Brazilian coast and detect the effects of global and regional environmental changes on these environments, starting a historical data series on benthic biodiversity along the Brazilian coast. Linked to the Coastal Zones Subnet of MCTI's Rede Clima and the National Institute for Science and Technology on Climate Change (INCT-MC), this network is divided in working groups for the following areas: Estuaries, Beaches, Submerged Vegetation Grounds, Coral Reefs and Cliffs, Mangroves and Marshes and Environmental Education.

SiMCosta: Approved by Ministry of Environment (MMA) in December 2011, the aim of the Monitoring System for the Brazilian Coast is to structure and maintain a network for monitoring of continuous flows of oceanographic and weather variables along the Brazilian coast. Initially, it will serve the States of São Paulo, Paraná, Santa Catarina and Rio Grande do Sul. Data obtained by the monitoring network will be used to: 1) Establish an early warning system for extreme events; 2) Predict processes linked to the effects of climate, such as El Nino/La Nina events; 3) Identify long-term trends; 4) Map vulnerabilities of coastal areas; 5) Predict impacts on physical, biotic and socioeconomic environments on the coastline; 6) Generate future scenarios; 7) Evaluate mitigation alternatives; 8) Provide reports for modelling and analysis of variables and on the status of coastal ecosystems; and 9) Expand national capacity to develop and administer oceanographic observation systems.

Brazilian Coastal Modelling System (SMC Brazil): Consists of a set of applications, databanks (bathymetry, waves and see levels) and structured numeric models according to the spatial and temporal scales of the various dynamics that affect the morphology of beaches. This numerical coastal-engineering tool enables technicians to prepare step-by-step studies, using work methodologies proposed in Thematic Documents. Through unification of technical criteria and systematic organization of numeric models, technicians aim to increase the quality of studies and, thereby, enhance reliability of their predictions.

To arrive at an accurate quantification of all climate-change vulnerabilities of the Brazilian coastal zone and to enhance the profile of the theme at the federal, state and local levels, mechanisms are needed to enable continuous monitoring, integrated research management and data collection.

11.5 Adaptation Strategy

11.5.1. Adaptation guidelines and actions

There is unquestionably an urgent need to adopt guidelines and actions for promoting adaptation in the Brazilian coastal zone. Though a number of localities in Brazil have begun to develop knowledge on the theme, such initiatives are hardly sufficient to serve as a basis for effective establishment of adaptation measures for addressing the observed impacts in the coastal zone.

Nonetheless, the expertise harnessed by the National Coastal Management Plan (PNGC)[87] has enabled building of an incipient national approach to adaptation in the coastal zone, based upon co-benefit criteria[88] and no-regrets[89] measures that take into account the systemic nature of adaptation for reducing vulnerability to climate change. In this context, Table 20 presents a set of guidelines and actions recommended for short, medium and long-term implementation of adaptation strategies in the Brazilian coastal zone. It should be stressed that, in some cases, these strategies are interdependent and that many of the guidelines and actions proposed combine planned coastal-management actions with those already underway.

[87] <http://www.mma.gov.br/destaques/item/8644-plano-nacional-de-gerenciamento-costeiro-pngc>

[88] Cobenefit: associated positive impacts.

[89] Definition in the glossary.

Table 20: Guidelines and actions for implementation of adaptation strategies in the Brazilian Coastal Zone

Impact: Erosion, Flooding and Extreme Events				
Guidelines and Actions	**Initiatives**	**Players**	**Expected outcomes**	**Period**
1. Plan-altimetric Mapping of the coastal zone	Define a single Datum for Brazil (prerequisite: a planimetric survey); Promote development of a planimetric (1:1000) and altimetric survey; Generate thematic maps of a preventive and corrective nature and make them available to society (risk areas, land-use and settlement); Establish a referenced planimetric system (SIRGAS 2000)	ANA, CPRM, DSG-Army, DZT-MMA, IBGE, INPE, INPH, INPOH, MD (Navy), MCid, MCTI, Municipalities, SAE-PR, Universities and Research Institutions	Altimetric Datum for the country set; Planimetric maps 1:1000 published (mostly coastal metropolises); Thematic maps of risk areas and land use published (mainly for coastal metropolises)	Short and Medium
2. Prepare a program for continuous and standardized data collection	Implement a geodetic network that meets topobathymetric survey needs; Expand and maintain a marigraphic network and wave monitoring network; Create, standardize and disseminate an oceanographic database (biotic and abiotic); Monitor biomass through satellite images; Encourage ReBentos to assess the impact of erosion on the benthic communities along the Brazilian coast;	ANTAQ, CONCAR, GIGERCO-MMA, IBGE, IEMAs, INMET, INPE, INPH, INPOH, MD (Navy), SECIRM, SEMAs, SEP-PR, SPU, MT	Database established; Densification of level references performed; Densification of maregraphic network/wave graphs performed; Data acquisition Protocol (waves, tides and topobathymetric); Continuous series of biological data established	Short
3. Integrate and operate monitoring information and data systems	Map, integrate and improve existing databases; Create protocols for integration of meteorological, rainfall climatological, fluviometric, geological, geomorphological and geotechnical databases. Create or designate a depository institution, coordinator of metocean data.	ANA, CEMADEN, CENAD, CPRM, Civil Defence, IBGE, INMET, INPE, MD (Navy), MCTI, MMA	National and geo-referenced system deployed and producing data for society	Long

Impact: Erosion, Flooding and Extreme Events				
Guidelines and Actions	**Initiatives**	**Players**	**Expected outcomes**	**Period**
5. Determine priority areas for intervention	Deploy an imaging system for monitoring port basins; Map areas at risk for flooding and erosion on a municipal scale; Draw up plans for identifying biologically and ecologically relevant areas; Support states in actions for identification and prioritization of intervention areas; Stimulate development and implementation of municipal plans for accommodation, protection, relocation and cushioning for erosion, flooding and urban expansion.	ANTAQ, CPRM, MCid, MI, MMA, SPU, States, Municipalities, Universities and Research Institutions	Local-scale flooding and erosion risk maps drawn up; Zoning of territorial planning areas concluded	Short and Medium
6. Establish contingency plans for the coastal zone	Include specificities of the Coastal Zone in disaster adaptation strategies; Promote guidelines for the Operational Coastal Areas Plan (considering degrees of emergency action – simple, medium and complex); Create an institutional framework (Monitoring and Evaluation Group; Support Committee); Draw up state and municipal-level plans	MMA, MD (Army, Navy, Air Force), MS, Secretariats and Agencies, Civil Defence, MI, MMA, MS, States, Municipalities	Contingency plan considering specificities of the coastal zone deployed and operational	Short

Table 20 (Continued): Guidelines and actions for implementation of adaptation strategies in the Brazilian Coastal Zone

Impact: Saltwater intrusion				
Guidelines and Actions	**Initiatives**	**Players**	**Expected outcomes**	**Period**
7. Improve integration between coastal Zone and river-basin management	Implement the PNRH IX programme, with a view to establishing guidelines for preparation of state water resources plans and plans for coastal basins; Identify lines of credit for development and deployment of plans for coastal basins; Ensure that drafting of plans includes public participation, especially of small farmers; Flow levels regularized; Preference for collective water-supply systems	Committee for Basins, Coastal Collegiate, Coastal Management Agency, Water Resources Management Agency	Guidelines for integration between coastal and river basins management established	Short and Medium
8. Generate knowledge for monitoring, diagnosis and forecasting of impacts and responses	Monitor the responses of natural systems to rises in sea levels (prerequisite: Action 1); Encourage and promote preparation of studies, inventories of biota and habitats, fishing statistics and scenario forecasts; Continuous training for coastal management professionals	CEPENE, CEPENOR, CEPSUL, CNPq, DHN, FAPs, FINEP, Fundacao CIDE, IBGE, INPH, MCTI, MMA, MPA, OMMAs, NGOs, Petrobras, Ports Network, SECIRM, SEMAs, Universities and research institutions	Monitoring sites encompassing different representative habitats along the coast established and supervised; Professionals trained	Short

Table 20 (Continued): Guidelines and actions for implementation of adaptation strategies in the Brazilian Coastal Zone

Impact: Compromising of natural resources and biodiversity				
Guidelines and Actions	**Initiatives**	**Players**	**Expected outcomes**	**Period**
9. Integrate public policies to enhance preventive and corrective actions	Develop Environmental Quality Reports on the coastal zone (RQA-ZC); Conduct scientific studies on recovery and protection of coastal ecosystems; Develop and execute plans for recovery and protection of coastal ecosystems; Integrate the National System of Conservation Units (SNUC) with coastal management instruments.	ANA, IBAMA, ICMBio, MMA, MPA, OMMAs, ONGs, SEMAs, SPU, Universities and research and technical-training institutions in other countries, civil society and legislatures (3 levels)	Comprehensive and periodic RQA-ZCs developed; Scientific studies carried out; UCs in coastal zone created and implemented, in accordance with coastal-management instruments	Short
10. Apply a climate lens on Coastal Management	Assimilate aspects relating to sea-level rises (SLR) into coastal-zone management and promotion instruments; Develop, implement or redesign land-use and settlement plans; Conduct coastal management taking into account coastal-ecosystem adaptation needs	ANA, IBAMA, ICMBio, CPRM, Civil Defence, DEMA, GIGERCO-MMA, IBGE, Legislative (3 spheres), MD (Navy), MCid, MI, MPA, OMMAs, SEMAS, SPU, coastal communities and civil society, municipalities, public and private funding agencies, Secretariat of Public Works, Secretariat of Urbanism, Universities	Processes/ instruments/ public-policies that effectively incorporate SLR aspects and impacts prepared; Land-use and settlement plans prepared, implemented and/or reconfigured, using information on SLR	Short and Medium

Table 20 (Continued): Guidelines and actions for implementation of adaptation strategies in the Brazilian Coastal Zone

Impact: Acidification				
Guidelines and Actions	**Initiatives**	**Players**	**Expected outcomes**	**Period**
11. Generate knowledge	Survey the current ocean acidification status (physical, chemical and biological); Award priority to specific areas; Establish an infrastructure network for monitoring carbon content of sediments and water, and biological parameters (performance of corals and algae, red tide blooms and health); Establish shared-use structures to meet demands generated by local and regional forecasting and monitoring; Create and maintain a database	INPE, INPH, INPOH, MCTI, MEC, MMA, MPA, NGOs, States, Municipalities, Universities	Monitoring and testing network established; Map of Brazilian coastal (environment and species) priorities drafted; Database established	Short
12. Promote conservation and management of carbon sinks	Macro-zoning of environmental carbon sequestration and carbon-sink ecosystems on the Brazilian coast (survey and data collection, if necessary); Select priority areas (geopolitical and biogeographic criteria); Promote consultation for preparation of a plan of action; Build appropriate institutional frameworks; Raise funds and implement the plan of action; Monitor the effectiveness of these actions; Evaluate the action plan and propose new actions	BrOA, ICMBio, INCTs, INPOH, MCTI, MDA, MDIC, MMA, MPA, NGOs, Municipalities, Universities	Map of priority areas drafted; Map of priorities drafted; Network for monitoring (biogeochemical) CO2 levels sequestered by the system established	Actions from 1 to 5: Short Actions from 6 to 7: Medium and Long

Bearing in mind the processes and efforts needed to prepare adaptation strategies for the Brazilian coastal zone, the following goals are proposed for the next four years:

Sectoral and Thematic Strategy: Coastal Zone

Objective 3. Identify and propose measures to promote adaptation to and reduction of climate risk

Goal 3.13	Initiatives	Responsible
Establish Reference Centres for Coastal Management and build and organise information and tools for climate-risk modelling and generation of qualified responses within the Coastal Zone.	Establishment of 4 Reference Centres for Coastal Management.	MMA
	Qualification and provision of instruments and tools for modelling and a knowledge-management platform for adaptation in the Coastal Zone.	
	Capacity-building for government and non-government players on deployment of adaptation activities.	
Indicator/Monitoring:	Number of Centres installed.	
	Number of managers trained.	
	Percentage of the knowledge-management system made available to the public.	
Impact:	Reference Centres established and working on models for analysis of the impacts of climate risks, for generation of qualified responses for public-policy management, and for government, civil-society and private-sector decision-making.	
	Foster coordination and cooperation among public bodies for management of climate risk.	
	Implement monitoring and evaluation of adaptation measures, with a view to continuous improvement of climate-risk management actions.	
	Promote and disseminate knowledge and include a climatic viewpoint into the methodology of the Waterfront Project (*Projeto Orla*) through enhancement of Ecosystems-based Adaptation actions.	

Objective 3. Identify and propose measures to promote adaptation to and reduction of climate risk	Sectoral and Thematic Strategy: Coastal Zone		
	Goal 3.14	**Initiatives**	**Responsible**
	Draft, deploy and earmark funding for a strategy to harmonise continental altimetry with marine bathymetry (AltBat).	Establish a work plan, with methodology, cost-assessment and pilot studies, to harmonize altimetry and bathymetry with measures and guidelines for prevention of the effects of erosion and flooding.	IBGE (CONCAR) and MMA
		Draw up a strategy, with short and medium-term actions, for deployment of a methodology and systems for harmonization of altimetry and bathymetry.	
		Preparation of standards for strategy implementation (structure for governance and budget).	
		Implementation of pilot projects in priority areas.	
	Indicator/Monitoring:	Percentage of the work plan completed.	
		Percentage of the strategy presented.	
		Pilot project signed (but not executed).	
		Draft of standards presented.	
	Impact:	Qualification of information for studies and projects in port, coastal, oil-producing, navigation and coastal-settlement areas.	
		Enable appraisal of insurance for works and projects in the Coastal Zone, where potential risk is assessed at R$136 billion.	

Objective 3. Identify and propose measures to promote adaptation to and reduction of climate risk	Sectoral and Thematic Strategy: Coastal Zone		
	Goal 3.15	**Initiatives**	**Responsible**
	Macro-diagnosis of the Coastal Zone (Macro-ZC) reviewed, considering climate-change related vulnerabilities.	Database for review of the Macro-diagnosis of the Coastal Zone organized from the standpoint of environmental, economic, social and cultural integration.	MMA
		Term of Reference for the review of the Macro-diagnosis of the Coastal Zone drafted and validated by a group of experts (researchers and coastal managers).	
		Macro-ZC review published and distributed; and managers, researchers and civil-society trained.	
	Indicator/Monitoring:	Percentage of the work plan completed.	
		Publication drafted and distributed.	
		Number of managers, researchers and civil-society staff trained.	
	Impact:	Provision of inputs for Coastal Zone managers at different levels, and guidance for public and sectoral policies and for intervention actions in support of adaptation to climate change.	

In addition to these guidelines, actions and goals, studies should be carried out on coastal metropolitan regions, encompassing interrelated socioeconomic, environmental and infrastructure aspects (urban development, sanitation, transport, etc.) from a climate perspective. Observations should be based upon essential measurable and replicable variables, in accordance with the model presented in the Integrated System for Monitoring and Sustained Observation of Oceans shown in Figure 19. Prioritization of a systematic and continuous monitoring will thus be strengthened by activities carried out under this NAP. There is also a need to advance with studies that examine links between the diversity of Brazilian coastal and marine landscapes and their ecosystem functions.

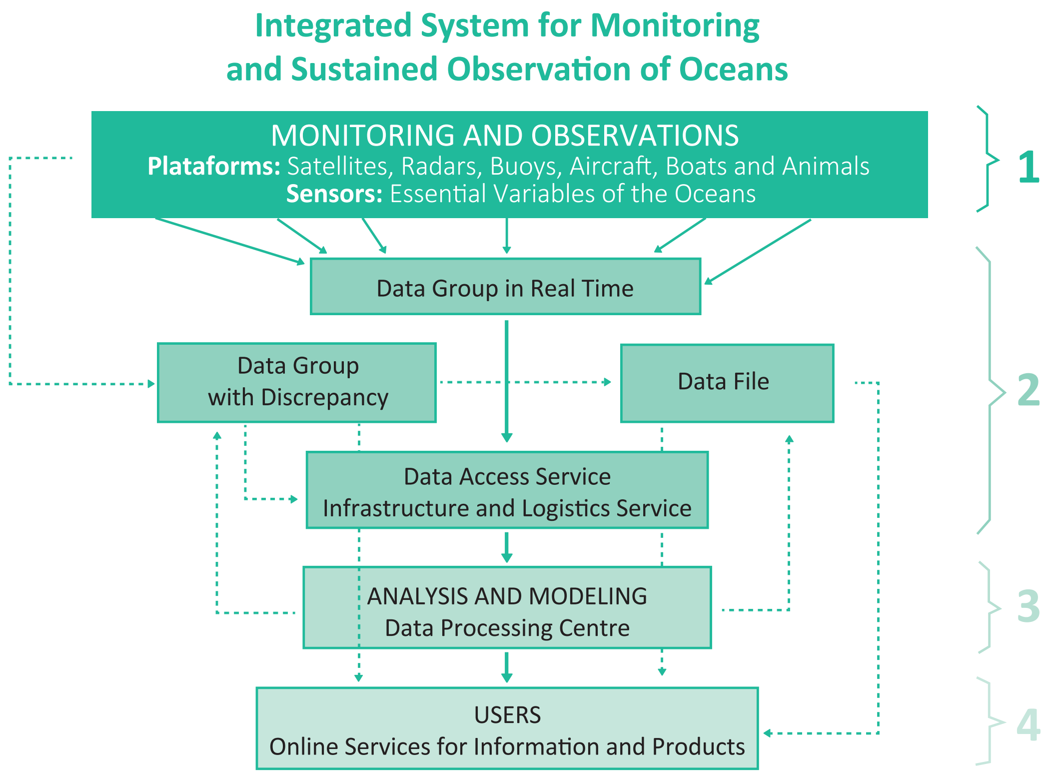


Figure 19- Integrated System for Monitoring and Sustained Observation of Oceans System for Monitoring and Observation of the Oceans

There is a need to promote Ecosystem-based Adaptation (EbA) measures, whereby ecosystem services and biodiversity form part of a broader local, regional, national and global adaptation strategy for assisting people and communities to adapt to the negative effects of climate change. (TRAVERS *et al.*, 2012). Healthy environments play an important role in protecting infrastructure and increasing human safety, acting as natural buffers that mitigate the impacts of extreme events. Along the coast, wetlands, tidal flats, deltas and estuaries serve to temper the effects of flooding. Coral reefs, dunes, sand bars, mangroves and mudflats reduce wave heights and abate erosion caused by storms and high tides, while protecting against intrusion of salt water, sediments and organic matter. These ecosystems also play an acknowledged role in supporting an abundant diversity of flora and fauna. In addition to assisting with adaptation to climate change, coastal-ecosystems management of mangroves, salt marshes and kelp forests can contribute to climate-change mitigation by reducing emissions and increasing carbon sequestration. (For more on this topic, see the Strategy on Biodiversity and Ecosystems).

11.5.2. Institutional framework for an Adaptation Strategy

The MMA is responsible for federal-level coordination of the National Coastal Management Plan (PNGC) and counts on support of the Coastal Management Integration Group (GI-GERCO) within the framework of the Inter-ministerial Committee for Marine Resources (CIRM). The management group was formed specifically for the purpose of collaborating with the MMA in fostering and coordinating federal actions relating to the Coastal Zone, including structuring of Federal Action Plans. Implementation of the PNGC will require alignment of efforts on the part of the 17 coastal states and almost 400 municipalities, and will require strong coordination on the part of the MMA to ensure deployment of the adaptation strategy for the coastal zone.

The PNGC provides instruments for addressing significant climate-change issues, including such measures as the Integrated Waterfront Management Plan, the Macro-diagnosis of the Coastal Zone, and Ecological and Economic Zoning of the Coastal Zone. Another potential strategy entails a networking approach to coastal management which, reflecting Brazil's federative structure, is presided by a federal coordination unit that maintains close links with state and municipal-level coastal-management committees of the *Projeto Orla*. This waterfront project adopts a local-level environmental and urban-planning shared-management approach that takes into account regulations and standards for waterfront management of lands under jurisdiction of the Navy. Among the outstanding adaptation issues addressed by *Projeto Orla* are rising sea levels and coastal erosion that may require management, or even removal of communities from sensitive waterfront areas.

11.5.3. Synergies with other sectors

Adaptation to climate change requires approaches that view the environment from a synergistic and integrated-planning standpoint that address all direct and indirect influences and fosters adaptive capacities in the broadest sense.

The territorial nature of this strategy for the coastal zone requires close collaboration on crosscutting themes addressed by the other sectors that have contributed toward this NAP. Synergies among these sectors underscore the need for integrated approaches to deployment of sectoral policies for adaptation to climate change. To this end, it is recommended that dialogue be maintained among managers involved in the many sectoral actions that affect the coastal zone, with a view to fostering delegation of functions and ensuring compatibility of management efforts at the local, regional and federal levels. Listed below are a few examples that illustrate how impact on one sector can affect activities of other sectors: 1) agriculture may be affected by seawater intrusion thus compromising the quality of water resources, thereby jeopardising food security; 2) lack of water of adequate quality affects health, thus compromising biodiversity and the sustainability of ecosystems and undermining the adaptive capacity of highly sensitive populations, such as artisanal fishermen, gatherers and extractivists; and 3) coastal erosion may compromise port infrastructures and damage industrial equipment and buildings (and even towns) in the path of advancing sand-dune formations, causing a need for substantial public investment in structural risk-management and disaster-prevention actions.

Such causal chains underscore the need for crosscutting and integrated management among federal line ministries, state and municipal bodies and civil-society organisations, for addressing issues raised by the need to adopt climate-change adaptation measures in the coastal zone.

11.6 Final considerations

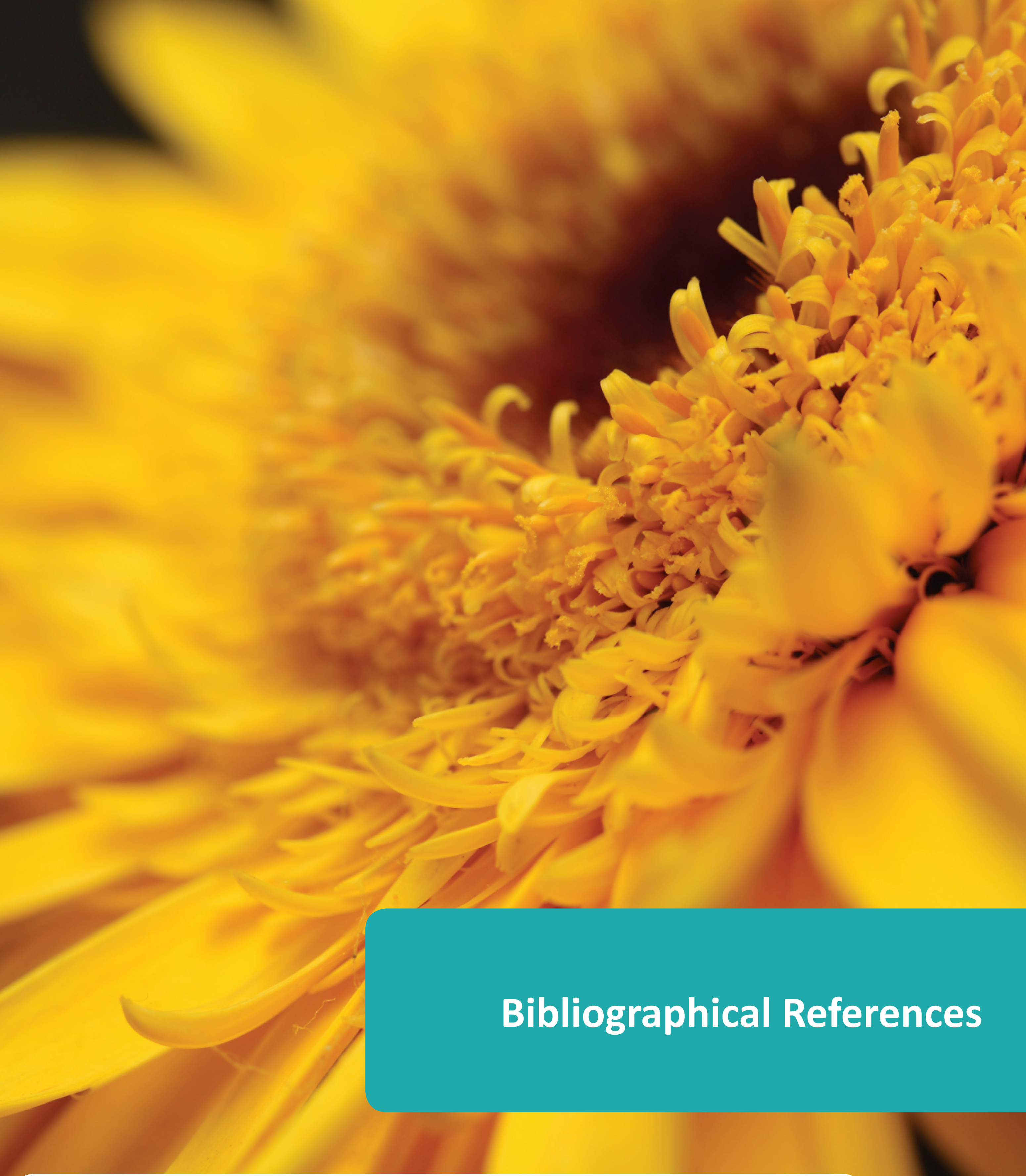
Knowledge gaps, and their implications for the various sectors that have contributed toward preparation of this NAP, pose the main difficulties for assessment of the vulnerabilities of Brazil's coastal zone to threats posed by climate change. Only by pursuing actions targeted at filling such gaps will it be possible to prepare diagnoses of vulnerabilities of the sea-land interface in Brazilian coastal areas. It must be emphasized that such actions constitute no-regrets measures, and that it is imperative that they be adopted immediately, in parallel with other prevention measures.

The proposed strategy for the coastal zone aims to establish a framework within which measures for its implementation will require coordinated efforts on the part of governmental bodies at different levels, the productive sector, and organised civil society. The strategy also aims to strengthen coastal-zone management actions by introducing a crosscutting climate perspective in all aspects of its implementation and when enlisting public support and participation, with a view to promoting local resilience, preventing disasters, and preparing adequate responses to challenges posed by the need to adapt to the effects of Climate Change.

Coordination: Ministry of Environment	***Karen Silverwood-Cope*** Director of Licensing and Environmental Evaluation of the Secretariat of Climate Change and Environmental Quality (SMCQ) ***Pedro Christ*** Deputy Director of Licensing and Environmental Evaluation of the Secretariat of Climate Change and Environmental Quality (SMCQ) ***Adalbert Eberhard*** Director of the Department of Territorial Zoning (DZT) ***Marcia Oliveira*** Manager of Coastal Management
Authors	Marcia Oliveira- MMA Flavia Cabral Pereira- MMA Adriana Brito da Silva- MMA Angelita Coelho- MMA Nathan Debortoli- Consultant

Collaborators in the Coastal Zone Task Force

Collaborators	Institution	Collaborators	Institution
Adalbert Eberhard	MMA/SRHU	Leila Menezes	SAE/PR
Adelias Bastos	MMA/DZT	Leila Swerts	MMA/DZT
Alessandro Ramalho	ANTAQ	Lidriana de Souza Pinheiro	UFC
Alexander Turra	USP	Luis Fernando Magnani	MPOG/SPI
Ana Paula Prates	SAE/PR	Marcos Maia Porto	ANTAQ
Ana Secchi	MF/SPE	Maria Cristina B. Lobianco	IBGE
Andrei Polejack	MCTI	Maria Luiza Almeida Gusmao	ANTAQ
Antonio Edson Farias	MME/SPG	Mariana Egler	MMA/SMCQ
Antonio Klein	UFSC	Mario Luiz Gomes Soares	UERJ
Bruno Eustaquio de Carvalho	SAE/PR	Nivia Regis di Maio Pereira	UERJ
Carlos Caruso	UFBA	Paula Benatti	CNI
Carlos Garcia	FURG	Paulo Gusmao	UFRJ
Christina ElizEbAth Paes de Vasconcelos	MME/SPG	Paulo Horta	UFSC
Claudio Neves	COPPE/UFRJ	Paulo Rosman	COPPE/UFRJ
Claudio Egler	UERJ	Pedro Pereira	UFPE
Dieter Muehe	UFRJ	Percy Soares Neto	CNI
Eduardo Nobre	MDIC	Roberto Luz	IBGE
Flavia Cabral Pereira	MMA/DZT	Salomao Soares	IBGE
Gustavo Luedemann	MCTI/SEPED	Salomar Mafaldo Junior	MMA/DZT
Helenice Vital	UFRN	Simone Vendruscolo	ANA
Helvio Polito	SEMA/PE	Teresa Cristina Cavalcante Soares	Navy of Brazil
Joao Nicolodi	FURG	Venerando Amaro	UFRN
Jose H Muelbert	FURG	Wilson Cabral de Sousa Jr	ITA
Jose Maria Landim Dominguez	UFRGS	Yvens Ely Martins Cordeiro	SEMA/PA



Bibliographical References

National Adaptation Plan
to Climate Change

Bibliographical References

Strategy for Agriculture

Assad, E. et al., (2013) Impactos das Mudanças Climáticas na Produção Agrícola Brasileira. Banco Mundial.

Beddington J, et al., (2012). Achieving food security in the face of climate change: Final Report from the Commission on Sustainable Agriculture and Climate Change. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.

Beilin, R.; Sysak, T. & Hill,S. (2012). Farmers and perverse outcomes: the quest for food and energy security, emissions reductions and climate adaptation. Global Environmental Change 22, p. 463-471.

Brasil (2012). Plano setorial de mitigação e de adaptação às mudanças climáticas para a consolidação de uma economia de baixa emissão de carbono na agricultura: plano ABC (Agricultura de Baixa Emissão de Carbono) / Ministério da Agricultura, Pecuária e Abastecimento, Ministério do Desenvolvimento Agrário, coordenação da Casa Civil da Presidência da República. Brasília: MAPA/ACS

BRASIL (2015). Brasil 2040 – Resumo Executivo – Secretaria de Assuntos Estratégicos/Presidência da República, 172 p.

Brasil (2015b). Plano Nacional de Exportações 2015-2018. MDIC/Governo Federal

Centro de Estudos em Sustentabilidade (GVces) (2014) Produto 2.0.1: diagnóstico preliminar das principais informações sobre projeções climáticas e socioeconômicas, impactos e vulnerabilidades disponíveis em trabalhos e projetos dos atores mapeados (relatório de consultoria MMA).

Deconto, J.G (coord) (2008). Aquecimento global e a nova geografia da produção agrícola no Brasil. Embrapa/Unicamp. https://www.agritempo.gov.br/climaeagricultura/download.html

FAO (2012). The State of Food and Agriculture. Food and Agriculture Organization of the United Nations. Rome.

Foresight. The Future of Food and Farming (2011). Final Project Report. The Government Office for Science. London.

Ghini, R.; Hamada, E. & Bettiol, W (eds.) (2011). Impactos das mudanças climáticas sobre doenças de importantes culturas no Brasil. Jaguariúna: Embrapa Meio Ambiente, 356 p.

Hoffmann, U. (2011). Assuring food security in developing countries under the challenges of climate change: key trade and development issues of a fundamental transformation of agriculture. UNCTAD/OSG/DP/2011/1

Ignaciuk, A. and D. Mason-D'Croz (2014). "Modelling Adaptation to

Climate Change in Agriculture", OECD Food, Agriculture and Fisheries Papers, Nº 70, OECD Publishing. http://dx.doi.org/10.1787/5jxrclljnbxq-en

IPCC (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability. Summaries, Frequently Asked Questions, and Cross-Chapter Boxes. A Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken,P.R. Mastrandrea, and L.L. White (eds.)]. World Meteorological Organization, Geneva, Switzerland, 190 p.

Marques, A.C.; Silva, J.C.B.V.; Hanisch, A.L. (2013). Mudanças Climáticas: impactos, riscos e vulnerabilidades na agricultura. Revistas de Estudos Vale do Iguaçu, Jan/Jun 2013, v. 1, nº 21, p.93-116.

Moorhead, A. (2009). Climate, agriculture and food security: A strategy for change. Alliance of the CGIAR Centers.

Nakai, A.M, et al., (LMA/CNPTIA; Embrapa) (2015). Análise de vulnerabilidades econômicas das principais culturas brasileiras (produto 6). Relatório Final Adaptação à Mudança do Clima: Cenários e Alternativas – Agricultura (Projeto Brasil 2040 SAE/PR).

Vermeulen, Sonja J. et al., (2013). Addressing uncertainty in adaptation planning for agriculture PNAS | May 21, 2013 | vol. 110 | nº. 21 | 8357–8362

Strategy for Biodiversity and Ecosystems

ALEIXO, A. et al., (2010) Mudanças climáticas e a biodiversidade dos biomas brasileiros: passado, presente e futuro. Natureza & Conservação, v. 8, n. 2, p. 194–196. Acesso em: 20/09/2014.

BEAUMONT, L. J. et al., (2015). Impacts of climate change on the world's most exceptional ecoregions. Proceedings of the National Academy of Sciences, v. 108, n. 6, p. 2306–2311. Acesso em: Acesso em: 2/03/2015.

BEGON, M.; TOWNSEND, C. R.; HARPER, J. L. (2006). Ecology: from individuals to ecosystems. Blakwell Publishing, Oxford.

BEISIEGEL, B. DE M. (2009). Inventário e diagnóstico da mastofauna terrestre e semi-aquática de médio e grande portes da Estação Ecológica da Terra do Meio e do Parque Nacional da Serra do Pardo, PA. Relatório de Pesquisa. Atibaia (SP): Centro Nacional de Pesquisas e Conservação dos Mamíferos Carnívoros - Instituto Chico Mendes de Conservação da Biodiversidade, 2009.

BRASIL, 2011. Ministério do Meio Ambiente. Quarto Relatório Nacional para a Convenção sobre Diversidade Biológica. Série Biodiversidade nº 38.

BRASIL, 2006. Ministério do Meio Ambiente. Lewinsohn, T., Coordenador. Avaliação do Estado do Conhecimento da Biodiversidade Brasileira, V. 1 e 2. Série Biodiversidade nº 15.

BRASIL/MMA (1992). Convenção sobre Diversidade Biológica - CDB/Cópia do Decreto Legislativo nº. 2, de 5 de junho de 1992. Brasília (DF): Ministério do Meio Ambiente.

CLOSEL, M. B.; KOHLSDORF, T. (2012). Mudanças climáticas e fossorialidade: implicações para a herpetofauna subterrânea. Revista da Biologia, v. 8, p. 19–24, 2012. Acesso em: Acesso em: 22/02/2015.

FUNDAÇÃO GRUPO BOTICÁRIO (2015). Adaptação Baseada em Ecossistemas: Oportunidades para políticas públicas em mudanças climáticas. Curitiba, PR.

HARLEY, C. D. (2011). Climate change, keystone predation, and biodiversity loss. Science, v. 334, no 6059, p. 1124–1127. Acesso em: 24/02/2015.

HILLERISLAMBERS, J. et al., (2013). How will biotic interactions influence climate change-induced range shifts? Annals of the New York Academy of Sciences, v. 1297, nº 1, p. 112–125. Acesso em: 23/02/2015.

IPCC. Summary for Policymakers. In: FIELD, C. B. et al., (Org.). (2014). Climate change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK e New York, NY: Cambridge University Press. p. 1–32.

IPCC (2007). Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Parry, M.L.; Canziani, O.F.; Palutikof, J.P.; van der Linden, P.J.; Hanson, C.E. (eds.) Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC (2001). Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. McCarthy, J. J.; Canziani, O. F.; Leary , N. A.; Dokken D. J; White K. S. (eds.)

LEÃO, Z.; KIKUCHI, R. K. P. DE; OLIVEIRA, M. DE D. M. DE. (2008a). Branqueamento de corais nos recifes da Bahia e sua relação com eventos de anomalias térmicas nas águas superficiais do oceano. Biota Neotropica, v. 8, n. 3, p. 69–82. Acesso em: 13/03/2015.

LEÃO, Z. M. A. N.; KIKUCHI, R. K. P. DE; OLIVEIRA, M. DE D. M. DE. Coral bleaching in Bahia reefs and its relation with sea surface temperature anomalies. Biota Neotropica, v. 8, n. 3, p. 0–0. Acesso em: 13/03/2015.

MARENGO, J. (2007) Mudanças climáticas globais e seus efeitos sobre a biodiversidade: caracterização do clima atual e definição das alterações climáticas para o território brasileiro ao longo do século XXI. Brasília (DF): Ministério do Meio Ambiente.

MARINI, M. Â.; BARBET-MASSIN, M.; LOPES, L. E. et al., (2010a). Predicting the occurrence of rare Brazilian birds with species distribution models. Journal of Ornithology, v. 151, n. 4, p. 857–866. Acesso em: 24/02/2015.

MARINI, M. Â.; BARBET-MASSIN, M.; MARTINEZ, J. et al., (2010b). Applying ecological niche modelling to plan conservation actions for the Red-spectacled Amazon (Amazona pretrei). Biological Conservation, v. 143, no 1, p. 102–112. Acesso em: 2/02/2015.

MARINI, M. Â. et al., (2009a). Major current and future gaps of Brazilian reserves to protect Neotropical savanna birds. Biological Conservation, v. 142, nº 12, p. 3039–3050. Acesso em: 2/02/2015.

MARINI, M. Â. et al., (2009b). Predicted Climate-Driven Bird Distribution Changes and Forecasted Conservation Conflicts in a Neotropical Savanna. Conservation Biology, v. 23, nº 6, p. 1558–1567. Acesso em: 24/02/2015.

MEA (2005). Millenium Ecosystem Assessment. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. 2005

PARMENSAN, C. (2006). Ecological and Evolutionary Responses to Recent Climate Change. Annual Review of Ecology, Evolution, and Systematics, v. 37, no 1, p. 637–669. Acesso em: 21/02/2015.

Painel Brasileiro de Mudanças Climáticas (PBMC) (2013). Contribuição do Grupo de Trabalho 2 ao Primeiro Relatório de Avaliação Nacional do Painel Brasileiro de Mudanças Climáticas. Sumário Executivo do GT2. PBMC, Rio de Janeiro, Brasil. 28 p. ISBN: 978-85-285-0208-4.

SILVA BEZERRA, D. DA; AMARAL, S.; KAMPEL, M. Impactos da elevação do nível médio do mar sobre o ecossistema manguezal: a contribuição do sensoriamento remoto e modelos computacionais. Ciência e Natura, v. 35, nº 2, p. 152–162. Acesso em: 22/02/2015.

SHELDON, K. S.; YANG, S.; TEWKSBURY, J. J. (2011). Climate change and community disassembly: impacts of warming on tropical and temperate montane community structure. Ecology Letters, v. 14, nº 12, p. 1191–1200. Acesso em: Acesso em: 23/02/2015.

VALE, M. M.; ALVES, M. A. S.; LORINI, M. L. (2009). Mudanças Climáticas: desafios e oportunidades para a conservação da biodiversidade brasileira. Oecologia Australis, v. 13, nº 3, p. 518–534. Acesso em: 22/02/2015.

VIEIRA, T. B.; MENDES, P.; OPREA, M. (2012). Priority areas for bat conservation in the state of Espírito Santo, southeastern Brazil. Neotropical Biology and Conservation, v. 7, nº 2, p. 88–96. Acesso em: 22/02/2015.

Strategy for Cities

BAPTISTA, M. E N. NASCIMENTO, (2002). Aspectos institucionais e de financiamento dos sistemas de drenagem urbana. Revista Brasileira de Recursos Hídricos, 7 (1), 29-49.

BERTONI, J.C. (2006). Urban floods in Latin America: reflections on the role of risk factors. In: TCHIGUIRINSKAIA, I; 2 THEIN KNN., HUBERT P (eds.). Frontiers in Flood Research, IAHS PUBLICATION, 305, 123-141.

BRASIL. Lei no. 10.257, de 10 de julho de 2001 (Estatuto da Cidade). Regulamenta os arts. 182 e 183 da Constituição Federal, estabelece diretrizes 8 gerais da política urbana e dá outras providências. Disponível em: http://www.planalto.gov.br/ccivil_03/leis/leis_2001/l10257.htm Acesso em: março de 2015.

BRASIL. Lei no 13.089, de 12 de Janeiro de 2015 (Estatuto da Metrópole). Institui o Estatuto da Metrópole, altera a Lei no 10.257, de 10 de julho de 2001, e dá outras providências. Disponível em: http://www.planalto.gov.br/ccivil_03/_Ato2015-2018/2015/Lei/L13089.htm Acesso em: abril de 2015.

CCST/INPE E NEPO/UNICAMP. Vulnerabilidades das megacidades brasileiras às mudanças climáticas. São Paulo, p. 185. 2011.

COLTEN, C.E., 2006: Vulnerability and place: Flat land and uneven risk in New Orleans. American Anthropologist, 31 108 (4), 731-734

DAEE, 2009: Plano Diretor de Macrodrenagem da Bacia do Alto Tietê. Departamento de Águas e Energia Elétrica (DAEE) do Governo de São Paulo, São Paulo, SP.

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE – IPCC. 2012: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX). A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 p.

NASCIMENTO, N. et al., 2006: Long term uncertainties and potential risks to urban waters in Belo Horizonte. SWITCH Project. First SWITCH Scientific Meeting, University of Birmingham, UK, 9-10 Jan 2006.

MARENGO, J.A., 2009: Impactos de extremos relacionados com o tempo e o clima – Impactos sociais e econômicos. Instituto Nacional de Pesquisas Espaciais, Centro de Ciências do Sistema Terrestre, São Paulo, Brasil. Boletim do Grupo de Pesquisa em Mudanças Climáticas (GPMC), 8(Edição especial), 1-5.

MINISTÉRIO DAS CIDADES; ALIANÇA DAS CIDADES (2010) - O Estatuto da Cidade : comentado. Organizadores Celso Santos Carvalho, Ana Claudia Rossbach. – São Paulo. 120 p.

MINISTÉRIO DAS CIDADES (2011) - Os planos diretores municipais pós-estatudo da cidade: balanço crítico e perspectivas / Orlando Alves dos Santos Junior, Daniel Todtmann Montandon (orgs.). – Rio de Janeiro: Letra Capital: Observatório das Cidades: IPPUR/UFRJ.

Montandon (orgs.). – Rio de Janeiro: Letra Capital: Observatório das Cidades: IPPUR/UFRJ.

Nathan, F., 2008: Risk perception, risk management and vulnerability to landslides in the hill slopes in the city of 39 La Paz, Bolivia. Disasters, 32 (3), 337-35

PAINEL BRASILEIRO DE MUDANÇAS CLIMÁTICAS (PBMC) – PBMC, 2014: Base científica das mudanças climáticas. Contribuição do Grupo de Trabalho 1 do Painel Brasileiro de Mudanças Climáticas ao Primeiro Relatório da Avaliação Nacional sobre Mudanças Climáticas [Ambrizzi, T., Araujo, M. (eds.)]. COPPE. Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brasil, 464 p. ISBN: 978-85-285-0207-7

PMSP, 1999a: Atlas ambiental da cidade de São Paulo. Prefeitura do Município de São Paulo, Secretaria Municipal do Verde e do Meio Ambiente (SVMA) e Secretaria Municipal de Planejamento Urbano (Sempla). Revisado em 2000. Disponível em http://atlasambiental.prefeitura.sp.gov.br/?id=1.

SATTERTHWAITE, D. Climate change and urbanization: effects and implications for urban governance. New York: United Nations Expert Group Meeting on Population Distribution, Urbanization, Internal Migration and Development, UN/POP/EGMURB/2008/16, 2008.

OLIVEIRA, Nathan Belcavello de; MOREIRA, Fabiana Borges da Silva. Da elaboração participativa à gestão democrática: considerações sobre a implementação do plano diretor municipal. In: CONGRESSO BRASILEIRO DE DIREITO URBANÍSTICO, 4., 2006, São Paulo. Anais do VI Congresso Brasileiro de Direito Urbanístico. São Paulo: IBDU, 2006. 1 CD-ROM. Disponível em: <www.ibdu.org.br/> Acesso em: abr. 2015.

UN-HABITAT (2003), The Challenge of Slums. Global report on human settlements 2003, Earthscan, London.

UTZINGER J, KEISER J (2006) Urbanization and tropical health–then and now. Ann Trop Med Parasitol 100: 517–533.

WORLD BANK. 2009. Can adapting to climate change also meet development goals in cities in developing countries?. CIVIS notes series; CIVIS series for sharing knowledge and learning from cities ; no. 2. Washington DC : World Bank

ZAHRAN S., S.D. Brody, W.G. Peacock, A. Vedlitz, and H. Grover, 2008: Social vulnerability and the natural and 30 built environment: a model of flood casualties in Texas. Disasters, 32 (4), 537-560

XIAOPEI, Y. et al., 2006: Urbanization research in China: many opportunities and challenges. IHDP Update. International Human Dimensions Programme on Global Enviromental Change (IHDP), Bonn, Germany

Strategy for Risks and Disasters Management

ANA – Projeto de Integração do Rio Sao Francisco (PISF) (2005) Nota Técnica 390/2005/SOC- Análise do pedido de outorga de direito de uso de recursos hídricos para o Projeto de Integração do Rio São Francisco com as Bacias Hidrográficas do Nordeste Setentrional.

BRASIL. Lei no 12.608, de 10 de abril de 2012. Institui a Política Nacional de Proteção e Defesa Civil – PNPDEC. Dispõe sobre o Sistema Nacional de Proteção e Defesa Civil. SINPDEC e o Conselho

Nacional de Proteção e Defesa Civil – CONPEDEC: Diário Oficial da União, Brasília.

CARDONA, O.D., 2011: Disaster risk and vulnerability: Notions and measurement of human and environmental insecurity. In: Coping with Global Environmental Change, Disasters and Security – Threats, Challenges, Vulnerabilities and Risks [Brauch, H.G., U. Oswald Spring, C. Mesjasz, J. Grin, P. Kameri-Mbote, B. Chourou, P. Dunay, J. Birkmann]. Springer Verlag, Berlin, Germany, p. 107- 122.

CARVALHO, L. M. V.; JONES, C.; LIEBMANN, B. 2002: Extreme precipitation events in southeastern South America and large-scale convective patterns in the South Atlantic convergence zone. JournalofClimate, 15, 2377–2394CHRISTENSEN, J.H., K. KRISHNA KUMAR, E. ALDRIAN, S.-I. AN, I.F.A. CAVALCANTI, M. DE CASTRO, W. DONG, P. GOSWAMI, A. HALL, J.K. KANYANGA, A. KITOH, J. KOSSIN, N.-C. LAU, J. RENWICK, D.B. STEPHENSON, S.-P. XIE AND T. ZHOU, 2013: Climate Phenomena and their Relevance for Future Regional Climate Change. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

ICSU-LAC, 2010a: Science for a better life: Developing regional scientific programs in priority areas for Latin America and the Caribbean. Vol 2, Understanding and Managing Risk Associated with Natural Hazards: An Integrated Scientific Approach in Latin America and the Caribbean [Cardona, O.D., J.C. Bertoni, A. Gibbs, M. Hermelin, and A. Lavell (eds.)]. ICSU Regional Office for LatinAmericaandtheCaribbean, Rio de Janeiro, Brazil.

ICSU-LAC, 2010b: Entendimiento y gestióndelriesgoasociado a lasamenazasnaturales: Un enfoque científico integral para América Latina y el Caribe. Ciencia para una vida mejor: Desarrollando programas científicos regionalesen áreas prioritarias para América Latina y el Caribe. Vol 2 [Cardona, O.D., J.C. Bertoni, A. Gibbs, M. Hermelin, and A. Lavell (eds.)]. ICSU Regional Office for Latin America and the Caribbean, Rio de Janeiro, Brazil

HAYLOCK, M. R., PETERSON, T. C., ALVES, L. M., AMBRIZZI, T., ANUNCIAÇÃO, Y. M. T., BAEZ, J., BARROS, V. R., BERLATO, M. A., BIDEGAIN, M., CORONEL, G., GARCIA, V. J., GRIMM, A. M., KAROLY, D., MARENGO, J. A., MARINO, M. B., MONCUNILL, D. F., NECHET, D., QUINTANA, J., REBELLO, E., RUSTICUCCI, M., SANTOS, J. L., TREBEJO, I., VINCENT, L. A. Trends in total and extreme South American rainfall 1960-2000 and links with sea surface temperature. Journal of Climate, v. 19, p. 1490-1512, 2006.

Held IM, Soden BJ (2006) Robust responses of the hydrological cycle to global warming. J Clim 19:5686–5699

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE – IPCC. 2012: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX). A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 p.

LIEBMANN, B.; JONES, C.; CARVALHO, L. M. V. 2001. Interannual variability of daily extreme precipitation events in the state of Sao Paulo, Brazil.JourmalofClimate, 14, 208–218.

MARENGO, J.A., 2009: Impactos de extremos relacionados com o tempo e o clima – Impactos sociais e econômicos. Instituto Nacional de Pesquisas Espaciais, Centro de Ciências do Sistema Terrestre, São Paulo, Brasil. Boletim do Grupo de Pesquisa em Mudanças Climáticas (GPMC), 8(Edição especial), 1-5.

MARULANDA, M.C., O.D. Cardona, and A.H. Barbat, 2008b: The economic and social effects of small disasters: Revision of the Local Disaster Index and the case study of Colombia. In: Megacities: Resilience and Social Vulnerability [Bohle, H.G. and K. Warner (eds.)]. SOURCE No. 10, United Nations University (EHS), Munich Re Foundation, Bonn, Germany

MARULANDA, M.C., O.D. Cardona, and A.H. Barbat, 2010: Revealing the socioeconomic impact of small disasters in Colombia using the DesInventar database. Disasters, 34(2), 552-570. Marulanda, M.C., O.D. Cardona, and A.H. Barbat, 2011: Revealing the impact of small disasters to the economic and social development. In: Coping with Global Environmental Change, Disasters and Security - Threats, Challenges, Vulnerabilities and Risks [Brauch, H.G., U. Oswald Spring, C. Mesjasz, J. Grin, P. Kameri-Mbote, B. Chourou, P. Dunay, and J. Birkmann (eds.)]. Springer-Verlag, Berlin, Germany

OBREGÓN,G.O.; MARENGO, J.A.; NOBRE, C.A. (2014) Rainfall and climate variability: long-term trends in the Metropolitan Area of São Paulo in the 20th century. Climate Research 61, 93-107. Online publication date: 23-Sep-2014

TRENBERTH, K.E.; SHEA, D.J. 2006.Atlantic hurricanes and natural variability in 2005. Geophysical Research Letters 33: L12704. DOI:10.1029/2006GL026894.

UFSC – CEPED. Atlas brasileiro de desastres naturais 1991 a 2012: volume Brasil. Florianópolis: CEPED UFSC, 2013.

UNISDR, 2009a: Global Assessment Report on Disaster Risk Reduction - Risk and Poverty in a Changing Climate: Invest Today for a Safer Tomorrow. United Nations International Strategy for Disaster Reduction, Geneva, Switzerland, 207 p.

UNISDR, 2011: Global Assessment Report on Disaster Risk Reduction: Revealing Risk, Redefining Development. United NationsInternationalStrategy for DisasterReduction, Geneva, 178 p.

VARANDA, A.P.M.; Ferreira, V. S. (2013) Políticas Públicas e Iniciativas da Sociedade Civil de Prevenção e Resposta a Situações de Desastres Climáticos. COEP, Rio de Janeiro. Relatório Síntese de Pesquisa. 25p.

VINCENT, L.A., T.C. PETERSON, V.R. BARROS, M.B. MARINO, M. RUSTICUCCI, G. CARRASCO, E. RAMIREZ, L.M. ALVES, T. AMBRIZZI, M.A. BERLATO, A.M. GRIMM, J.A. MARENGO, L. MOLION, D.F. MONCUNILL, E. REBELLO, Y.M.T. ANUNCIAÇÃO, J. QUINTANA, J.L. SANTOS, J. BAEZ, G. CORONEL, J. GARCIA, I. TREBEJO, M. BIDEGAIN, M.R. HAYLOCK, D. KAROLY. 2005. Observed trends in indices of daily temperature extremes in South America 1960-2000. Journal of Climate, 18, 5011-5023

Strategy for Industry and Mining

Dos Santos, E.T., Haddad E. A. Mapeamento das perdas econômicas potenciais dos pontos de alagamento do município de São Paulo. Ambiente & Sociedade n São Paulo v. XVII, n. 4 n p. 77-94, 2014. Disponível em: http://www.scielo.br/pdf/asoc/v17n4/a05v17n4.pdf

Sussman and Freed, 2008. Adapting to climate Change: A Business Approach. Pew Center on Global Climate Change. Adaptado do documento "Contribuições Preliminares da Indústria – CNI", disponível no endereçoeletrônico:http://www.mma.gov.br/images/arquivo/80182/Contribuicoes_Peliminares_PNA _ Setor%20In dustrial_CNI.pdf, acessado em 11/03/15.

Strategy for Infrastructure

ARNDT, C.; CHINOWSKY, P., 2012: Climate Change and Roads: A Dynamic Stressor–Response Model. Review of Development Economics, 16(3), 448–462.

ANTP - Avaliação de Vulnerabilidade Ambiental e Socioeconômica Curitiba – 2014

BECKER, A., INOUE, S; FISCHER, M; SCHWEGLER,B. 2012: Climate Change Impacts on International Seaports: Knowledge, Perceptions, and Planning Efforts Among Port Adminstrators. Climatic Change, 110: 5-29.

CALIFORNIA NATURE RESOURCES AGENCY. California Climate Adaptation: a report to the governor of state of California in response to Executive Order S-13-2008, USA: California Strategy for Energy & Transportation. 2009. Cap. 10.

ELETROBRAS CEPEL, 2001: Atlas do Potencial Eólico Brasileiro- 2001

EU (União Europeia) strategy on adaptation to climate change – 2013

FGV. 2013: Diagnóstico Preliminar das principais informações sobre projeções Climáticas e Socioecômicas, impactos e vulnerabilidades disponíveis em trabalhos e projetos dos atores mapeados.

GIZ- Adapting Urban Transport to Climate Change - 5F-ACC-en GIZ – Vulnerability Sourcebook – Guidelines for Assessments – 2014INPE.2010: Sumário Executivo Vulnerabilidade das Megacidades Brasileiras às Mudanças Climáticas: Região Metropolitana de São Paulo. Brasil. 2010.

IBGE. Censo Demográfico 2010. Disponível em: <http://www.censo2010.ibge.gov.br>

IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

KOETSE, M. J.; RIETVELD., P. Climate Change, Adverse Weather Conditions, and Transport: A Literature Survey. Vrije Universiteit. Amsterdam. 2007.

KREKT AH, VAN DER LAAN TJ, VAN DER MEER RAE, TURPIJN B, JONKEREN OE, VAN DER TOORN A, MOSSELMAN E, VAN MEIJEREN J, GROEN T (2011): Climate change and inland waterway transport: impacts on the sector, the Port of Rotterdam and potential solution. Research Project HSRRCB, National Research Programme Knowfedge for Climate, Secretarist of the Knowledge for Climate Programme, University of Utrecht, Nethelands, 74 p.

LAVIN, P.G., 2003: Asphalt Pavements: A Practical Guide to Design, Production, and Maintenance for Architects and Engineers. Spon Press. 416 p.

LIMA, JOSÉ WANDERLEY MARANGON: Efeitos e Mudanças Climáticas na Geração de Energia Elétrica – São Paulo: AES Tietê, 2014.

LEMMEN, D. AND F. WARREN, 2010: Climate Change Impacts and Adaptation: A Canadian Perspective. [Lemmen, D. and Warren, F. (eds.)]. Natural Resources Canada.

MACARTHUR, K. E., 2013: Assessing public transportation agencies' climate change adaptation activities and needs. Submitted for presentation and publication to the 92th Annual Meeting of the Transportation Research Board.

MEYER, M. D., 2008: Design Standards for U.S. Transportation Infrastructure: The Implications of Climate Change. Georgia Institute of Technology. Atlanta, p. 30.

MIDDELKOOP, H., DAAMEN, K., GELLENS, D., GRABS, W., KWADIJK, J.C.J., LANG, H., PARMET BWAH, SCHADLER, B., SCHULLA, J., WILKE, K., 2001: Impact of climate change on hydrological regimes and water resources management in the Rhine basin. Climatic Change 49: 105–128

MME; EPE, 2015: Balanço Energético Nacional 2015

MME; EPE, 2015: Plano Decenal de Energia 2024

MME; EPE, 2007: Plano Nacional de Energia 2030

MT, 2011. Plano Nacional de Logística e Transportes: Relatório Executivo. 260p.

MT, 2013. Plano Hidroviário Estratégico: Sumário Executivo. 70p.

OSWALD, M., 2009: Literature Review: Transportation Adaptation in Response to Climate Change. Universidade de Delaware.Delaware, 2009.

POTTER, J., V. BURKETT, M. SAVONIS, AND D. DOKKEN, 2008: Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I. [Potter, J., Burkett, V., Savonis, M. and Dokken, D. (eds.)]. U.S. Climate Change Science Program.

Plan NYC - A Strong More Resilient New York – 2013

SECRETARIA DE ASSUNTOS ESTRATÉGICOS, 2015. Projeto 2040.

SOO HOO, W. K.; SUMITANI, M., 2005: Climate Change will Impact the Seattle Department of Transportation. University of Washington. Washington, p. 49.

UNCTAD, 2009. Trade and investment opportunities and challenges under the Clean Development Mechanism (CDM). Note by the UNCTAD secretariat for UNCTAD Trade and Development Board, Expert Meeting on Trade and Climate Change: Trade and Investment Opportunities Under the Clean Development Mechanism (CDM), Geneva, 1–3 April 2009.

UNECE; UNCTAD, 2010: Climate Change Impacts on International Transport Networks Joint UNECE – UNCTAD Workshop,8 September 2010, Geneva.

UK Gov- The National Adaptation Program – 2013

Strategy for Vulnerable Peoples and Populations

BRASIL. Cadastramento diferenciado. Diversidade no Cadastro Único – Respeitar e Incluir. Brasília, DF: MDS; Secretaria Nacional de Renda e Cidadania. 53p. 2014.

BRASIL. DECRETO no 6.040, DE 7 DE FEVEREIRO DE 2007. Institui a Política Nacional de Desenvolvimento Sustentável dos Povos e Comunidades Tradicionais. Diário Oficial [da República Federativa do Brasil], Brasília, DF.

BRASIL. DECRETO no 7.747, DE 5 DE JUNHO DE 2012. Institui a Política Nacional de Gestão Territorial e Ambiental de Terras Indígenas – PNGATI, e dá outras providências. Diário Oficial [da República Federativa do Brasil], Brasília, DF.

DIREITO, D. e LÍCIO, E.C. A experiência Brasileira de Cadastramento Diferenciado de Grupos Populacionais Tradicionais e Específicos.30p. (s/d).

FIOCRUZ - CONFALONIERI U.; CHANG M.; NAHAS M. e BARATA, M.Modelo Conceitual para avaliação municipal da vulnerabilidade humana à mudança do clima no Brasil: contribuição da FIOCRUZ ao Plano Nacional de Adaptação. SUMÁRIO EXECUTIVO. 23p. 2015.

ICLEI. Local Governments for Sustainability. Ecosystem-based Adaptation: a Guiding Framework for decision making criteria. ICLEI, s/d. Disponível em:http://www.durbanadaptationcharter.org/Content/Docs/Urban%20EBA%20Guiding%20Decision-Making%20Framework%202013.pdf. Acesso em 2 abril de 2015.

IOM – International Organization for Migration. IOM Outlook on Migration, Environment and Climate Change (123p.). Geneva, 2014, p. 23. Disponível em: http://publications.iom.int/bookstore/free/MECC_Outlook.pdf. Últimoacessoem: 25 jun. 2015.

IPCC- Intergovernmental Panel on Climate Change. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the FourthAssessment Report of the Intergovernmental Panel on Climate Change. CoreWriting Team, Pachauri, R.K and Reisinger, A. (eds.). IPCC, Geneva, Switzerland,2007.

IPCC- Intergovernmental Panel on Climate Change. Summary for Policymakers. In: Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC, Geneva, Switzerland, 2014.

SCHUSCHNY, A. Indicadores compuestos: Algunasconsideraciones metodológicas (Apresentação em Power Point). In: SIMPÓSIO INTERNACIONAL DE MUDANÇAS CLIMÁTICAS E POBREZA NA AMÉRICA DO SUL. Universidade de São Paulo. 2010.

UNIVERSIDADE FEDERAL DE SANTA CATARINA/UFSC. Centro Universitário de Estudos e Pesquisas sobre Desastres. Atlas brasileiro de desastres naturais 1991 a 2010: volume Brasil / Centro Universitário de Estudos e Pesquisas sobre Desastres. Florianópolis: CEPED UFSC, 94p. 2012.

Strategy for Water Resources

AGÊNCIA NACIONAL DE ÁGUAS (BRASIL), Conjuntura dos recursos hídricos no Brasil: informe 2014 – Brasília: ANA, 2015.

AGÊNCIA NACIONAL DE ÁGUAS (BRASIL). Atlas Brasil de Abastecimento Urbano de Água, ANA 2011. Disponível em http://atlas.ana.gov.br/Atlas/forms/Home.aspx.

BRASIL. Lei nº 9.433, de 8 de janeiro de 1997. Institui a Política Nacional de Recursos Hídricos, cria o Sistema Nacional de Gerenciamento de Recursos Hídricos, regulamenta o inciso XIX do Art. 21 da Constituição Federal, e altera o Art. 1º da Lei nº 8.001, de 13 de março de 1990, que modificou a Lei nº 7.990, de 28 de dezembro de 1989.

CAMPOS , J. N. B.; NÉRIS, L. F. A. Mudanças Climáticas e Disponibilidades Hídricas no Semiárido: Resultados Preliminares. In: SERVAIN, J., CAMPOS, J.N.B., MARTINS, E.S.P.P. Clima do Atlântico Tropical e Impactos Sobre o Nordeste (CATIN), 2009.

DÖLL, P.; FLÖRKE, M. Global-Scale Estimation of Diffuse Groundwater Recharge. Frankfurt Hydrology Paper 03. Frankfurt am Main: Institute of Physical Geography, Frankfurt University, 2005.

KUNDZEWICZ, Z. W. et al., Freshwater resources and their management. In: PARRY, M.L. et al., (Eds.). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, 2007.

MMA. Plano Nacional de Recursos Hídricos: Prioridades 2012-2015. Ministério do Meio Ambiente - MMA/ Secretaria de Recursos Hídricos e Ambiente Urbano - SRHU/Agência Nacional de Águas - ANA, Brasília, DF, 2011.

MILLY, P. C. D. ; DUNNE, K. A. ; VECCHIA, A. V. Global pattern of trends in streamflow e water availability in a changing climate. Nature, vol. 438, 17 Nov. 200. Doi:10.1038/nature 04312, 2005.

MEDEIROS, Y.D.P. Análise dos Impactos das Mudanças Climáticas em Região Semiárida. Revista Brasileira de Recursos Hídricos, v. 8, n. 2, p. 127-136. 2003.

MELO, D. C. D. Estimativa de impacto de mudanças climáticas nos níveis do Sistema aquífero do Guarani. Dissertação de mestrado – Escola de Engenharia de São Carlos, Universidade de São Paulo, São Carlos, 2013.

NÓBREGA, M.T. et al., Uncertainty in climate change impacts on water resources in the Rio Grande Basin, Brazil. Hydrol. Earth Syst. Sci., v. 15, p. 585–595, 2011.

SALATI, T. et al., Economia das Mudanças Climáticas no Brasil. Estimativas da Oferta de Recursos Hídricos no Brasil em Cenários Futuros de Clima. Fundação Brasileira para o Desenvolvimento Sustentável, 2008. 80 p.

TOMASELLA, J. et al., Estudo de impacto das mudanças climáticas sobre os recursos hídricos superficiais e sobre os níveis dos aqüíferos na Bacia do Rio Tocantins. CCST/INPE, Cachoeira Paulista, 2009.

UK MET OFFICE. Climate change, rivers and rainfall. Recent research on climate change science from the Hadley Centre, dez. 2005.

Disponível em http://cebds.org/publicacoes/gerenciamento-de-riscos-hidricos/#.VddBD4tRGUk.

IBGE, 2010. Disponível em http://www.ibge.gov.br/home/estatistica/economia/

Site http://www.tratabrasil.org.br/saneamento-no-brasil acessado em 25/03/2015.

AGÊNCIA NACIONAL DE ÁGUAS (BRASIL), Conjuntura dos recursos hídricos no Brasil: informe 2014 – Brasília: ANA, 2015.

AGÊNCIA NACIONAL DE ÁGUAS (BRASIL). Atlas Brasil de Abastecimento Urbano de Água, ANA 2011. Disponível em http://atlas.ana.gov.br/Atlas/forms/Home.aspx.

BRASIL. Lei nº 9.433, de 8 de janeiro de 1997. Institui a Política Nacional de Recursos Hídricos, cria o Sistema Nacional de Gerenciamento de Recursos Hídricos, regulamenta o inciso XIX do Art. 21 da Constituição Federal, e altera o Art. 1º da Lei nº 8.001, de 13 de março de 1990, que modificou a Lei nº 7.990, de 28 de dezembro de 1989.

CAMPOS , J. N. B.; NÉRIS, L. F. A. Mudanças Climáticas e Disponibilidades Hídricas no Semiárido: Resultados Preliminares. In: SERVAIN, J., CAMPOS, J.N.B., MARTINS, E.S.P.P. Clima do Atlântico Tropical e Impactos Sobre o Nordeste (CATIN), 2009.

DÖLL, P.; FLÖRKE, M. Global-Scale Estimation of Diffuse Groundwater Recharge. Frankfurt Hydrology Paper 03. Frankfurt am Main: Institute of Physical Geography, Frankfurt University, 2005.

http://www.aneel.gov.br/aplicacoes/capacidadebrasil/OperacaoCapacidadeBrasil.cfm, acessado em 12/03/2015.

Bezerra, M. I. S. Análise de Séries Temporais. 2006. Disponível em http://www.ebah.com.br/content/ABAAAe8xcAD/apostila-analise-series-temporais)

KUNDZEWICZ, Z. W. et al., Freshwater resources and their management. In: PARRY, M.L. et al., (Eds.). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, 2007.

Lei nº 9.433, de 8 de janeiro de 1997. Institui a Política Nacional de Recursos Hídricos, cria o Sistema Nacional de Gerenciamento de Recursos Hídricos, regulamenta o inciso XIX do Art. 21 da Constituição Federal, e altera o Art. 1º da Lei nº 8.001, de 13 de março de 1990, que modificou a Lei nº 7.990, de 28 de dezembro de 1989. (http://www.planalto.gov.br/ccivil_03/leis/L9433.htm).

MEDEIROS, Y.D.P. Análise dos Impactos das Mudanças Climáticas em Região Semiárida. Revista Brasileira de Recursos Hídricos, v. 8, n. 2, p. 127-136. 2003.

MELO, D. C. D. Estimativa de impacto de mudanças climáticas nos níveis do Sistema aquífero do Guarani. Dissertação de mestrado – Escola de Engenharia de São Carlos, Universidade de São Paulo, São Carlos, 2013.

MILLY, P. C. D. ; DUNNE, K. A. ; VECCHIA, A. V. Global pattern of trends in streamflow e water availability in a changing climate. Nature, vol. 438, 17 Nov. 200. Doi:10.1038/nature 04312, 2005.

MMA. Plano Nacional de Recursos Hídricos: Prioridades 2012-2015. Ministério do Meio Ambiente - MMA/Secretaria de Recursos Hídricos e Ambiente Urbano - SRHU/ Agência Nacional de Águas - ANA, Brasília, DF, 2011.

NÓBREGA, M.T. et al., Uncertainty in climate change impacts on water resources in the Rio Grande Basin, Brazil. Hydrol. Earth Syst. Sci., v. 15, p. 585–595, 2011.

SALATI, T. et al., Economia das Mudanças Climáticas no Brasil. Estimativas da Oferta de Recursos Hídricos no Brasil em Cenários Futuros de Clima. Fundação Brasileira para o Desenvolvimento Sustentável, 2008. 80 p.

TOMASELLA, J. et al., Estudo de impacto das mudanças climáticas sobre os recursos hídricos superficiais e sobre os níveis dos aqüíferos na Bacia do Rio Tocantins. CCST/INPE, Cachoeira Paulista, 2009.

UK MET OFFICE. Climate change, rivers and rainfall. Recent research on climate change science from the Hadley Centre, dez. 2005.

World Bank, 2010. Disponível em http://siteresources.worldbank.org/EXTTOOLKIT3/Resources/3646250-1250715327143/GN5.pdf).

Strategy for Health

Alderman, K., Turner, L. R., & Tong, S. (2012). Floods and human health: a systematic review. Environment international, 47, 37-47.

Barcellos, C., Monteiro, A. M. V., Corvalán, C., Gurgel, H. C., Carvalho, M. S., Artaxo, P., & Ragoni, V. (2009). Mudanças climáticas e ambientais e as doenças infecciosas: cenários e incertezas para o Brasil. Epidemiologia e Serviços de Saúde, 18(3), 285-304.

BRASIL. Ministério da Saúde. Secretaria de Vigilância em Saúde. Coordenação-Geral de Vigilância em Saúde Ambiental. Programa Nacional de Vigilância em Saúde Ambiental relacionada à qualidade da água para consumo humano / Ministério da Saúde, Secretaria de Vigilância em Saúde, Coordenação-Geral de Vigilância em Saúde Ambiental. – Brasília : Editora do Ministério da Saúde, 2005. Disponível em http://portalsaude.saude.gov.br/images/pdf/2014/maio/30/Programa-Nacional-de-Vigilancia-da-Qualidade-da-agua-para-consumo-humano.pdf

BRASIL. Ministério da Saúde. Secretaria de Vigilância em Saúde. Departamento de Vigilância em Saúde Ambiental e Saúde do Trabalhador. Plano de segurança da água : garantindo a qualidade e promovendo a saúde : um olhar do SUS / Ministério da Saúde, Secretaria de Vigilância em Saúde, Departamento de Vigilância em Saúde Ambiental e Saúde do Trabalhador. – Brasília : Ministério da Saúde, 2013. Disponível em http://portalsaude.saude.gov.br/images/pdf/2015/maio/19/plano-seguranca-agua-2013-web.pdf.

BRASIL. Ministério da Saúde. Asis- Análise de Situação de Saúde / Ministério da Saúde, Universidade Federal de Goiás – Brasília: Ministério da Saúde, 2015. Disponível em http://bvsms.saude.gov.br/bvs/publicacoes/asis_analise_situacao_saude_volume_1.pdf), acessado em Março de 2016.

BRASIL. Ministério da Saúde, 2016. Vigilância de A a Z. Disponível em: http://portalsaude.saude.gov.br/index.php/vigilancia-de-a-a-z. Acessado em: 26/03/2016.

Cançado, J. E. D., Braga, A., Pereira, L. A. A., Arbex, M. A., Saldiva, P. H. N., & Santos, U. D. P. (2006). Repercussões clínicas da exposição à poluição atmosférica. J bras pneumol, 32(Supl 1), S5-S11.

HOTEZ, P. The giant anteater in the room: Brazil's neglected tropical diseases problem. PLoS Neglected Tropical Diseases. ; v. 2, n.:77, 2008.

IPCC, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge

University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 p

LINDOSO, JAL. LINDOSO, AABP. Neglected tropical diseases in Brazil. Rev. Inst. Med. trop. S. Paulo. São Paulo: v.51, n. 5, Sept./ Oct., 2009.

Organização Pan-Americana da Saúde. Mudança Climática e Saúde: um perfil do Brasil. Brasília, DF: OPAS, Ministério da Saúde, 2009. 44 p:. il. (Saúde Ambiental,3).

Organização Pan-Americana da Saúde, 2011. Organização Pan-Americana da Saúde. Estratégia e Plano de Ação sobre Mudança Climática, 51º Conselho Diretor 63ª Sessão do Comitê Regional. Disponível em www.paho.org/hq/index.php?option=com_docman&task=doc. Acessado em Março de 2016.

Organização das Nações Unidas, 2012. Future We Want – Outcome document. Disponível em: http://sustainabledevelopment. un.org/futurewewant.html, acessado em Maio de 2014.

Organização Pan-Americana da Saúde. Ministério da Saúde. Desastres Naturais e Saúde no Brasil. Brasília, DF: OPAS, Ministério da Saúde, 2014. 49 p:. il. (Série Desenvolvimento Sustentável e Saúde, 2).

Organização Pan-Americana da Saúde. Proteger a saúde frente à mudança climática: avaliação da vulnerabilidade e adaptação. Brasília, DF: OPAS, 2014. Disponível em: http://www.paho.org/bra/index.php?option=com_docman&task=doc_view&gid=1498&Itemid=423. Acessado em Março/2016.

RIPSA – Rede Interagencial de Informação para Saúde. Disponível em: http://www.ripsa.org.br/. Acessado em Abril/2015.

World Health Organization, 2015. Reducing Global Health Risks Through Mitigation of Short-Lived Climate Pollutants. Scoping Report For Policy-makers. Disponível em http://apps.who.int/iris/tstream/10665/189524/1/9789241565080_eng.pdf?ua=1. Acessado em Março de 2016.

Strategy for Food and Nutritional Security

DIEESE. NEAD. Estatísticas do Meio Rural 2010/2011. Brasília: MDA: DIEESE, 2011.

Embrapa; Unicamp. Aquecimento Global e a Nova Geografia da Produção Agrícola no Brasil. Agosto de 2008.

Feres, J.; Speranza, J.; Antônio Viana, P.; Barcellos, T.; Braga, Y. Padrão de Uso da Terra. In: Margulis, S.; Dubeux, C. (Ed.); Marchovitch, J. (Org). Economia da Mudança do Clima no Brasil: Custos e Oportunidades. São Paulo: IBEP Gráfica, 2011.

HIGH LEVEL PANEL OF EXPERTS ON FOOD SECURITY AND NUTRITION. Food security and climate change. Disponível em: <http://www.fao.org/3/a-me421e.pdf>. Acesso em: 10/04/2015.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. Indicadores de Desenvolvimento Sustentável – Brasil 2012. Rio de Janeiro: IBGE, 2012.

Censo Agropecuário. Rio de Janeiro, 2006. CD-ROM.

KEPPLE, A. W. O estado da segurança alimentar e nutricional no Brasil: um retrato multidimensional. Brasília: FAO, 2014. Disponível em: <https://www.fao.org.br/download/SOFI_p.pdf> Acesso em: 10/04/2015.

Margulis, S.; Dubeux, C.;Marchovitch, J. Economia da Mudança do Clima no Brasil: Custos e Oportunidades. São Paulo: IBEP Gráfica, 2011.

CARTER, M. Combatendo a desigualdade social: o MST e a reforma agrária no Brasil. São Paulo: Editora Unesp, Centro para Estudos Brasileiros, Universidade de Oxford, NEAD, MDA, 2010.

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO. Estimativas anuais de emissões de gases de efeito estufa no Brasil, volume 2. Disponível em: <http://www.mct.gov.br/upd_blob/0235/235580.pdf>. Acesso em: 10/04/2015.

MONZONI, M. Diagnóstico preliminar das principais informações sobre projeções climáticas e socioeconômicas, impactos e vulnerabilidades disponíveis em trabalhos e projetos dos atores. Disponível em: <http://www.mma.gov.br/images/arquivo/80182/D_Produto_2.0.1_Diagnostico%20preliminar%20sobre%20projecoes%20climaticas%20%20impactos%20e%20vulnerabilida des.pdf>. Acesso em: 10/04/2015.

OLIVIER, D.S. Agroecologia e o Direito Humano à Alimentação Adequada. Brasília: Caderno SISAN 01/2012.

PBMC, 2014: Impactos, vulnerabilidades e adaptação às mudanças climáticas. Contribuição do Grupo de Trabalho 2 do Painel Brasileiro de Mudanças Climáticas ao Primeiro Relatório da Avaliação Nacional sobre Mudanças Climáticas [Assad, E.D., Magalhães,A. R. (eds.)]. COPPE. Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brasil, 414 p. ISBN: 978-85-285-0207-7.

PAUPITZ, J. Relatório Técnico. Projeto de Cooperação Técnica PCT BRA/IICA/05/004 - PAN Desertificação de "Apoio às ações de implementação do Programa de Ação Nacional de Combate à Desertificação e Mitigação dos Efeitos da Seca – PAN-Brasil". Disponível em: <http://www.iicabr.iica.org.br/wp-content/uploads/2014/03/Produto- 3-e-Folha-de-Rosto-Vers%C3%A3o-Final-J%C3%BAlio-Paupitz.pdf> Acesso em: 10/04/2015.

SPERANZA, J., BARCELLOS, T., CABALLERO, B., CHAGAS, N. Impactos, vulnerabilidades e riscos da mudança climática global para a segurança alimentar e nutricional no Brasil. Relatório de Pesquisa MMA/Oxfam. Disponível em: <http://www.mma.gov.br/clima/adaptacao/projetos> Acesso em: 18/05/2015.

UNSCN. The Nutrition Sensitivity of Agriculture and Food Policies. A synthesis of eight country case studies. United Nations Standing Committee on Nutrition, March, 2014.

Strategy for Coastal Zones

BRASIL – MMA/IHC/UFSC. Projeto SMC-Brasil: Documento Temático sobre Ondas. 155p. (s/d)

BRASIL. Decreto nº 5.300, de 07 de dezembro de 2004. Regulamenta a Lei nº 7.661/88, que institui o Plano Nacional de Gerenciamento Costeiro. Diário Oficial da República Federativa do Brasil, Brasília, 2004. Disponível em: <http://www.planalto.gov.br/ccivil_03/_ato2004-2006/2004/decreto/D5300.htm>Acessoem: 23 set. 2014.

BRASIL. Lei nº 7.661 de 16 de maio de 1988. Institui o Plano Nacional de Gerenciamento Costeiro. Diário Oficial da República Federativa do Brasil, Brasília, 1988. Disponível em:<http://www.planalto.gov.br/ccivil_03/leis/l7661.htm> Acesso em: 23 set. 2014.

BRASIL. Os 25 anos do gerenciamento costeiro no Brasil: Plano nacional de Gerenciamento costeiro (PNGC). Lei Nº 7.661, de 16 de maio de 1988, Resolução CIRM Nº 01/90, de 21 de novembro de 1990, Ministério do Meio Ambiente, 2014.

CASTRO, BM; FP Brandini; IEKC Wainer & M Dottori. O mar de amanhã, com as mudanças climáticas de hoje. Cienc. Cult., São Paulo, v. 62, n. 3, 2010.

DIETER M. Erosão e progradação no litoral brasileiro. Brasília: MMA, 476 p. 2006.

HORTA, P.A et al., Rhodoliths in Brazil: current knowledge and potential impacts of climate change. Brazilian Journal of Oceanography, 2015.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE). Atlas Geográfico das Zonas Costeiras e Oceânicas. 2011. 177p.

INSTITUTO BRASILEIRO DO MEIO AMBIENTE E DOS RECURSOS NATURAIS RENOVÁVEIS (IBAMA). Relatório de Qualidade do Meio Ambiente – RQMA, Brasília. 2013, 268 p.

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. Cambridge University Press, 2012, 582 p.

MARGULIS e SCHMIDT. Economia da Mudança do Clima no Brasil: Custos e Oportunidades. São Paulo: IBEP Gráfica, 2010. 82 p.

MINISTÉRIO DO MEIO AMBIENTE (MMA). Macrodiagnóstico da Zona Costeira e Marinha do Brasil, Brasília. 2008. 242p.

MINISTÉRIO DO MEIO AMBIENTE. Panorama da Conservação dos Ecossistemas costeiros e marinhos no Brasil. Ministério do Meio Ambiente, Secretaria de Biodiversidade e Florestas, Gerência de Biodiversidade Aquática e Recursos Pesqueiros, Brasília. 2010. 148p.

NEVES, C.F e MUEHE, D. Vulnerabilidade, impactos e adaptação a mudanças do clima: Zona Costeira. Parcerias Estratégicas, n.27, p217-295. Brasília, 2008.

NICOLODI JL e PETERMANN RM. Mudanças Climáticas e a Vulnerabilidade da Zona Costeira do Brasil: Aspectos ambientais, sociais e tecnológicos. Revista da GestãoCosteiraIntegrada. 10(2):151-177, 2010.

PAINEL BRASILEIRO DE MUDANÇAS CLIMÁTICAS (PBMC), 2014: Impactos, vulnerabilidades e adaptação às mudanças climáticas. Contribuição do Grupo de Trabalho 2 do Painel Brasileiro de Mudanças Climáticas ao Primeiro Relatório da Avaliação Nacional sobre Mudanças Climáticas [Assad, E.D., Magalhães, A. R. (eds.)]. COPPE. Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brasil, 414 p. ISBN: 978-85-285-0207-7

TRAVERS, A.; ELRICK, C.; KAY, R.; VESTERGAARD, O. Ecosystem based adaptation guidance: Moving from principles to practice – Working Document. UNEP, 2012.

UNESCO GOOS 193. Requirements for Global Implementation of the Strategic Plan for Coastal GOOS Panel for Integrated Coastal Observation (PICO-I) Intergovernmental Oceanographic Commission. 200p. 2012

Glossary

National Adaptation Plan to Climate Change

Glossary

ADAPTATION: The process of adjustment to current and expected climate effects. In human systems adaptation seeks to moderate or prevent damage or exploit beneficial opportunities. In some natural systems, human intervention can facilitate adjustment to expected climate change and its effects.

EXPOSURE: The presence of people, livelihoods, species or ecosystems; environmental functions, services and resources; infrastructure or economic, social or cultural goods in places that may be adversely affected.

IMPACTS: Effects on natural and human systems. In this text, the term impact is primarily used to refer to the effects of extreme weather and climatic events on natural and human systems. Generally, impacts include effects on lives, livelihoods, health and ecosystems or hazardous weather events occurring over a specific period and the vulnerability of an exposed system or society. Impacts are also referred to as consequences or results. The impacts of climate change on geological systems, including floods, droughts and rising sea levels are a subset known as physical impacts.

NO-REGRETS MEASURES: are adaptation actions that promote benefits to sectors regardless of whether or not forecast impacts to climate change occur.

CLIMATE CHANGE: Refers to a change in climate status corroborated (using statistical tests) by changes in average and/or variability of properties, persisting for an extended period, typically decades or longer.

Climate change may be caused by natural internal processes or external forces such as solar-cycle modulations, volcanic eruptions, and persistent anthropogenic changes in composition of the atmosphere or in land use. Note that the article 1 of the United Nations Framework Convention defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". The UNFCCC thus makes a distinction between climate change attributable to human activities that alter composition of the atmosphere, and climate variability from natural causes.

RISK: Potential consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as a probability of occurrence of hazardous events or trend multipliers by impacts, if these events or trends occur. Risk results from the interaction of vulnerability, exposure and hazard. In this report, the term risk is used primarily to refer to the risks of impacts related to climate events.

SENSITIVITY: Degree of reaction of elements and systems when confronted with a threat.

VULNERABILITY: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity and susceptibility to damage and poor capacity to cope and adapt.

14.15.1. GLOSSARY OF THE STRATEGY FOR VULNERABLE PEOPLES AND POPULATIONS

GYPSIES (*CIGANOS*): Gypsies are a people with a common past, originating possibly from Northern India, who dispersed between Asia, Europe, North-Africa roughly one thousand years ago, and subsequently across the Americas. The earliest record of arrival of gypsies in Brazil dates from 1574. They are usually nomadic (but in some cases, sedentary by choice or by obligation), and cherish their freedom and distinctive culture. They speak either the Romani or Chibe language, depending upon origin and ethnicity. Over the centuries gypsies have developed various ethnicities and subgroups, according to their specific roots, origins, cultures and territories. They also maintain a strong sense of family.90

EXTRACTIVISTS (EXTRATIVISTAS): The term extractivist as used in this text refers to peoples, groups and communities with specific values and cultures, whose livelihoods or subsistence depends upon hunting or gathering of plant and/or animal species. They may be small-scale farmers whose ways of life and subsistence are intimately connected to the ecosystems they inhabit. These groups possess empirical knowledge of their environments and use simple low-impact production methods. Gathering or extraction of locally available resources enables subsistence or income generation for maintenance of their lifestyles. A wide variety of types and forms of extractivism are practiced in Brazil.91

ARTISANAL FISHERMEN (*PESCADOR ARTESANAL*): There is a lack of consensus on the technical definition of this term that encompasses non-industrial fishing, also known as small-scale fishing. Generally, the term is used in apposition to large-scale industrial fishing, which relies on costly equipment that is unaffordable to non-industrial fishermen. Small-scale fishing communities with a great variety of regional traits are to be found on rivers, lakes and along the coast throughout Brazil. The common characteristic all these different groups share is a daily routine on the water. Their lifestyles reliy on an accumulation of specific local knowledge about winds, tides, and the ebb and flow of the waters, position and movement of the shoals, etc., combined with traditional fishing skills and navigation techniques.

SPECIFIC TRADITIONAL POPULATION GROUPS (STPGs) (*GRUPOS POPULACIONAIS TRACICIONAIS ESPECÍFICOS - GPTEs*): Groups that are distinct and that acknowledge such distinction, that possess their own forms of social organization, territorial identities and use natural resources as the basis of their social, cultural, religious, economic, and ancestral identities, based upon traditional knowledge and practices.

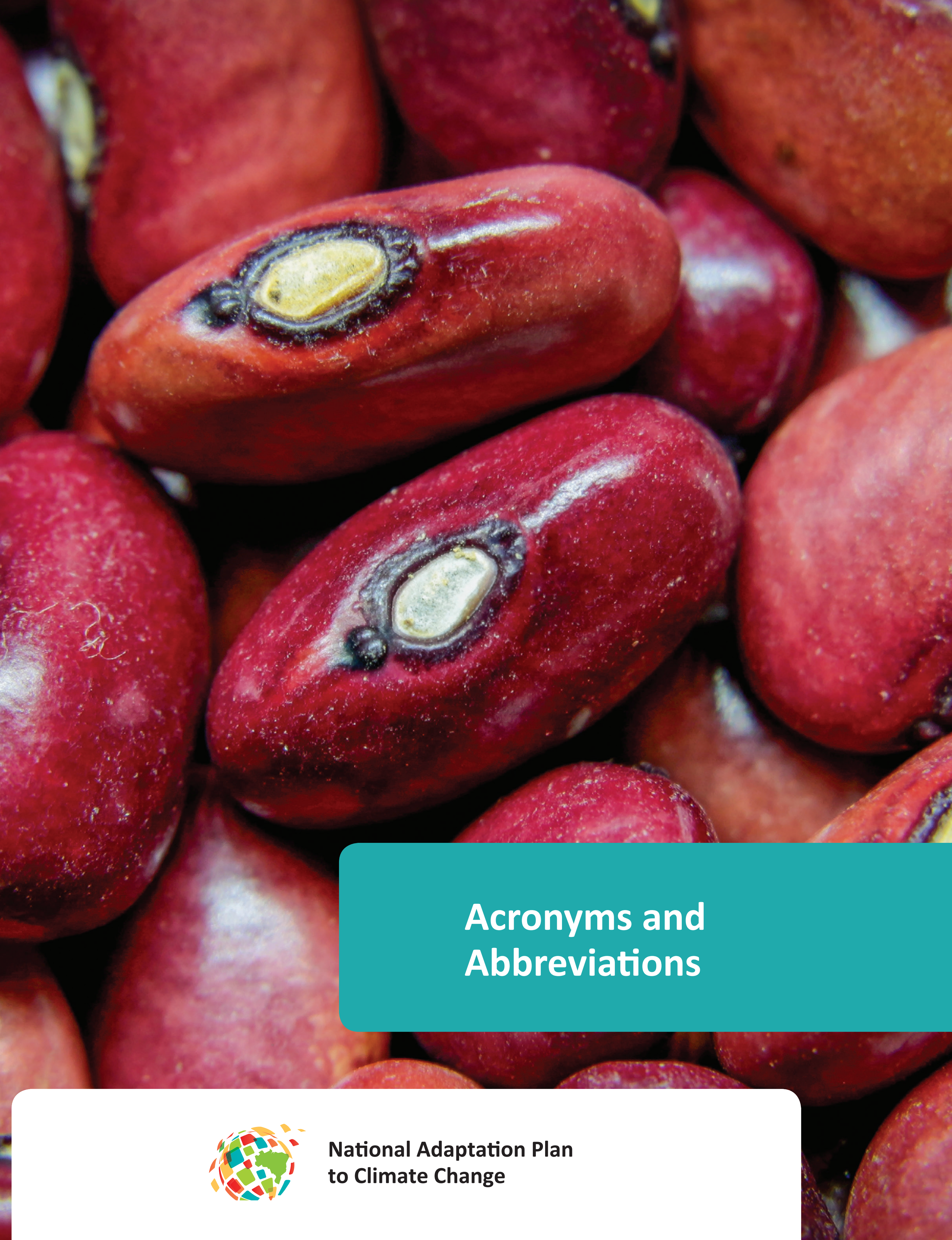
INDIGENOUS PEOPLES (*POVOS INDIGENAS*): According to ILO Convention 169 – "People whose ancestors inhabited a place or a country when persons from another culture or ethnic background arrived on the scene and dominated them through conquest, settlement, or other means and who today live more in conformity with their own social, economic, and cultural customs and traditions than those of the country of which they now form a part."

INDIGENOUS LANDS (*TERRAS INDIGENAS - TI*): According to § 1 of article 231 of the Federal Constitution of 1988 - are "Lands traditionally occupied by Indians are those on which they live on a permanent basis, those used for their productive activities, those indispensable to the preservation of the environmental resources necessary for their well-being and for their physical and cultural reproduction, according to their uses, customs and traditions."

***QUILOMBOLAS*:** Members of contemporary *quilombola* communities are descendants of former-slaves. The term is self-applied and a source of ethnic pride, though it reflects a history of persecution and discrimination. *Quilomobos* were formed by runaway slaves of African origin and historically marked resistance of the enslaved black population to oppression under colonial and imperial regimes. A number of such communities are to be found scattered throughout rural and urban areas of Brazil. Today, affirmation of membership of such groups is a means of reinforcing ethnic identity and claiming ownership to territories. Nonetheless, such communities are generally characterised by poor social indicators and low incomes.92

LANDRACE OR NATIVE SEEDS (*SEMENTES CRIOULAS*): are those seeds that have not undergone genetic modification through scientific genetic-selection techniques. Such seeds are called creole or native because they have generally been developed by traditional quilombola, riparian or indigenous communities.93

TRADITIONAL TERRITORIES: land permanently or temporarily used for cultural, social and economic activities by traditional, indigenous or quilombola communities to safeguard specificities, as provided for in law.



Acronyms and Abbreviations

National Adaptation Plan
to Climate Change

Acronyms and Abbreviations

ABC - Agricultura de Baixa Emissão de Carbono	LCA- Low-Carbon Agriculture
ANA- Agência Nacional de Águas	National Water Agency
ANTAQ- Agência Nacional de Transportes Aquaviários	National Waterway Transport Agency
ANVISA - Agência Nacional de Vigilância Sanitária	National Health Surveillance Agency
APP- Área de Preservação Permanente	Permanent Preservation Area
	AR - Assessment Report
ARP - Sistema de Análise de Risco de Pragas	Pest Risk Analysis System
ATER - Assistência Técnica e Extensão Rural	Technical Assistance and Rural Extension
BH- Balanço Hídrico	WB- Water Balance
BNDES - Banco Nacional de Desenvolvimento Econômico e Social	Brazilian Development Bank
BrOA - Grupo Brasileiro de Pesquisa em Acidificação dos Oceanos	Brazilian Ocean Acidification Research Group
CadRisco - Cadastro Nacional de Municípios com Áreas Suscetíveis à Ocorrência de Deslizamentos, Inundações ou Processos Geológicos ou Hidrológicos Correlatos	National Registry of Municipalities with Areas Susceptible to Landslides, Flooding or Correlated Geologic or Hydrologic Processes
CadÚnico - Cadastro Unico de Programas do Governo Federal	Single Registry for SocialProgrammes of the Brazilian federal government
CAISAN - Câmara Interministerial de Segurança Alimentar e Nutricional	Inter-ministerial Chamber for Food and Nutritional Security
CAR- Cadastro Ambiental Rural	Environmental Rural Registry
CCEE - Câmara de Comercialização de Energia Elétrica	Brazilian Electric Energy Trading Chamber
CDB- - Convenção da Diversidade Biológica	CBD- Convention on Biological Diversity

CEBDS - Conselho Empresarial Brasileiro para o Desenvolvimento Sustentável	Brazilian Business Council on Sustainable Development
CEMADEN - Centro Nacional de Monitoramento e Alertas de Desastres Naturais	National Centre for Monitoring and Early Warning of Natural Disasters
CENAD - Centro Nacional de Gerenciamento de Riscos e Desastres	Brazilian National Centre for Disaster Risks Management
CEPEDES - Centro de Estudos e Pesquisas em Emergência de Desastres em Saúde	Study and Research Centre on Emergency Health Disasters
CEPEL - Centro de Pesquisas de Energia Elétrica	Electrical Energy Research Centre
CEPENE - Centro Nacional de Pesquisa e Conservação da Biodiversidade Marinha do Nordeste	National Centre for Research and Conservation of Marine Biodiversity of the Northeast
CEPENOR - Centro de Pesquisa e Gestão de Recursos Pesqueiros do Litoral Norte	Research and Management Centre for Northern Coastline Fishing Resources
CEPLAC - Comissão Executiva do Plano da Lavoura Cacaueira	Executive Commission for the Planning of Cocoa Cultivation
CEPSUL - Centro Nacional de Pesquisa e Conservação da Biodiversidade Marinha do Sudeste e Sul	Research Center and Resource Management Fishing the Southeast Coast and South
CF - Constituição Federal	Federal Constitution
CGEE - Centro de Gestão e Estudos Estratégicos	Management and Strategic Studies Centre
CGVAM - Coordenação Geral de Vigilância em Saúde Ambiental	General Coordination of Environmental Health Surveillance
CIAPO - Câmara Interministerial de Agroecologia e Produção Orgânica	Inter-ministerial Chamber of Agro-ecology and Organic Production
CIM - Comitê Interministerial sobre Mudança do Clima	Inter-ministerial Committee on Climate Change
CMSE - Comitê de Monitoramento do Setor Elétrico	Power Sector Monitoring Committee
CNAPO - Comissão Nacional de Agroecologia e Produção Orgânica	National Agroecology and Organic Production Committee
CNI - Confederação Nacional da Indústria	National Confederation of the Industry
CNPq - Conselho Nacional de Desenvolvimento Científico e Tecnológico	National Council for Scientific and Technological Development

CONAB - Companhia Nacional de Abastecimento	National Supply Company
CONCAR - Comissão Nacional de Cartografia	National Cartography Commission
CONSEA - Conselho Nacional de Segurança Alimentar e Nutricional	National Food and Nutritional Security Council
COPPE- Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa de Engenharia	The Alberto Luiz Coimbra Institute for Postgraduate Engineering Research
CPRM - Companhia de Pesquisa de Recursos Minerais - Serviço Geológico do Brasil	Brazilian Geological Survey
CTPIn - Comissão Técnica do Plano Indústria	Technical Committee for the Industry Plan
DDA- Doença diarreica aguda	ADD- Acute Diarrheal Disease
DEMA - Delegacia Especial do Meio Ambiente	Special Environmental Police Authority
DESAM - Departamento de Saúde Ambiental	Department of Environmental Health
DETER - Sistema de Detecção de Desmatamento em Tempo Real da Amazônia	Amazon Real-Time Deforestation Detection System
DHAA - Direto Humano à Alimentação Adequada	HRAF- Human Right to Appropriate Food
DHN - Diretoria de Hidrografia e Navegação	Directorate for Hydrography and Navigation
DSAST - Departamento de Vigilância em Saúde Ambiental e Saúde do Trabalhador	Department for Surveillance of Environmental and Workers' Health
DSG - Diretoria de Serviço Geográfico do Exército	Directorate for Geographical Services of the Army
DZT - Departamento de Zoneamento Territorial	Territorial Zoning Department
EMBRAPA- Empresa Brasileira de Pesquisa Agropecuária	Brazilian Agricultural Research Corporation
ENSP-- Escola Nacional de Saúde Pública	National School of Public Health
EPE- Empresa de Pesquisa Energética	Energy Research Company
	FAO- Food and Agriculture Organization
FAP- Fundação de Amparo à Pesquisa	Research Support Foundation
Fiocruz- Fundação Oswaldo Cruz	Oswaldo Cruz Foundation

FN-SUS- Força Nacional do SUS	SUS National Force
FUNAI- Fundação Nacional do Índio	National Indian Foundation
Funasa- Fundação Nacional de Saúde	National Health Foundation
CIDE- Centro de Informações e Dados do Rio de Janeiro	Rio de Janeiro Information and Data Centre
UFRGS - Universidade Federal do Rio Grande do Sul	FURG- Federal University of Rio Grande do Sul
GEE- Gases de efeito estufa	GGE- Greenhouse Gas Emissions
Gg CO_2eq - Milhares de Toneladas de Carbono Equivalente	K-ton Carbon dioxide Equivalent
Sistema de Observação Global dos Oceanos	GOOS- Global Observation of the Oceans System
GS- Garantia Safra	Harvest Guarantee Programme
IBAMA - Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis	Brazilian Institute for Environment and Renewable Natural Resources
IBGE- Instituto Brasileiro de Geografia e Estatística	Brazilian Institute for Geography and Statistics
ICMBio - Instituto Chico Mendes de Conservação da Biodiversidade	Chico Mendes Institute for Biodiversity Conservation
IEC- Instituto Evandro Chagas	Evandro Chagas Institute
IEMA - Instituto Estadual de Meio Ambiente	State Environmental Institute
IESC/UFRJ- Instituto de Estudos e Saúde Coletiva da Universidade Federal do Rio de Janeiro	Collective Health Studies of the Federal University of Rio de Janeiro
IIMR- Instrumento de Identificação dos Municípios de Risco	Instrument for Identification of High-Risk Municipalities
iLPF - integração Lavoura-Pecuária-Floresta	integrated Crop-Livestock-Forestry
INCRA- Instituto Nacional de Colonização e Reforma Agrária	National Institute for Colonization and Agrarian Reform
INCT- Institutos Nacionais de Ciência e Tecnologia	National Science and Technology Institutes
INMET - Instituto Nacional de Meteorologia	National Meteorology Institute
INPE - Instituto Nacional de Pesquisas Espaciais	National Institute for Space Research

INPH - Instituto Nacional de Pesquisas Hidroviárias	National Institute for Waterways Research
INPOH - Instituto Nacional de Pesquisas Oceânicas e Hidroviárias	National Institute for Oceanic and Waterways Research
Painel Intergovernamental sobre Mudança do Clima	IPCC- Intergovernmental Panel on Climate Change
IPEA - Instituto de Pesquisa Econômica Aplicada	Institute for Applied Economics Research
ITA- Instituto Tecnológico de Aeronáutica	Technological Institute of Aeronautics
JBRJ- Jardim Botânico do Rio de Janeiro	Botanical Gardens Rio de Janeiro
LOSAN- - Lei Orgânica de Segurança Alimentar e Nutricional	Organic Law for Food and Nutritional Security
Mapa- Ministério da Agricultura, Pecuária e Abastecimento	Ministry of Agriculture, Livestock and Food Supply
MC- Mudança do Clima	CC- Climate Change
MCid- Ministério das Cidades	Ministry of Cities
MCTI- Ministério da Ciência, Tecnologia e Inovação	Ministry of Science, Technology and Innovation
MD- Ministério da Defesa	Ministry of Defence
MDA - Ministério do Desenvolvimento Agrário	Ministry of Agrarian Development
MDIC - Ministério do Desenvolvimento, Indústria e Comércio Exterior	Ministry of Development, Industry and Foreign Trade
MDS - Ministério do Desenvolvimento Social e Combate à Fome	Ministry of Social Development and Combating Hunger
MEC- Ministério da Educação	Ministry of Education
MI- Ministério da Integração Nacional	Ministry of National Integration
MMA- Ministério do Meio Ambiente	Ministry of Environment
MME- Ministério de Minas e Energia	Ministry of Mines and Energy
MPA- Ministério da Pesca e Aquicultura	Ministry of Fisheries and Aquiculture
MPOG - Ministério do Planejamento, Orçamento e Gestão	Ministry of Planning, Budget and Management
MRE- Ministério de Relações Internacionais	Ministry of Foreign Affairs
MRV - monitoramento, reporte e verificação	MRV - measurement, reporting and verification
MS- Ministério da Saúde	Ministry of Health
MT- Ministério dos Transportes	Ministry of Transport

OMMA - Órgãos municipais de meio ambiente	Municipal environmental agencies
OMS- Organização Mundial da Saúde	WHO- World Health Organization
ONG- Organização não governamental	NGO- Non-Government Organization
ONS - Operador Nacional do Sistema Elétrico	National Operator of the Electricity System
ONU- Organização das Nações Unidas	UN- United Nations Organisation
OPAS - Organização Panamericana de Saúde	PAHO- Pan American Health Organization
PAA- Programa de Aquisição de Alimentos	Food Procurement Programme
PAC - Programa de Aceleração do Crescimento	Growth Acceleration Programme
PBMC - Painel Brasileiro de Mudanças Climáticas	Brazilian Panel on Climate Change
PD- Plano Diretor Municipal	Municipal Master Plan
PELD - Programa Ecológico de Longa Duração	Long Term Ecology Programme
PGPM- Bio - Política de Garantia de Preço Mínimo para os Produtos da Sociobiodiversidade	Minimum Price Policy for Products of Sociobiodiversity
PHE- Plano Hidroviário Estratégico	Strategic Waterways Plan
PIB- Produto Interno Bruto	GDP- Gross Domestic Product
	PIRATA- Prediction and Research Moored Array in the Tropical Atlantic
PLANAPO - Plano Nacional de Agroecologia e Produção Orgânica)	National Plan of Agroecology and Organic Production
Plansab- Plano Nacional de Saneamento Básico	National Basic Sanitation Plan
PLANSAN- Plano Nacional de Segurança Alimentar e Nutricional	National Food and Nutritional Security Plan
PMCMV- Programa Minha Casa, Minha Vida	Low-income housing Programme
PMRR-- Plano Municipal de Redução de Risco	National Risk Reduction Plan
PNA - Plano Nacional de Adaptação à Mudança do Clima	NAP- National Adaptation Plan

PNAD- Pesquisa Nacional por Amostra de Domicílios	National Household Sample Survey
NAPE- Programa Nacional de Alimentação Escolar	National School Meals Programme
PNBOIA- Programa Nacional de Boias	Brazilian National Buoy Programme
PNBSB - Plano Nacional para a Promoção dos Produtos da Sociobiodiversidade	National Plan for Promotion of Socio-biodiversity Products
PNGATI - Política Nacional de Gestão Territorial e Ambiental	National Territorial and Environmental Management Policy
PNGC- Plano Nacional de Gerenciamento Costeira	National Coastal Management Plan
PNLT - Plano Nacional de Logística e Transportes	National Logistics and Transport Plan
PNMC - Política Nacional sobre Mudança do Clima	National Climate Change Policy
PNMU - Política Nacional de Mobilidade Urbana	National Urban Mobility Policy
PNRH - Plano Nacional de Recursos Hídricos	National Water Resources Plan
PNSAN - Política Nacional de Segurança Alimentar e Nutricional	National Food and Nutritional Security Policy
PNSB - Plano Nacional de Saneamento Básico	National Basic Sanitation Plan
PPA- Plano Plurianual	Multi-year Plan
PP-Caatinga - Plano de Ação para Prevenção e Controle do Desmatamento e das Queimadas da Caatinga	Plan of Action for Prevention and Control of Deforestation and Burning in the Caatinga
PRA - Programa de Regularização Ambiental	Environmental Regularisation Programme
PROAGRO - Programa de Garantia da Atividade Agropecuária	Agricultural Activity Guarantee Programme
PROAGRO Mais - Programa de Garantia da Atividade Agropecuária da Agricultura Familiar	Family Farming Activity Guarantee Programme
PRODES - Projeto de Monitoramento do Desflorestamento na Amazônia Legal	Brazilian Amazon Deforestation Monitoring Project
PRONAF - Programa Nacional de Fortalecimento da Agricultura Familiar	National Programme for Strengthening Family Farming

PSA- Pagamento por Serviços Ambientais	PES- Payment for Environmental Services
PSMC-Saúde - Plano Setorial da Saúde para Mitigação e Adaptação à Mudança do Clima	Health Sector Plan for Mitigation and Adaptation to Climate Change
PSR- Programa de Subvenção ao Prêmio do Seguro Rural	Rural Insurance Premium Subsidy Programme
PSTM - Plano Setorial de Transporte e de Mobilidade Urbana para Mitigação e Adaptação a Mudanças do Clima	Transportation and Urban Mobility Sector Plan for Mitigation and Adaptation to Climate Change
Rede Clima- Rede Brasileira de Pesquisas sobre Mudanças Climáticas Globais	Brazilian Research Network on Global Climate Change
ReBentos - Rede de Monitoramento de Habitats Bentônicos Costeiros	Coastal Benthic Habitats Monitoring Network
Ripsa- Rede Interagencial de Informações para a Saúde	Interagency Health Information Network
RL- Reserva Legal	Legal Reserve
SAE- Secretaria de Assuntos Estratégicos da Presidência da República	Secretariat for Strategic Affairs of the Presidency of the Republic
SAN- Segurança Alimentar e Nutricional	FNS- Food and Nutritional Security
SAS- Secretaria de Atenção à Saúde	Healthcare Secretariat
SBF - Secretaria de Biodiversidade e Florestas	Secretariat for Biodiversity and Forests
SCenAgri - Simulação de Cenários Agrícolas Futuros	Future Agricultural Scenario Simulation
SCTIE- Secretaria de Ciência, Tecnologia e Insumos Estratégicos	Secretariat for Science, Technology and Strategic Inputs
SDP/MDIC - Secretaria do Desenvolvimento da Produção do Ministério do Desenvolvimento, Indústria e Comércio Exterior	Secretariat for Production Development of the Ministry of Development, Industry and Foreign Trade
SE- Secretaria Executiva	Executive Secretariat
SEAF - Seguro da Agricultura Familiar	Family Farming Insurance
SECIRM - Comissão Interministerial para os Recursos do Mar	Inter-ministerial Committee for Marine Resources
SEDEC - Secretaria Nacional de Proteção e Defesa Civil	National Secretariat for Protection and Civilian Defence
SEDR - Secretaria de Desenvolvimento Rural Sustentável	Secretariat Sustainable Rural Development

SEMA - Secretaria de Estado de Meio Ambiente	State Secretariat of Environment
SEP - Secretaria de Portos da Presidência da República	Secretariat for Ports of the Presidency of the Republic
SES/SP - Secretaria Estadual de Saúde de São Paulo	Secretariat of Health of the State of São Paulo
SESAI - Secretaria Especial de Saúde Indígena	Special Secretariat for Indigenous Health
SFB - Serviço Florestal Brasileiro	Brazilian Forestry Service
SGEP - Secretaria de Gestão Estratégica e Participativa	Secretariat for Strategic and Participative Management
SGM/MME - Secretaria de Geologia, Mineração e Transformação Mineral do Ministério de Minas e Energia	Secretariat for Geology, Mining and Mineral Processing of the Ministry of Mines and Energy
SGTES - Secretaria da Gestão do Trabalho e da Educação na Saúde	Secretariat for Labour Management and Education in Health
SIBBR - Sistema de Informação sobre a Biodiversidade Brasileira	Brazilian Biodiversity Information System
SIMCosta - Sistema de Monitoramento da Costa Brasileira	Brazilian Coastal Monitoring System
SIN - Sistema Interligado Nacional	National Interconnected Transmission System
Singreh - Sistema Nacional de Gerenciamento de Recursos Hídricos	National Water Resources Management System
SINPDEC - Sistema Nacional de Proteção e Defesa Civil	National Protection and Civilian Defence System
SISAM - Sistema de Informações Ambientais Integrado à Saúde	Environmental Information System IntegratedtoEnvironmental Health
SISAN - Sistema Nacional de Segurança Alimentar e Nutricional	National Food and Nutritional Security System
Sisdagro - Sistema de Suporte à Decisão na Agropecuária	Agricultural Decision-Making Support System
SISNAMA - Sistema Nacional de Meio Ambiente	National Environment System
SMC Brasil - Sistema de Modelagem Costeira brasileiro	Brazilian Coastal Modelling System

SMCQ - Secretaria de Mudanças Climáticas e Qualidade Ambiental	Secretariat for Climate Change and Environmental Quality
SNIRH - Sistema Nacional de Informações sobre Recursos Hídricos	National Water Resources Information System
SNV - Sistema Nacional de Viação	National Roadways System
SOMABRASIL - Sistema de Observação e Monitoramento da Agricultura no Brasil	Agriculture Observation and Monitoring System in Brazil
SPU - Secretaria de Patrimônio da União	Secretariat for Inventory of Federal Assets
SRAG - Síndrome respiratória aguda grave	SARS - Severe Acute Respiratory Syndrome
	SREX - Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation
SRHU - Secretaria de Recursos Hídricos e Ambiente Urbano	Secretariat for Water Resources and Urban Environment
SSD - Sistemas de Suporte à Decisão	Decision-Making Support System
SUDENE - Superintendência do Desenvolvimento do Nordeste	Superintendence for Development of the Northeast
SUS - Sistema Único de Saúde	Unified Health System
SVS - Secretaria de Vigilância em Saúde	Secretariat for Health Surveillance
UCs - Unidades de Conservação	CUs - Conservation Units
UERJ - Universidade Estadual do Rio de Janeiro	Rio de Janeiro State University
UFBA - Universidade Federal da Bahia	Federal University of Bahia
UFC - Universidade Federal do Ceará	Federal University of Ceará
UFRGS - Universidade Federal do Rio Grande do Sul	Federal University of Rio Grande do Sul
UFRJ - Universidade Federal do Rio de Janeiro	Federal University of Rio de Janeiro
UFRN - Universidade Federal do Rio Grande do Norte	Federal University of Rio Grande do Norte
UFSC - Universidade Federal de Santa Catarina	Federal University of Santa Catarina
UnB - Universidade de Brasília	University of Brasilia
Convenção-Quadro das Nações Unidas sobre Mudança do Clima	UNFCCC - United Nations Framework Convention on Climate Change
UNIFESP - Universidade Federal de São Paulo	Federal University of Sao Paulo

UR- Uso Restrito	Restricted Use
USP- Universidade de São Paulo	University of São Paulo
VBP-- Valor Bruto da Produção	Gross Production Value
V-DL - 5ª Divisão de Levantamento do Exército	Army 5th Survey Division
Vigiagua- Vigilância da qualidade da água para consumo humano	Surveillance of drinking water quality
Vigiar- Vigilância em saúde de Populações Expostas à Poluição Atmosférica	Health Surveillance of Populations Exposed to Air Pollution
Vigidesastres - Vigilância em saúde ambiental dos riscos associados aos desastres	Surveillance of environmental health of risks associated with disasters
VLTs- Veículo leve sobre trilhos	Light rail
ZC- Zona Costeira	CZ- Coastal Zone

MINISTRY OF
ENVIRONMENT

ORDEM E PROGRESSO
BRASIL
BRAZILIAN GOVERNMENT