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

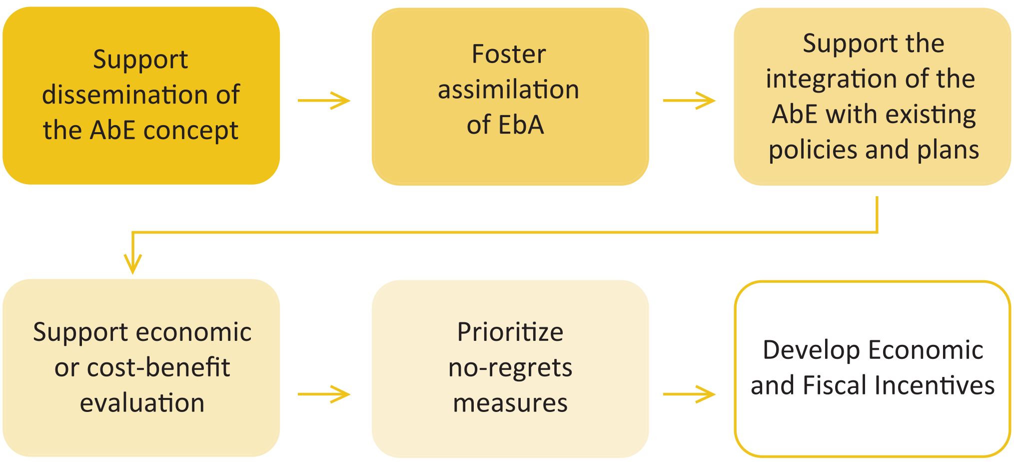

Figure 2. Framework for incorporation of EbA measures into sectoral adaptation policies

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.	

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