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 Chapter on 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

4. Integrate territorial planning systems of different levels with a focus on coastal erosion	Include in environmental licensing a requirement for vulnerability studies on erosion and flooding; Establish the dimension of flooding and set parameters for no-building zones; Promote development policies for the municipalities/states, tied to compliance with the requirements related to erosion and flooding; Strengthen coastal management instruments (GERCO)	MCid, MMA, MI, SEMAs, State Secretariats for Planning, Town Halls	Legal framework for flood/erosion established; Credit line to support of states and municipalities established.	Short
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 natural-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:

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) 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.

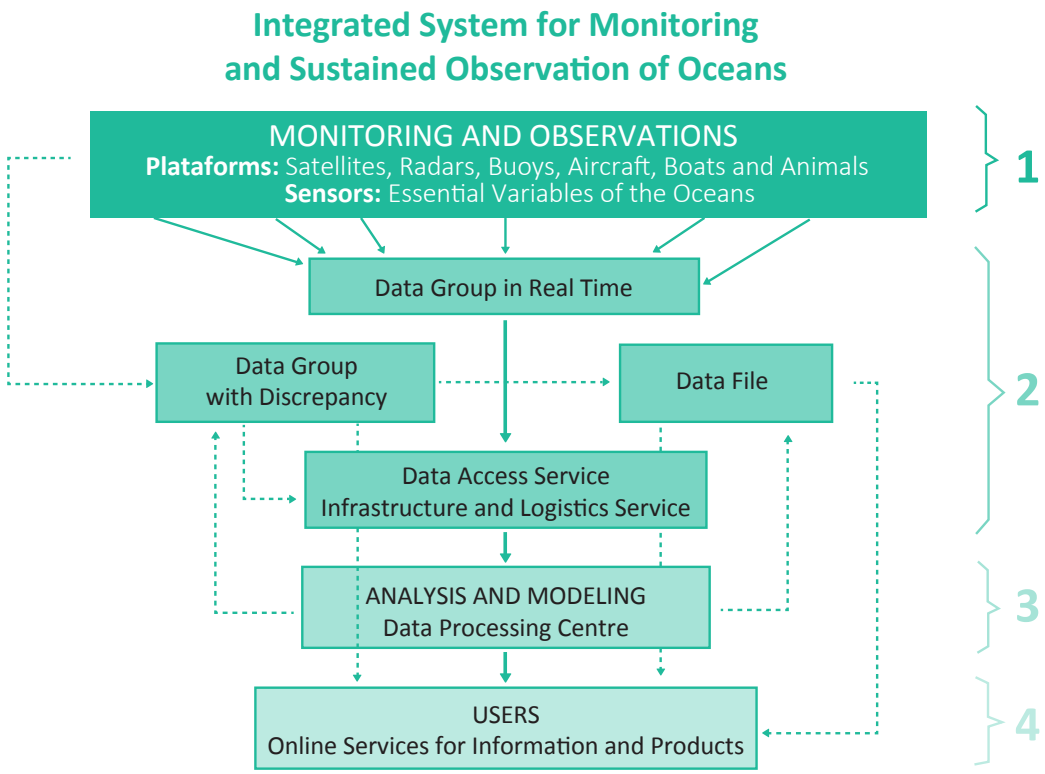

Figure 19- Integrated System for Monitoring and Sustained Observation of Oceans
System for Monitoring and Observation of the Oceans

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.

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